Environmental Taxation

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Draft: December 1, 2015

This paper examines potential environmental tax policy reforms. It focuses primarily on a carbon tax, but also more briefly considers a range of other possible changes. These include revising or eliminating various energy and environmental tax credits and deductions (many of which might become unnecessary in the presence of a carbon tax), as well as changes to energy taxes that have substantial environmental implications (such as the federal gasoline tax). The paper draws on recent theoretical and empirical research to evaluate the effects of such reforms on tax revenue, pollution emissions, economic efficiency, and income distribution.

This paper was written for the 2015 Conference on the Economics of Tax Policy, sponsored by the Robert D. Burch Center at UC Berkeley, the Penn Wharton Public Policy Initiative, and the Urban-Brookings Tax Policy Center.

1. Introduction

Long-term projections of the US federal budget show an increasingly large deficit, which would be difficult to address using spending cuts alone. But tax reform proposals tend to be much more concrete about tax cuts than about how those cuts will be paid for (much less how to achieve a net increase in tax revenues). Thus, potential new sources of tax revenue are in demand.

There is also increasing recognition of the need to take action to limit emissions of greenhouse gases and to further reduce emissions of local air pollutants. Using traditional command-and-control environmental regulation to accomplish those goals would be costly.

Environmental taxes have the potential to address both of those issues, providing a source of new tax revenue and a cost-effective way to reduce pollution emissions.

This paper examines potential environmental tax policy reforms. It focuses primarily on a carbon tax, which is the largest and most important potential new environmental tax. It also more briefly considers a range of other potential reforms. These include revising or eliminating various energy and environmental tax credits and deductions (many of which might become unnecessary in the presence of a carbon tax), as well as changes to energy taxes that have substantial environmental implications (such as the federal gasoline tax). The paper draws on recent theoretical and empirical research to evaluate the effects of such reforms on tax revenue, pollution emissions, economic efficiency, and income distribution.

The next section of this paper provides some background: an overview of the theory behind environmental taxation and a brief discussion of environmental taxation in the United States. Section 3 discusses carbon taxes. Section 4 considers changes to taxes on motor fuels (gasoline and diesel fuel). Section 5 briefly looks at reforms to existing environment- and energy-related tax credits and deductions. The final section summarizes and concludes.

2. Background

This section provides first an overview of the theory of environmental taxation and then a short discussion of the existing environmental tax provisions in the United States.

A. Theory of Environmental Taxation

This sub-section discusses the theory of environmental taxation and the key implications of that theory for the design and implementation of environmental taxes. It starts by considering environmental taxes as corrective taxes, providing incentives to lower pollution emissions. It then goes on to consider the role of environmental taxes within the larger tax system, considering both the potential for using environmental tax revenue to lower other taxes (or prevent raising them) and how environmental taxes interact with the rest of the tax system.

i. Corrective Taxation

The concept of using taxation to correct negative externalities such as pollution is generally credited to Pigou (1920), and such corrective taxes are sometimes referred to as Pigouvian Taxation. The basic idea is simple. A negative externality – a case in which production or consumption of some good harms someone other than the buyer or seller of that good – represents a market failure because the buyer's and seller's decisions fail to take into account that external cost. Consequently, an unregulated free market will generally result in an inefficiently high quantity of any good with an associated negative externality. Imposing a tax on the externality-generating good can correct the externality. If the tax rate is set equal to marginal external damage (the total harm to parties other than the buyer and seller from one additional unit of the good), it brings that external cost into the transaction, ensuring that the buyer pays the full marginal social cost of the good. Thus, the incentive provided by the tax ensures that the market produces the efficient level of the good (in the absence of any other uncorrected market failures).

One complication would be if the marginal external damage from a good varies based on who produces the good or how it is produced. For example, the carbon dioxide (CO_2) emissions from a megawatt-hour of electricity produced from a power plant that burns natural gas are much lower than the CO_2 emissions if the same quantity of electricity is produced by burning coal (and much lower still if produced by a wind turbine). But that apparent complication is easily incorporated into this simple theory, either by viewing those as different goods (and thus charging different tax rates on electricity produced from different sources), or, more simply, by viewing CO_2 emissions as the good with the negative externality, and imposing a tax per ton of CO_2 emissions. Similarly, if the marginal damage from local air pollutants varies based on where those pollutants are emitted,[1] then emissions in different locations should face different tax rates.

In practice, imposing a theoretically ideal tax can be challenging. Estimating marginal damage is difficult, particularly in cases where the harm will occur in the future

[1] For example, the marginal damage from emissions immediately upwind of a major city tend to be much higher than those in a sparsely populated rural area, because the number of people affected is much greater.

(as with greenhouse gas emissions) or where damage varies widely across space or time (as with local air pollutants). And in many cases, it is difficult for taxing authorities to directly measure emissions, and thus imposing the tax on some proxy for emissions (such as the amount of fuel burned) makes it much easier to enforce. In such cases, any tax will need to depart from the theoretical ideal, but the theory provides some general principles: set tax rates based on the best estimate of marginal damage; and when it is impractical to tax emissions directly, choose a proxy that is as close as practicable to what matters for marginal damage. Taxing based on those principles will most efficiently correct the negative externality from pollution.

Note that I have not yet mentioned the use of revenue from an environmental tax. Many non-economists would define an environmental tax as a tax whose revenue is used to address environmental goals. But to most economists, an environmental tax is a tax on pollution emissions (or on a good proxy for pollution emissions). This latter definition focuses on the corrective role of environmental taxes. In general, the revenue raised by efficient levels of taxes on emissions could be greater or less than the efficient level of spending to address environmental goals, and thus economic theory argues that environmental tax revenue should not necessarily be spent on environmental ends, nor should environmental spending necessarily be financed by environmental taxes.

ii. Environmental Taxes as Part of the Broader Tax System

Of course, environmental taxes don't just correct externalities. They also raise revenue, and that can be a major advantage. That revenue can be used to cut (or prevent increasing) other taxes, to reduce the budget deficit, to pay for public goods, to address distributional goals, or for many other purposes. At the same time, interactions between environmental taxes and other pre-existing taxes (primarily income and payroll taxes) can significantly raise the efficiency costs of environmental taxes (or any other excise tax or similar policy). This sub-section reviews research on the potential gains from using environmental tax revenue, as well as the potential extra costs implied by interactions with other taxes.

