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A conceptual framework for measuring the effectiveness of green fiscal reforms

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A Conceptual Framework for Measuring the Effectiveness of Green Fiscal Reforms

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A Conceptual Framework for Measuring the Effectiveness of Green Fiscal Reforms

Gilbert E. Metcalf

Abstract

This paper provides a conceptual framework for assessing the effectiveness (strengths and weaknesses) of a green fiscal reform. Economic theory is clear on the process for designing efficient environmental policies: eliminate energy production and consumption subsidies and use a Pigouvian fee to send appropriate signals through the market on the optimal use of different energy sources. Beyond that policy prescription, a number of choices remain: use of revenues, costs of administration, monitoring and oversight and other practical issues.

Policies can be assessed along a number of non-environmental dimensions including potential for raising revenue, efficiency and distributional implications, broader economic impacts (e.g. economic growth, labor market outcomes), and political feasibility. The paper views a number of green fiscal reforms throughout the world through these various dimensions.

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I. Introduction

The past two decades has seen the emergence of green fiscal reforms as an increasingly important element in fiscal reforms in many countries and sub-national jurisdictions. This is quite remarkable given the fact that it has not been that long that environmental and public finance economists have focused on the links between their fields and the possibilities for policy synergies. Many countries have embraced the idea of environmental elements to fiscal reforms and, as such, it is worth some stock-taking. What makes for a green fiscal reform? What elements should be part of a reform and how do we assess the merits and weaknesses of various proposals? Are there simple metrics that can be applied with readily available data?

This paper provides a conceptual framework for assessing the effectiveness (strengths and weaknesses) of a green fiscal reform. The next section provides some definitions and identifies the scope of analysis for the paper. This section also sketches out a set of questions that provide the framework for analysis of given environmental fiscal reforms. The following section provides four case studies. The case studies were chosen to span a range of criteria: developed versus developing countries, national versus sub-national policies, transport versus carbon tax versus subsidy reform on both the production and consumption side. Section IV identifies some lessons for effective environmental fiscal reforms and develops a template for assessing green fiscal reforms. The following section concludes.

II. Objectives of Environmental Fiscal Reform

A. Environmental Fiscal Reforms: Scope

The Organization for Economic Co-Operation and Development (2005) defines an environmental fiscal reform to include "a range of taxation and pricing measures which can raise fiscal revenues while furthering environmental goals" (p. 12). A more general definition includes in the scope of environmental fiscal reforms direct spending on green investment. While it is important to recognize the value of well-directed incremental investments in green technology and infrastructure, the main focus in this paper is on instruments that directly impact government revenues including environmental taxes and fees, auctioned rights to pollute (e.g. cap and trade systems), clean energy production and investment tax credits, energy related tax preferences, and feebates, among other things.[1] We can categorize these instruments conveniently in one of four groups:

1. *Pigouvian Pricing:* Pigou (1932) introduced the idea of a tax on pollution set equal to the social marginal damages of pollution. Such a tax "internalizes the external cost" of pollution by raising the private cost to equal the social cost taking into account the damages from pollution. A Pigouvian tax, as it has come to be known, is efficient and is intuitively appealing in that adheres to the "polluter pays" principle. The prescription to set the tax rate equal to the social marginal damages at the optimal level of pollution requires that we set the tax on the pollution itself (e.g. tailpipe emissions from motor vehicles or carbon dioxide from burning coal to produce electricity) rather than some proxy for pollution (e.g gasoline or electricity).[2]

A cap and trade system is equivalent to an environmental tax in the sense of adding a private cost per unit of pollution to the firm's cost function. Abstracting from uncertainty over future marginal abatement costs, a Pigouvian tax and a cap and trade system with a market clearing price for allowances equal to the tax rate provide lead to identical economic outcomes. In the context of Green Fiscal Reforms, whether cap and trade permits are auctioned or freely distributed has substantial distributional as well as efficiency implications. Fullerton and Metcalf (2001) note that a cap and trade system with freely distributed allowances is equivalent to a Pigouvian tax system in which revenue is returned lump-sum in the same fashion as

[1] The case studies note the (partial) use of green revenues in green infrastructure investments in some instances. In general economists do not support earmarking of green revenues for green spending arguing that spending programs should stand or fall on their own merits and not on the basis of the source of funds. Political considerations and constraints provide a rationale for earmarking in some instances.

[2] In a general equilibrium setting with pre-existing distortionary taxes, the optimal tax rate on pollution may fall short of social marginal damages as shown by Bovenberg and de Mooij (1994) and Parry (1995), among others. Kaplow (1996), however, has argued that even with distortionary taxation the first best rule to set the tax rate equal to the social marginal damages of pollution still holds. Distortions, Kaplow argues, follow from redistribution inherent in tax policy. An implication of Kaplow's argument is that the degree to which optimal tax rates fall short of social marginal damages is reform specific. I abstract from this issue in this report; given the major departures from optimal taxation of pollution in the real world, optimally adjusting the tax rate away from social marginal damages is likely to yield second-order benefits.

allowances are allocated.[3] Clearly, a system of freely distributed allowances has substantial distributional implications and, as noted by Goulder, Parry and Burtraw (1997) among others, foregoes the opportunities for efficiency enhancing reductions in existing distortionary tax rates.

2. *Energy-Related Tax Preferences:* Fossil fuel combustion is associated with both greenhouse gas emissions (a global pollutant) and sulfur dioxide, nitrous oxides, PM-2.5 and other local pollutants. In countries with privately owned energy companies, subsidies may be provided to fossil fuel producers in the form of production or investment tax credits, special depreciation schedules, and tax exemptions of one form or another. Eliminating these subsidies is a clear win-win in improving environmental quality while raising revenue that can be used in socially productive ways.

3. *Pricing of Publically Provided Energy and Natural Resources:* Governments often provide energy (e.g. petroleum products and electricity) and natural resources (e.g. water) at prices below the marginal cost of production. While motivated by equity and political considerations, they lead to overconsumption and environmental degradation. G20 leaders meeting in Pittsburgh committed to "rationalize and phase out over the medium term inefficient fossil fuel subsidies that encourage wasteful consumption."[4] Figure 1 from Clements, Coady, Fabrizio, Gupta, Alleyne and Sdralevich (2013) shows global fossil fuel subsidies between 2007 and 2011. Subsidies peaked in 2011 at US $492 billion and, as the authors note, are closely correlated with world energy prices. Davis (2014) reports global subsidies to motor vehicle fuel consumption in 2012 of $110 billion. In addition to causing large drains to public treasuries, subsidies create significant economic distortions. Davis estimates the deadweight loss of the fuel subsidies at $44 billion annually. This does not take into account any externalities associated with fuel production or consumption. Accounting for externalities raises the efficiency cost of fuel subsidies to $76 billion annually. While subsidies are often justified on equity grounds, they are very poorly targeted subsidies to the poor. International Energy Agency (2011) documents that 6 percent of fossil fuel subsidies to gasoline

[3] This assumes the freely allocated allowances and rebated revenues are treated similarly by the tax system.
[4] See IEA, OPEC, OECD and World Bank (2011) and International Energy Agency (2011) for recent updates and analyses of this commitment.

and diesel are received by the lowest income quintile in a number of African and Asian countries (Figure 14.8). Similarly poor targeting for water subsidies has been documented in the literature (e.g. Angel-Urdinola and Wodon, 2012, and Barde and Lehmann, 2014).

4. Natural Resource Extraction and Harvesting Policies: Many countries have significant non-renewable resources (e.g. minerals, oil and natural gas) as well as renewable resources (e.g. forests, fisheries). Best practices natural resource management combines capacity building, fiscal oversight, and improved transparency in the case of publicly owned resources. Creating and maintaining well-defined property rights in an economy with privately owned resources also can contribute to improved resource management. One aspect of any effort to improve natural resource management includes improved fiscal oversight.[5] Raising royalty rates for non-renewable resource extraction can effect a more sustainable sector over time while harvest taxes for renewable resources can help bring about more sustainable renewable resource management.