The argument that the revenue-raising role of environmental taxes is a substantial additional reason to implement such taxes first came to prominence in the "double dividend" literature.[2] The idea is simple: if revenue from an environmental tax can be used to finance a cut in the tax rate for a pre-existing distortionary tax (such as the income tax), that cut produces an efficiency gain in addition to the other effects of the environmental tax. The term "double dividend" refers to the claim that environmental taxes raise economic efficiency through two separate channels, both by correcting an externality and by raising revenue that can be used to cut other taxes. That second "dividend" has since come to be known as the "revenue-recycling effect."[3] And that basic concept also applies to a broader range of uses for the revenue: spending the revenue on public goods or using it to cut the budget deficit could produce similar gains in economic efficiency.[4]

[2] See, for example, Tullock (1967), Pearce (1991), Repetto (1992), and Oates (1995).

[3] The terms "revenue-recycling effect" and "tax-interaction effect" are due to Goulder (1995).

[4] If the levels of the budget deficit and of spending on public goods are efficient *ex ante*, then at the margin, using environmental tax revenue to cut the deficit or increase public good provision will have the same efficiency benefit as using it to cut other taxes. To the extent that those levels are not optimal, those alternative uses could produce larger or smaller gains.

Early papers in the double dividend literature argued that because of that gain from recycling revenue, environmental taxes would still be worthwhile even if the pollutant being taxed turned out to be harmless: that the efficiency gain from revenue-recycling would more than cover the efficiency cost of the tax. That was a particularly attractive argument in the case of a carbon tax, because at the time the early double-dividend papers were written, there was still significant scientific uncertainty about the relationship between anthropogenic carbon emissions and climate change (and it remains a potentially attractive political argument even today, given that many Americans still doubt that relationship). However, subsequent work showed that argument – now referred to as the "strong double-dividend" – does not generally hold.

What those early double-dividend studies missed was the general-equilibrium interactions between environmental taxes and pre-existing distortionary taxes. Environmental taxes lower the real returns to factors of production such as capital and labor, either directly by reducing wages and returns on capital, or indirectly by pushing up the prices of polluting goods. This discourages the supply of those factors, and because pre-existing taxes have already distorted those factor markets (causing the marginal social cost of supplying those factors to be lower than their marginal product), this creates a welfare loss.

Under central-case assumptions, the extra cost from this "tax-interaction effect" is actually slightly larger than the gain from the revenue-recycling effect, and thus not only is there no strong double dividend, but the efficient level of an environmental tax is slightly lower than marginal pollution damage. The intuition for that result is that broader taxes are generally more efficient revenue-raising instruments, and an environmental tax is a narrower tax than an income tax (because the income tax covers all production, whereas the environmental tax covers only polluting production).

More recent work has pushed back to some extent against that conclusion. To pick just one example, Parry and Bento (2000) suggest that inefficient tax preferences within the income tax system (tax deductions, credits, and exemptions that are not justified by market failures) narrow the tax base of the income tax, and that taking this into account means that environmental taxes are more efficient at raising revenue than the income tax – and thus that the optimal environmental tax is more than marginal damage. A major problem with that argument is that it compares the existing (inefficiently designed) income tax to an efficiently designed environmental tax. If a real-world environmental tax also includes inefficient deductions or exemptions, then this would weaken or overturn Parry and Bento's argument.

This literature has not come to a single clear and unambiguous conclusion about whether interactions with the broader tax system cause the optimal environmental tax to be slightly higher or lower than marginal damage. But the literature has generally rejected arguments that such effects cause the optimal tax to be dramatically different from marginal damage.

B. Environmental Taxes in the United States

Metcalf (2009) says that "Environmental taxes in the United States are like virtue: much discussed but little practiced." Williams (2009) notes that definitions of what constitutes an environmental tax vary, and measures of the magnitude of environmental taxation will vary correspondingly. But under any reasonable definition, the current level of environmental taxation in the United States is very low, relative either to environmental taxation in other developed countries or to the levels that would efficiently correct major pollution externalities.

By far the largest existing environmental tax in the US is the motor fuels excise tax: state and federal taxes on motor fuels accounted for approximately $70 billion in 2005, which was roughly 94% of all US environmental tax revenue (Metcalf, 2009). The remainder comes from a variety of much smaller taxes. While some of these are intended to provide incentives (e.g., the “gas guzzler” tax on cars with especially low fuel mileage), most are designed simply to raise money to remediate environmental problems (e.g., an excise tax on oil to fund the Oil Spill Liability Trust Fund, or the excise tax on coal which funds the Black Lung Disability Fund). Fullerton (1996) notes that this latter group provides only relatively weak incentives to reduce pollution, because the tax bases for these taxes are not tightly connected to pollution emissions.

Metcalf (2009) compared environmental tax revenue in the United States to other OECD countries, using data from the mid 2000s. Environmental tax revenue as a share of GDP was lower for the US than for all but one other country (Mexico), and was far less than the average (US environmental tax revenue was 0.9% of GDP, compared to 2.23% for the average OECD country). Looking at environmental tax revenue relative to total tax revenue yields a similar picture: the US was the lowest of all countries in the sample. Using more recent data would, if anything, strengthen that pattern: the US has not imposed any substantial new federal environmental taxes, and the tax rate for the biggest environmental tax in the US – the motor fuels excise tax – has remained constant in nominal terms per gallon since 1993, thus falling in real terms.

An alternative comparison would be to the level of environmental taxation that would efficiently correct major environmental externalities. Again, current levels of environmental taxation look very low. First consider motor fuel taxes. Rates for these taxes are well below the efficient level (i.e., marginal external damage). The current combined federal and average state tax is 48.69 cents/gallon,[5] whereas Parry and Small (2005) find that the efficient tax rate would be roughly $1/gallon.[6]

Including other possible environmental taxes widens this gap much more. Consider the carbon tax. Carbone *et al*. (2013) estimate that a $30/ton carbon tax would raise an average of $226 billion/year (in 2012 dollars) over the first 10 years after implementation. That's more than twice the total revenue per year from all existing state and federal environmental taxes. And that rate is somewhat lower than most recent estimates of marginal damage.[7] Thus, even if one only considers those two environmental taxes – motor fuels taxes and a carbon tax – the revenue from setting those taxes at levels necessary to correct externalities would dwarf existing US environmental tax revenue.[8]

There are also a variety of environmental tax incentives that aren't environmental taxes, but rather tax expenditures: tax deductions, credits, or exemptions that provide

[5] This figure comes from American Petroleum Institute (2015).

[6] West and Williams (2007) find that interactions with the rest of the tax system (as discussed in Section 2.A.ii) imply an even higher efficiency-maximizing gas tax rate.

[7] For example, a recent Inter-Agency Working Group report (US IAWG, 2013) estimates that the marginal external damage per ton of carbon is roughly $42.

[8] One can't simply add together revenue from motor fuels taxes and a carbon tax, both set to the efficient level, because this would entail some double-counting: most estimates of the marginal damage associated with motor fuel use include carbon emissions from motor fuels. However, this double-counting is small: carbon emissions account for slightly less than 5% of Parry and Small's (2005) estimate of the efficient gasoline tax.

incentives for "clean" (i.e., less polluting, at least on some dimension) energy or energy conservation. These are small in absolute terms (in fiscal year 2010, the largest was the alcohol fuel credit and excise tax exemption, which cost $5.75 billion, and that provision has since expired), but nonetheless large relative to all existing US environmental taxes other than motor fuels taxes.

3. A Carbon Tax

Increasing concentrations of greenhouse gases in the Earth's atmosphere are trapping heat, thus leading to an overall warming of the globe and other related changes to the climate. The most important of these gases is carbon dioxide, which is emitted primarily through burning fossil fuels, though other gases such as methane are also important. Reducing emissions of greenhouse gases is the most reliable way to limit or prevent such changes. A tax on such emissions – generally referred to as a carbon tax, even though it could apply to a broader range of gases than just carbon dioxide – would be a cost-effective means of reducing such emissions.

This section reviews research on the design of a carbon tax and on what effects such a tax would have. The first subsection reviews key design elements of such a tax, including the tax base, initial tax rate, time profile, and related issues. The next subsection looks at estimates of key aggregate effects of a carbon tax: the effect on emissions, the potential revenue raised, and the implications of a carbon tax for growth and economic efficiency. The final subsection considers the incidence of a carbon tax: how the burden of the tax is distributed across different US states and income groups.

A. Carbon Tax Design

This subsection focuses on details of a carbon tax, such as what the tax base is, at what point in the production process the tax could be imposed, the tax rate, and the path for the rate. In each of these cases, economic theory gives a simple and clear answer for what will maximize efficiency, though real-world proposals often vary substantially from that.

i. Tax Base and Point of Collection

The primary role of a carbon tax is as an externality-correcting tax, with the goal of reducing emissions of greenhouse gases. Thus, the theoretically ideal tax base would be all greenhouse gas emissions, with each gas taxed based on how large an effect one unit of emissions of that gas has on climate change. As the name "carbon tax" suggests, such a tax would apply to carbon dioxide emissions, but would also apply to a range of other greenhouse gases, such as methane, nitrous oxide, and chlorofluorocarbons. In practice, however, there are a number of practical difficulties in implementing such a tax.

First, reducing the climate-changing effects of a particular gas to a single number is not a simple exercise. Different gases both trap heat to a different extent and persist for different periods of time in the atmosphere. Methane, for example, is a much more potent greenhouse gas than carbon dioxide (one extra ton of methane in the atmosphere has approximately the same short-run greenhouse effect implications as a hundred tons of CO_2), but persists for a much shorter period (with an atmospheric lifetime of roughly 12 years, versus estimates for CO_2 ranging from 30-95 years), so the relative effects of the two gases depend crucially on the time period used for evaluation.[9]

The standard approach in the literature is to calculate the "global warming potential" (GWP) for a given gas: the sum of its climate-changing effect over a given period of time, taking into account the gradual decay of the gas in the atmosphere over time, but not taking into account discounting or changes over time in the marginal damage from a particular temperature change.[10] The GWP for a particular gas is then expressed relative to that of CO_2. For example, the GWP of methane is 72 over a 20-year time horizon, indicating that over the first 20 years after it is emitted, a ton of methane will cause the same total warming over that period as 72 tons of CO_2. The analogous numbers for longer time horizons are 25 over 100 years, and 7.6 over 500 years, which shows how dramatic an effect the time horizon can have on this measure. Emissions are then generally expressed in terms of CO_2 equivalent quantities (CO_{2e}), typically based on a 100-year time-horizon GWP estimate. Adopting this approach for a tax would imply taxing CO_{2e} emissions, or, equivalently, taxing emissions of each gas based on its GWP.

A more important problem is that monitoring emissions of many of these gases is difficult. CO_2 is relatively straightforward in this regard, because the vast majority of anthropogenic CO_2 emissions come from combustion of fossil fuels (e.g., 94% of US

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[9] These numbers and the GWP estimates in the following paragraph are taken from IPCC (2007), table 2.14.

[10] A theoretically ideal measure for economic purposes would make these two adjustments (for discounting and changes over time in marginal damage from climate change), and would use an infinite time horizon. But such a calculation would requires choosing a discount rate and estimating the time path of marginal damage. One can view the standard GWP approach as a rough approximation to that.

CO_2 emissions in 2013 were from combustion[11]), and the CO_2 emitted by combustion is simply proportional to the quantity of carbon in the fuel.[12] Thus, a tax on fossil fuel combustion, based on the carbon in the fuel, is equivalent to a tax on combustion-related CO_2 emissions. Moreover, much of the non-combustion CO_2 emissions are from large industrial uses such as cement manufacture and use, which are also relatively easy to monitor. Thus, including nearly all CO_2 emissions is relatively easy.