Regulatory policies can have price impacts but are not included in my catalog of instruments for environmental fiscal reforms. I limit my attention to instruments that a) can lead to reduced environmental degradation; and b) provide revenue that can contribute to broader fiscal reforms. The U.S. ban on crude oil exports, for example, depresses refinery acquisition costs for domestic crude thereby benefitting refineries and, potentially, U.S. consumers. Removing the ban would not directly lead to additional government revenues (except to the extent the lifting of the ban stimulated domestic crude oil production thereby providing severance tax payments to state governments and royalty payments to the federal government for oil from off-shore and federal lands).

Fiscal reforms can take a number of forms. *Revenue neutral* reforms would match changes in environmental revenues with offsetting changes in other taxes or fees while *balanced budget* reforms would ensure that any net changes in revenue are matched by equal changes to spending. The distinction is relevant in economies where there exists political disagreement over the appropriate size of government spending. In such cases, revenue neutral reforms ensure a decoupling of the debate over the appropriate size of government

[5] See Natural Resource Charter (2012) for a case study application to Nigeria.

from the merits of any given environmental fiscal measures under consideration.[6] Fiscal reforms can be revenue neutral (or balanced budget) year by year or over a longer budget window. In the latter case, there is more flexibility in designing revenue neutral reforms, for example. Reforms that frontload tax reductions with future revenue increases run the risk, however, that the promised revenue increases may fall short of projections either because of the difficulty of projecting future tax revenues or the risk of policy changes that undercut future tax revenues.

B. Goals Addressed Through Environmental Fiscal Reforms

Countries will differ in the emphasis they give to different aspects of environmental fiscal reforms but in general they will always combine some degree of enhanced environmental benefits and improved fiscal position.

1. Environmental Goals

An environmental fiscal reform directly addresses some environmental problem. If the problem is one of local or global pollution – for example, emissions from automobiles in the first instance and greenhouse gas emissions in the second – then raising the price to more closely align social and private marginal costs of production or consumption is warranted. This would include the removal of consumption subsidies to fossil fuels that lower the consumer cost below the cost of production as well as the imposition of Pigouvian taxes. In the area of road transport where congestion and accident externalities dominate, taxes on road usage (e.g. vehicle miles traveled charges on congested roads) combined with auto insurance rates tied to mileage and type of driving would be a preferred set of instruments. Fuel taxes may be a second-best fallback given the difficulties associated with measuring and taxing vehicle miles traveled (though this may change as technology for monitoring vehicle miles traveled improves assuming public acceptability of the new technologies).

2. Fiscal Goals

Revenues from an environmental fiscal reform can be used to improve the efficiency of overall tax collections, to address equity concerns, to shift the tax code in a way that reduces the administrative or compliance costs of taxation, to finance socially productive spending

[6] Deficit reducing reforms are a third form of a fiscal reform. This is especially germane given the large run-up in national debts (relative to GDP) since the 2008 fiscal crisis.

(including green investments), or to reduce the deficit. This long list simply highlights the fiscal flexibility potential of green revenue reforms. Generally, there is a tension between revenue reforms that improve the efficiency of the tax system and reforms that enhance equity. Reductions in capital income taxation are a good example. Capital income taxes are generally more distortionary than labor taxes (see, for example, Ballard, Fullerton, Shoven and Whalley, 1985) but tend to fall disproportionately on owners of capital and thus are progressive.   In other cases, reforms may be complimentary. Using environmental revenues to increase exemptions and so remove lower income households from the income tax rolls increases the progressivity of the tax system while reducing administrative and compliance costs for the income tax.

C. Framework for Assessing Environmental Fiscal Reforms

I propose a simple framework for assessing environmental fiscal reforms that proceeds on the basis of questions that focus attention on key elements of the reform and the implications for environmental improvement, fiscal solvency, efficiency, fairness, and ease of administration and compliance.