Mansur (2012) provides an excellent discussion of important considerations in choosing the point in the supply chain to apply a corrective tax. Because combustion-related CO_2 emissions depend only on the carbon content of the fuel, these considerations argue for imposing the tax at natural choke points in the fossil fuel supply chain, where the number of entities subject to the tax would be relatively small, thus minimizing enforcement and compliance costs. For example, there are roughly 150 refineries in the United States, so taxing the carbon content of oil at the refinery level (and applying an equivalent tax to imports of refined petroleum products when they enter the country) would be vastly simpler than taxing consumer purchases of refined petroleum products. Metcalf and Weisbach (2009) suggest that if the tax is applied in this manner, taxing a few thousand fossil fuel firms could cover roughly 80% of US CO_{2e} emissions.

Adding some other greenhouse gases to the base of a carbon tax could also be easy. Chlorofluorocarbons are already regulated and taxed (because of their role in depleting the ozone layer), so they would be easy to include in a carbon tax, and

[11] The emissions figures here and in the next paragraph come from U.S. EPA (2015).

[12] This is because all of the CO_2 produced by combustion is released into the atmosphere. Carbon capture and storage (CCS) technology could change this. CCS would capture CO_2 released by combustion and store it so it is not released into the atmosphere. But CCS will only become cost-effective if technology advances dramatically or if carbon tax rates are much higher than the range of current proposals.

extending that to cover the closely related hydrochlorofluorocarbons (which are much less damaging to the ozone layer but similar in terms of greenhouse gas effects) would also be straightforward.

However, including most other greenhouse gases (which made up roughly 18% of US CO_{2e} emissions in 2013) is substantially more difficult. Advances in remote sensing could help to track methane and nitrous oxide emissions, but it is still likely that including these gases in the base for a carbon tax would need to rely on taxing readily observable proxies for emissions, rather than emissions itself – and to the extent that those aren't perfect proxies, this could entail potentially significant inefficiencies (which would need to be weighed against the inefficiency of leaving those emissions out of the tax base[13]). Including these gases could also be politically difficult, because agriculture is responsible for a substantial share of emissions of these gases, and is very politically powerful.

ii. Initial Tax Rate and Time Path of Rate

As discussed earlier, the basic theory of corrective taxes suggests that the optimal corrective tax rate should equal the marginal damage per unit of emissions. Interactions with the broader tax system may raise or lower this somewhat, but don't dramatically alter that basic conclusion.

The key question, then, is what is the marginal damage from greenhouse gas emissions. This is a complex and difficult question to answer, both because the exact

[13] For example, leaks from the natural gas extraction and distribution system are responsible for a substantial share of methane emissions. Natural gas has lower CO_2 emissions per unit of energy than other fossil fuels, so a carbon tax would likely cause a shift from other fossil fuels toward natural gas. If methane leaks are significant, and are not taxed, then it's possible that the shift toward natural gas could actually raise CO_{2e} emissions. But taxing leaks is difficult.

climate effects of a given level of greenhouse gases remain uncertain, and because changes to the climate have a wide range of effects, most occurring well into the future, and these are both uncertain and difficult to value accurately. Thus, any estimate will necessarily be highly uncertain.

A recent US inter-agency working group report (US IAWG 2015) estimated the marginal damage from carbon emissions (also referred to as the social cost of carbon, or SCC) to be roughly $42/ton. Because this report could not follow all potential channels for climate change damages, this is likely to be an underestimate, though it is obviously difficult to predict the degree of underestimation. And the report has generally been highly controversial. Nonetheless, this represents the best available estimate, and thus is a good general guideline for the efficient carbon tax rate, suggesting a rate of $42/ton CO_{2e}.

Weitzman (2009) argues that uncertainty about climate-change damages should imply a much more aggressive policy to limit climate change. The argument is that the probability distribution of climate change is "fat-tailed" – put simply, that as we consider very unlikely, highly catastrophic outcomes, the probability of those outcomes falls as we consider more and more severe possible outcomes, but falls relatively slowly compared to most commonly used probability distributions. This means that those catastrophic outcomes – even though they are very unlikely – are still enormously important in determining the expected harms from climate change. And thus, including those potentially catastrophic outcomes implies a much higher SCC estimate (indeed, in its most extreme form, Weitzman's argument implies an infinitely high SCC). More intuitively, Weitzman's argument suggests that we should view climate change policy more as buying insurance against the worst possible outcomes than as trying to reduce damages in the relatively likely moderate-damage cases. Including such effects in a numerical estimate is very difficult, and thus the IAWG did not incorporate them, another reason why it might represent an underestimate.

A closely related question is what the optimal time path for the tax rate is. Should the tax start immediately at the SCC, or should it be gradually phased in? And once it is fully in place, how should it change over time?

Williams (2012) shows that the efficient carbon tax would not be pre-announced or gradually phased in, but would start immediately at the SCC, even when households and firms would face substantial capital adjustment costs in responding to the tax (e.g., the cost of retiring coal-fired electric plants before the end of their useful lives). Shimer (2013) finds an analogous result for labor adjustment costs such as layoffs in fossil-fuel industries.

The intuition for these results is simple: while those adjustments are costly, and affect the optimal quantity path for emissions (with higher adjustment costs implying a slower drop in emissions), the adjustment costs are not market failures, and thus they don't influence the optimal corrective tax, which still equals marginal damage. Williams (2012) notes, however, that these adjustment costs can be important for the distribution of costs, and that while other approaches such as direct transfers would be more efficient, if such alternatives are not possible, a gradual phase-in could be useful for meeting distributional objectives.

In general, the efficient carbon tax will rise over time at the same rate as marginal damage. The IAWG estimates suggest that the SCC rises at roughly 1.5% - 2% per year (in real terms), which would imply a similar rate of increase for the efficient carbon tax rate.[14]

Nonetheless, many carbon-tax proposals have rates that rise more quickly than that. Many proposals call for a tax that rises at 4% or 5% in real terms (e.g., Morris's (2013) proposal for the Hamilton Project suggests a 4% real rise), and it is not uncommon to see proposals that rise far faster than that (recent proposals from the Carbon Tax Center, for example, start at $10/ton and rise by $10/ton each year, an extremely fast rate of increase). There are three main reasons for this.

First, many of these proposals start at rates below the SCC and thus must rise more quickly in order to catch up. It would be more efficient to start at a higher rate and rise more slowly, but if distributional or political considerations prevent that, then starting low and rising quickly is a reasonable alternative.

Second, some proposals are aimed at emissions reduction pledges (e.g., an 80% reduction in US emissions by 2050) or at specific temperature-change limits (e.g., a 2^{o} C rise in global temperatures), and these typically entail very modest short-term reductions and very aggressive longer-term reductions in emissions, which are consistent with a very rapidly rising carbon price. These targets are generally arbitrary, and rarely based even in part on any analysis of costs and benefits. Thus, the tax paths necessary to follow these emissions trajectories are often far from efficient. Nonetheless, such targets may have substantial political value. And the carbon tax is still a cost-effective approach for following any arbitrary trajectory.

[14] Daniel *et al.* (2015) argues that uncertainty about climate change (including the tail risk mentioned earlier in this section) implies a substantially different time profile for the optimal carbon tax, one that starts much higher and actually declines over time.

Third – and most common among proposals by economists – proposals are sometimes based on the idea that the tax rate should rise at the real rate of interest. This is the tax path that minimizes present-discounted costs of hitting a given total quantity of emissions over time (and is also the price path – in the absence of uncertainty – that a system of bankable and tradable carbon permits would follow). This has some appeal on cost-effectiveness grounds. But looking only at total emissions over a long period (rather than year-by-year emissions) makes sense only if the present-discounted marginal damage from emissions is constant over time. Put differently, this approach minimizes the discounted costs of hitting a target expressed in undiscounted tons, a combination that doesn't generally make sense. Again, there may be political value to hitting this kind of target, but it's not efficient.

B. Effects on Greenhouse Gas Emissions, Tax Revenue, Growth, and Efficiency

This section looks at estimates for important aggregate effects of a carbon tax: how it affects greenhouse gas emissions, the potential tax revenue, and effects on economic growth.

i. Greenhouse Gas Emissions

The primary purpose of a carbon tax is to reduce emissions of greenhouse gases. Thus, a key question for carbon tax models to answer is the extent to which a given carbon tax will actually reduce emissions. Estimates vary somewhat for a given carbon tax across different models. And they obviously vary substantially based on the details of the carbon tax, with the tax rate being the most important and the time path also playing an important role, while other details, such as the use of revenue from the tax play less important roles. The degree of coverage of the tax (the fraction of total GHG emissions that are in the tax base) is also potentially important, though differences here come mostly from whether the tax misses major fossil-fuel uses rather than the extent to which it includes non-CO_2 gases.

Two key points to note when evaluating estimates of emissions reductions are what year (or years) are under consideration, and what reference point is used for measuring reductions. In general, a given tax rate will generate larger emissions reductions further into the future, because some responses to the tax take a significant period of time, and thus the long-run elasticity of emissions with respect to the tax rate is much higher than the short-run elasticity. The point of reference for reductions also matters. National pledges to reduce emissions are typically expressed relative to emissions in some base year (e.g., under the UN Framework Convention on Climate Change the US pledged to reduce emissions in 2025 to 26% - 28% below 2005 levels), and model estimates are sometimes also expressed this way. More commonly, estimates from economic models are reported as reductions below "business-as-usual" (BAU) emissions, meaning the level that would have occurred in a given year in the absence of the policy.[15] The latter measures the effect of the policy, whereas the former shows the actual level of emissions.

Hafstead and Kopp (2015) find that a $45/ton carbon tax, starting in 2016 and rising at 2%/year in real terms, would reduce US emissions in 2025 by 41% relative to BAU, which is equivalent to 45% below 2005 levels. In contrast, Carbone *et al*. (2013) estimate that a $50/ton carbon tax (starting in 2015 and held constant in real terms) would

[15] A further complication is that BAU sometimes refers to emissions in the absence of the particular policy under consideration, and sometimes to emissions in the absence of any GHG emissions reduction policies.

reduce US emissions in 2025 by roughly 23% below BAU. Part of that difference reflects differences in the tax rate under consideration, but more of the difference comes from differences in the models used. Estimating the responsiveness of large sectors of the economy to a carbon tax is very difficult, given that the US has never imposed such a policy, and thus estimates vary significantly across models.

By way of comparison, the latter study also finds that a $30/ton tax would reduce emissions by roughly 17% below BAU, and a $20/ton tax by roughly 12%. In general, the effect on emissions rises less than linearly with the tax rate (e.g., doubling the tax rate will less than double the emissions reductions). These estimates vary somewhat based on how the revenue from the tax is used, but those differences are relatively small: for example, the estimated emissions reduction from a $30/ton carbon tax is 14.92% if the carbon tax revenue is recycled to finance tax cuts on capital income, versus 16.61% if it is returned to households via lump-sum transfers. That difference arises largely because of differences in overall economic growth caused by the different uses of revenue.

Most models suggest that the vast majority of emissions reductions will come from the electricity sector, at least for moderate carbon tax rates. For example, the same Hafstead and Kopp (2015) study find that 72% of the emissions reductions in 2025 come from the electricity sector. This is because switching away from coal to lower-carbon sources of electricity is one of the least expensive ways to reduce carbon emissions.

An alternative approach when considering the emissions effect of a carbon tax is to look at the question from the other direction: what tax rate is necessary to achieve a particular level of emissions reductions in a given year (or a particular path of emissions over a range of years). Fawcett *et al*. (2015) reports results from a Stanford Energy

Modeling Forum exercise that took this approach, using eight different models under a range of different assumptions about technology changes and other key influences. The exercise looked at what carbon tax rate would be needed to achieve a 17% reduction (relative to 2005) by 2020 and 50% reduction by 2050. On average across the different models and assumptions, this required a tax rate of $41/ton in 2020 and $192/ton in 2050 (both expressed in 2012 dollars). This again shows the non-linearity of the response to the tax: getting a reduction roughly three times as large requires a tax rate more than three times as high. Those estimates also ranged widely across models, with a standard deviation of $35/ton in 2020 and $113/ton in 2050, which again demonstrates the degree of uncertainty about how large the response to any given tax would be.

ii. Carbon Tax Revenue

Given an estimate of the emissions effects of a carbon tax, estimating the gross revenue the tax will raise is simple: the tax rate times the emissions subject to the tax. The revenue from a moderate carbon tax is potentially substantial. Carbone *et al*. (2013) estimates that a $30/ton carbon tax (held constant in real terms) would raise a total of $2.26 trillion in gross revenue over the first ten years. Marron *et al.* (2015) scale a Congressional Budget Office estimate and find that a $25/ton carbon/ton tax (rising at 2%/year in real terms) would raise $1.6 trillion in gross revenue over ten years.