- *Are there subsidies to the production or consumption of energy and/or natural resources (as evidenced by a wedge between the marginal cost of production/supply and consumer price)?*

This question focuses specifically on a very basic point: a high proportion of subsidy to tax revenues or GDP indicates considerable scope for an improved fiscal position that also provides, in the case of subsidies to fossil fuels, clear environmental benefits given the various local pollutants associated with fossil fuel combustion as well as greenhouse gas emissions, a global pollutant. Removing fuel subsidies also addresses other externalities including road congestion and accident externalities through the effect on vehicle miles traveled.   As noted above, this has been a major policy focus since the 2009 Pittsburgh G20 leaders' declaration. In the case of subsidies to renewable resources such as forests, local fisheries, or water, the removal of subsidies contributes to the sustainability of the resource in question.

For energy subsidies, the price-gap approach used in studies such as Clements, et al. (2013) provides the basic methodology governments require to assess whether such subsidies exist and their importance (when scaled against GDP or tax revenues).[7] The analysis for renewable resources is not as straightforward. The optimal cutting rate for forests, for example, varies by type of land, species of trees, and other conditions so that it is difficult to make sweeping policy statements. But at a high level, it should be straightforward for governments to assess whether their resources are being sustainably harvested and, when there is overexploitation, whether market mechanisms, along with clarifying and enforcing property rights, can be used to reduce harvesting to sustainable levels.

- *Do market prices reflect the social costs of production or consumption taking into account pollution generating activities?*

In the first stage of analysis, I isolated subsidies that led to divergences between the producer and consumer price. That analysis ignored the impact of externalities. This stage adds those externality costs (net of any positive energy taxes) and measures the revenue that could be raised from pricing fuels at their full social cost. While conceptually there is no reason to treat subsidies and pollution separately, it may be helpful from a political perspective. Longstanding differences of opinion, for example, between governments on the need for developing countries to undertake mitigation obligations under the UNFCCC climate negotiations highlight the sensitivity of carbon pricing for certain governments. By separating the issue of subsidies from externalities, any controversy about whether pollution should be priced can be separated from discussion of removing subsidies to energy production or consumption.

- *What are the efficiency and distributional implications of any proposed environmental fiscal reforms:*

Different governments will have different goals for their environmental fiscal reforms. To the extent distributional considerations drive policy, reductions to existing taxes can be designed to offset any regressive pattern that arises from aligning energy prices, for example,

[7] The price-gap approach measures subsidies to energy consumption as the difference between the supply cost of the energy product and its consumer price. See Coady, Fabrizio, Hussain, Shang and Zouhar (2013), p. 6 for a fuller description of the methodology.

with the social costs of production and consumption. As we'll see below in the case studies, political leaders have generally struck a balance between equity and efficiency, using environmental tax revenues to lower some existing business taxes while also protecting low income households who are disproportionately impacted by higher energy prices as a share of income.

- *Should fiscal reforms be revenue neutral? If so, should revenue neutrality be assessed on an ex ante or an ex post basis?*

Whether the environmental fiscal reform raises additional revenue or not is another design consideration. In addition, there is the question of whether any net revenue target is met on an *ex ante* or *ex post* basis.[8] An environmental fiscal reform could be designed to raise new net revenue or be revenue neutral. A country facing a chronic budget deficit might find a net positive revenue green fiscal reform attractive. Not all reforms necessarily are revenue neutral or revenue raising. British Columbia's carbon tax is structured to avoid raising net new revenue. As discussed below, BC's reform has actually returned more money than has been collected with the tax.

- *What are the relevant administrative, compliance, and enforcement issues that should be addressed with the reform?*

A critical feature of any tax reform is the impact on administration, compliance, and enforcement. This is especially important for developing countries where tax compliance is less than comprehensive and enforcement especially difficult, especially in the case of income taxes. This gets played out across a number of dimensions. How broad the environmental tax base is depends on the nature of the pollutant and distribution of sources. Metcalf and Weisbach (2009) argue in the context of a carbon tax that administrative and compliance costs rise as the tax base becomes more comprehensive. At some point the marginal benefit of adding more carbon sources to the tax base is exceeded by the marginal cost of doing so. For

[8] With an *ex ante* target, budget planners would make a good faith effort to design an environmental levy to achieve a particular revenue target but would not require adjustments if revenues exceed or fall short of the revenue goal. An *ex post* target would require some revenue adjustment during the fiscal year in response to changing conditions. *Ex post* budget rules instill some fiscal discipline in the event of overly optimistic initial budget assumptions; on the other hand, making mid-course corrections to the budget can be disruptive and generate high adjustment costs to other parts of the budget.

the United States, they argued that roughly 80 to 90 percent of domestic greenhouse gas emissions could be easily brought into a carbon tax.