However, imposing a carbon tax can change the revenues from other taxes and the cost of goods and services that the government buys. Thus, the most relevant question isn't the level of gross revenue, but the net revenue: the amount of revenue left after compensating for those other changes to the government budget. The Joint Committee on Taxation (JCT) and CBO impose a standard offset factor (informally known as a "haircut") to account for effects of indirect taxes (such as a carbon tax) on revenue from other taxes, which reduces the amount of revenue available by 25%.[16] To the extent that the carbon tax affects the overall size of the economy, those effects will also influence net revenue (with greater economic growth implying more net revenue relative to gross revenue from the tax).

Applying that standard offset reduces the gross estimates above to net revenue of $1.7 and $1.2 trillion, respectively, over the next ten years. This still represents a large amount of revenue. By way of comparison, the corporate income tax is estimated to bring in $4.6 trillion in revenue over that period, the total of all excise taxes $1.1 trillion, and the estate and gift tax $246 billion, and the primary budget deficit over that period is projected to be $2 trillion (CBO 2015). Thus, a carbon tax could finance substantial reductions in other taxes or in the budget deficit.

iii. Effects of a Carbon Tax on Economic Growth

By itself, a carbon tax is likely to slow economic growth slightly. Fossil fuels are used throughout the economy, and thus taxing carbon acts as an implicit tax on all production. This lowers the return to factors of production such as capital and labor (either directly, though effects on wages and profits, or indirectly, by raising product prices and thus lowering real returns), and thus discourages work, saving, and investment.

[16] The rationale for this standard offset is that for a given total amount of total economic activity, each dollar of indirect tax revenue will reduce total wage and profit income by a dollar, thus reducing revenue by the amount of tax that would have been collected on that dollar. If tax rates average roughly 25%, then this implies a correction factor of roughly 25%. Note that this does not include any effects on the overall size of the economy.

This effect is significant but not dramatic: Carbone *et al.* (2013) estimates that a $30/ton carbon tax would reduce GDP by roughly 3.5% in 2050.[17] Note that figure expresses a difference in GDP levels, whereas we usually hear about GDP growth rates. A 3.5% difference in GDP levels 35 years from now is equivalent to roughly a 0.1% difference in average annual growth rates over that time.

That estimate assumes that the entire revenue from the tax is returned to households in lump-sum transfers. If the revenue is used in some alternative way that provides a boost to growth, such as cutting marginal tax rates, reducing the budget deficit, or funding growth-enhancing public goods, then this would reduce or even reverse the drag on GDP. For example, Carbone *et al*. (2013) finds that if the net revenue from the carbon tax is used to fund cuts in taxes on capital income, that reverses the effect on GDP, leading to a roughly 1.3% higher level of GDP in 2050.

Williams and Wichman (2015) review estimates for the effect of a carbon tax on growth from a range of different models, carbon tax rates, and uses of revenue, and all of them lie between the two estimates cited in the previous two paragraphs. Most cluster around a 0.5% to 0.7% lower level of GDP by 2040, with higher GDP estimates

[17] This section focuses on effects on GDP because it is an easily understood measure of economic growth. However, it is worth noting that GDP only measures the value of market goods and services, and leaves out many other goods that are valuable but not sold in the market (for example, the value of leisure time or of goods produced at home, such as childcare and home-cooked meals). Many studies find that using GDP overstates the cost of a carbon tax relative to more complete measures of economic well-being (such as equivalent variation).

associated with revenue used for capital tax cuts and lower estimates associated with revenue used for lump-sum rebates and/or with extremely high carbon tax rates.[18]

C. Distribution of the Cost of a Carbon Tax

While the aggregate effects of a carbon tax are important, they are certainly not all that matters. The distribution of those effects is also important, because of both equity and political considerations. This sub-section considers how the costs of a carbon are distributed across income groups and across states and regions of the US.

It is natural to think that a carbon tax will be quite regressive. The most obvious effect of a carbon tax is to raise the prices that consumers pay for direct energy goods: electricity, natural gas, gasoline, heating oil, etc. And these goods represent a larger share of the budget for poor households than for wealthier households.

Williams *et al*. (2015) shows that the burden imposed by higher direct energy good prices caused by a carbon tax, expressed as a percentage of income, is roughly five times as large for the bottom income quintile (the poorest 20% of households in the US) as it is for the top income quintile. Those figures are based on current-year income, and it is well-known that such measures tend to overstate how regressive increases in consumer prices are, relative to measures based on income over a longer term (or proxies for longer-term income such as current-year consumption). But even using estimates from Hassett *et al*. (2007) based on current-year consumption, the burden from direct energy good price increases is 2.5 times as large for the bottom decile as for the top decile.

[18] For example, NERA (2013) estimates a 3.4% lower GDP in 2050 for a case that reduce carbon emissions by 80% in 2050 – which in their model requires a carbon price of almost $1,000/ton.

However, the effects of a carbon tax on consumer prices go well beyond just the effects on direct energy goods. Every good in the economy has some energy use somewhere in its production process, and almost certainly some associated carbon emissions, so one would expect a carbon tax to influence the prices of all goods. Direct energy goods account for only about half of all carbon emissions in the US. And the effects on the prices of other goods are spread much more evenly through the income distribution. Hassett *et al.* (2007) find that when using measures based on current-year consumption, the distribution of this indirect burden is slightly progressive, though very close to equal across the income distribution. Thus, taking into account the effects on all prices, not just on prices of direct energy goods, shows that the carbon tax is not as regressive as it might first appear.

Moreover, a carbon tax doesn't just affect prices of consumer goods, it can also affect sources of income such as wages and returns to capital. Most studies of the distributional effects of carbon taxes (or carbon pricing in general) miss those effects, because they assume that the entire carbon tax is passed forward into produce prices. In fact, some portion of it will be passed backward, affecting the prices of factors of production used to produce carbon-intensive goods.

The few studies that include effects on sources of income find that these effects make the carbon tax more progressive. Carbon-intensive goods tend also to be capital-intensive in production, so a carbon tax causes a drop in capital demand relative to demand for labor. Moreover, even to the extent that the tax is passed forward into product prices, this also raises the price of capital goods, acting as an implicit tax on capital.[19] Together, these effects cause the carbon tax to fall disproportionately on capital income relative to labor income, and capital income goes disproportionately to higher income people. Moreover, income from government transfers – which goes disproportionately to poorer households – are typically indexed for inflation, and this helps to compensate poorer households for the consumer price effects of the carbon tax.[20]

Williams *et al*. (2015) finds that effects on incomes substantially reduce the regressivity of a carbon tax, though the tax remains slightly regressive. Rausch *et al.* (2011) finds an even stronger result, with these effects sufficient to make the carbon tax slightly progressive.

Finally, the use of the revenue from the carbon tax can dramatically influence the overall distributional implications of the policy. Williams *et al*. (2015) find, for example, that using carbon tax revenue to cut taxes on capital income makes the top income quintile better off (even ignoring any environmental gains), while making the other four quintiles worse off (with the loss getting larger as a percentage of income as one moves down the income distribution). Conversely, returning the revenue via equal-per-capita lump-sum transfers to households makes the bottom three quintiles better off and the top two worse off (with the gain getting smaller or the loss getting larger as one moves up the income distribution). Returning the revenue via cuts in labor taxes falls in between, with a roughly flat distribution of burden. Marron *et al*. (2015) finds quite similar results using a substantially different model.

[19] Many economists incorrectly view a carbon tax as having similar effects to a broad-based consumption tax such as a VAT, because they see it as raising consumer good prices. But the carbon tax implicitly taxes all production – whether used for consumption or investment.

[20] This point was first made by Parry and Williams (2010) and then was studied in more detail by Fullerton *et al*. (2011).

These results indicate that the use of the carbon tax revenue is more important than the effect of the carbon tax itself in determining the overall distributional effect of the policy. The carbon tax by itself is mildly regressive. Combining it with a regressive use of revenue (such as a cut in taxes on capital) makes it substantially more regressive. Combining it with a progressive use of revenue (such as lump-sum transfers) makes it substantially progressive.

4. Motor Fuel Taxes

While a carbon tax is the largest and likely most important potential new environmental tax, motor fuel taxes (taxes on gasoline and diesel fuel) are by far the most important existing environmental tax, accounting for more than 90% of environmental tax revenue in the US (and playing a similarly dominant role in nearly all other industrialized nations). This section focuses on motor fuel taxes, with the first subsection considering research on the efficient rates for these taxes, and the second subsection focusing on their distributional effects.

A. The Efficient Level of Motor Fuel Taxes

There are many negative externalities associated with motor vehicle use, including environmental externalities such as emissions of GHGs and local air pollutants, as well as other externalities such as traffic congestion and vehicle accidents. The most economically efficient approach would be to correct each of these externalities with a policy specifically targeting that externality: for example, a corrective tax aimed at traffic congestion would charge tolls that vary across roads and times of day, with the toll being highest when traffic congestion is at its worst, and falling to zero when a road is empty. The gasoline tax is a very blunt instrument by comparison. But there are practical difficulties with imposing a full set of policies to address those externalities, and it is much easier to adjust the level of existing motor fuel taxes. And regardless of why, to the extent that those other externalities are not fully corrected, they will influence the efficient level of taxes on motor fuels.

A naïve analysis would simply estimate the average level of each of those externalities on a per-gallon basis and add them up to calculate the efficient level for a corrective tax. For externalities that are directly proportional to the amount of fuel burned (such as carbon emissions), that's the correct approach, but not for other externalities. For example, suppose that a particular driver's contribution to traffic congestion is proportional to how much driving he does. If he responds to a higher gasoline tax only by driving less, then the reduction in the externality is directly proportional to the drop in fuel use. But if the higher tax also causes the driver to buy a more fuel-efficient car, then the reduction in the traffic externality is smaller than the drop in fuel use – and in that case, because the gas tax does less to address the traffic externality, that externality adds less to the efficient level of the tax.

Parry and Small (2005) review the various externalities associated with driving, also take into account interactions with the rest of the tax system (as discussed earlier, in section 2.A.ii) and calculate the efficient tax on gasoline to be approximately \$1.01/gallon (in 2000 dollars).[21] West and Williams (2007) find that higher gasoline prices boost household labor supply (more than one would expect simply based on

[21] In comparison, they find that a naïve calculation, simply adding up the externalities, would suggest a much higher rate of \$1.76/gallon.

income effects), and that this further raises the efficient gas tax, to \$1.12/gallon.[22] Converting that to 2015 dollars implies an efficient tax rate of \$1.55/gallon. That is far above the current combined federal and state tax on gasoline, which averages 48.69 cents/gallon, and ranges as high as 73.7 cents/gallon (in Pennsylvania).[23]

Far fewer studies look at the efficient level of taxes on diesel fuel, but the efficient tax on diesel fuel used by passenger cars should be roughly similar to that for gasoline, with some upward adjustment based on the greater GHG and local air pollution emissions per gallon, and the higher average miles per gallon (which magnifies per-mile externalities when converted to a per-gallon basis). Parry (2008) finds that the optimal tax on diesel fuel used by heavy-duty trucks is \$1.12/gallon (a figure that appears to be in year 2000 dollars, equivalent to \$1.55/gallon in 2015). Again, this is well above the current average combined federal and state diesel tax rate of 54.41 cents/gallon (API, 2015).

B. Distributional Implications of Motor Fuel Taxes

One major argument against increasing taxes on gasoline is that such a tax is regressive: lower-income households spend a larger fraction of their budgets on gasoline than do wealthier households. Unlike with other energy goods, this doesn't hold throughout the entire income distribution – the very poorest households are less likely to own cars – but it does hold for most of the income distribution.

As noted earlier, in section 3.C, studies based on one year's income tend to make taxes on consumer goods look more regressive than studies based on income over a

[22] This figure again is in 2000 dollars, and is based on the externality estimates taken from Parry and Small

[23] See American Petroleum Institute (2015).

longer time period (or proxies for longer-term income, such as expenditures). Poterba (1991) showed that this effect was important for analysis of the gas tax. West (2004) and West and Williams (2004) pointed out that lower-income households have more elastic gasoline demand than higher-income households, and that this lowers the burden they bear from a price increase, making the gas tax less regressive than if the elasticity were constant across incomes.

Nonetheless, even after taking those effects into account, the gas tax is still somewhat regressive. West and Williams (2004) find that the burden of a gas tax is highest for the second-lowest income quintile and lowest for the top quintile, though it is relatively flat across the bottom four quintiles: they estimate that raising the gas tax to the efficient rate (an increase of roughly $1/gallon) would impose a burden of 2.78% of annual expenditures for the bottom quintile, and 3.01% 2.88%, 2.49% and 1.60% for the second through fifth quintiles, respectively.

5. Environmental and Energy Tax Credits and Deductions

Many of the current environmental and energy provisions within the US tax code are not environmental or energy taxes, but rather tax credits, exemptions, and deductions. Rather than taxing pollution, energy use, or similar activities that government wants to discourage, these tax expenditures are implicit subsidies. This section briefly reviews two of the larger energy/environmental tax expenditures, discusses their effects, and considers whether they could be removed or replaced with more efficient alternatives.

A. Tax Credits for Renewable Electricity Generation

The renewable energy production tax credit (PTC) provides a tax credit of 2 cents/kWh of electricity generated from qualifying renewable sources (primarily solar, wind, and biomass). Alternatively, firms can take a investment tax credit (ITC) of 30% of the cost of investing in qualifying generating equipment. These credits substantially lower the cost of generating power from renewable sources, and thus encourage use of renewable energy.

This policy can be viewed as correcting a pollution externality, to the extent that renewable power substitutes for other more polluting sources of electricity (and that those pollution externalities are not already corrected by other policies). One might also argue that the policy addresses externalities in technology development (such as research and development spillovers), though that justification is more tenuous, given that these are not brand-new technologies and that the US represents a relatively small share of world demand.

Nordhaus *et al*. (2013) looked at the effects of the PTC and ITC on carbon emissions, and found relatively small effects: eliminating these provisions would increase carbon emissions by roughly 360 million metric tons, less than 0.3% of US energy-sector emissions. Moreover, this is a relatively expensive way to reduce carbon emissions: the government gives up more than $250 in tax revenue per ton of CO_2 reductions.[24]

Thus, if the goal of the PTC and ITC is to reduce carbon emissions, these credits are a relatively expensive way to achieve that goal. A carbon tax – even one with a very low rate – would do much more to reduce emissions, and at a lower cost.

[24] Note that revenue cost is not the same thing as the economic cost of the policy, and unfortunately the model used could not provide estimates of social cost. Nonetheless, this suggests that the policy is quite costly relative to its modest effects.

B. Depletion Allowances for Oil and Gas Wells

Owners of oil and gas wells can deduct a depletion allowance, which is intended to reflect the decline in the value of oil and gas reserves as those reserves are extracted and sold. That depletion is a cost, and thus should be deductible, just as other business costs are. However, independent companies producing in the US are allowed to use percentage depletion – deducting a percentage of gross income associated with the sale of the oil and/or gas – which typically allows for deductions that exceed the actual cost of acquiring and developing the resource. Thus, the difference between percentage and cost depletion represents an implicit subsidy to oil and gas production by independent producers. The JCT estimates that the difference reduced tax revenue by $4.1 billion over the 2010-2014 period.

This subsidy is difficult to justify on economic grounds. There is no obvious positive externality associated with domestic oil and gas production. "Energy security" is sometimes used as an argument for domestic production, but it is not clear why this represents an externality, nor is it clear that promoting depletion of reserves enhances energy security (indeed, one could argue that energy security is greater if those reserves are left in the ground so they can be used later in case of an energy crisis). The subsidy today largely benefits natural gas producers, and gas is a relatively clean fuel, which suggests there might be some environmental justification. But Nordhaus (2013) finds that eliminating percentage depletion would actually reduce GHG emissions slightly (a net drop of 37 million metric tons per year).

6. Conclusions

This paper has reviewed major potential environmental and energy tax changes. It focused primarily on a carbon tax, but also considered potential changes to the taxes on motor vehicle fuels (currently by far the largest environmental taxes in the US) and to two of the largest environmental and energy tax expenditures.

A carbon tax represents a cost-effective way of reducing greenhouse gas emissions. Research suggests that an efficient carbon tax would be imposed on the carbon content of fossil fuels at a rate equal to the social cost of carbon (SCC), which is currently estimated at roughly $45/ton, and would rise slowly over time, reflecting the projected rise over time in the SCC of roughly 1.5% - 2%/year.

Such a tax would likely slow economic growth, but that effect is very small, especially if the tax revenue is used in ways that promote economic growth, such as cutting marginal rates of other taxes, reducing the budget deficit, or financing growth-enhancing public goods. The tax would also be mildly regressive, imposing a slightly higher burden on lower-income households than on higher-income households, though much less regressive than it is widely perceived to be. Moreover, this regressivity could be overcome if some of the revenue is used in a progressive way.

Taxes on motor fuels are also well below economically efficient levels, by roughly $1/gallon. These taxes are somewhat regressive.

Finally, the two tax expenditures considered – the production and investment tax credits (PTC and ITC) for renewable energy and percentage depletion for oil and gas – have relatively small environmental effects. The PTC and ITC provide environmental benefits, but at relatively high cost: a carbon tax would do far more to reduce pollution emissions, and in a much more cost-effective way. Percentage depletion is slightly damaging to the environment, and is generally difficult to justify based on economic efficiency arguments.

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Note: this reference list is very incomplete and will be updated

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