What portion of a pollutant is covered depends in part on the sources of emissions and various points at which the tax can be levied. For a carbon tax, emissions from the use of electricity produced by coal could be taxes at the end-use level – under the principle that consumer choices drive emissions. This would be extremely costly, however, given the sheer number of electricity end users in a country. Moving the tax upstream to the electricity generators or even further upstream to the point of extraction or import of coal reduces compliance costs dramatically. In the United States, for example, there are just over 1200 coal mines (U.S. Energy Information Administration, 2013) and a similar number of coal fired electric generating units**.** Combining an upstream carbon tax on coal mines or coal fired power plants would be much simpler to administer and could piggy-back on existing fuel related taxes (e.g. the federal coal excise tax in the United States), thereby lowering administrative oversight and compliance costs.[9]

Whether the locus of taxation can be moved to different stages of production or consumption depends on the pollutant in question. It is particularly easy to tax carbon at different stages of production as emissions per unit of energy are constant.[10] For other pollutants, where and how the tax is imposed can affect the efficiency of the tax. In principle, a tax on tailpipe emissions would encourage the use of less fuel through lower driving as well as vehicle tune-ups and the replacement of dirtier burning engines with cleaner burning ones. (I say "in principle" because to my knowledge there does not exist a tailpipe emissions tax anywhere.) A tax on fuel incentivizes lower fuel consumption but provides no benefits for maintaining vehicles and tuning engines to minimize pollution per gallon of fuel consumed.[11,12]

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[9] If a carbon tax is moved upstream to the mine mouth, then generators should be able to receive a tax credit for any captured and sequestered emissions. See Metcalf and Weisbach (2009) for further details.

[10] This assumes that tax credits are allowed for carbon capture and sequestration if the tax is imposed upstream. Natural gas has one added complication in that natural gas leakages lead to methane emissions, a more potent but short-lived climate pollutant. Taxing at wellhead doesn't entirely address the problem since methane has a 100 year global warming potential some 28 to 34 times that of carbon dioxide (depending on whether one accounts for climate feedbacks or not). Global warming potential numbers are from Chapter 8 of IPCC (2013).

[11] Fullerton, Hong and Metcalf (2001) discuss the welfare implications of taxing a proxy for pollution when the pollutant cannot be directly taxed. The efficiency costs of taxing proxies for pollution rather than pollution itself can be quite high when production input substitution is possible for the taxed good in question. Taxing gasoline,

Summing up, a number of key design principles stand out. First, an environmental fiscal reform should remove subsidies to activities that generate pollution as a by-product. Subsidies to gasoline and diesel consumption are one example but indirect subsidies such as subsidized parking for commuters in central business districts should also be re-evaluated. Second, environmental taxes should be levied on the externality causing behavior as much as possible. Congestion and accident externalities are not caused by fuel consumption per se but by the miles driven. A first best congestion tax would be levied on vehicle miles traveled rather than gasoline (and would vary by time of day depending on the level of congestion). As technology improves, congestion and accident externality pricing become increasingly feasible. Second best alternatives of using fuel taxes as proxies combined with vehicle bans in the CBD may approximate the first best but likely come with some efficiency cost, as discussed below.

Third, efforts to ameliorate any regressive elements of an environmental tax are best addressed through reductions in other taxes (or direct payments through social safety networks in countries where low-income households pay little in the way of direct taxes) rather than through exemptions or reduced tax rates to certain groups or exemptions to specific sectors. Finally, the existence of multiple externalities calls for the use of multiple instruments. Parry and Small (2005), for example, document that congestion and accident externalities dominate the externalities from driving followed by local and global pollutants. Combining a congestion adjusted VMT tax with a carbon tax would be a first-best approach to addressing driving related externalities.

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for example, rather than emissions is more costly per unit of emissions reduced given the foregone opportunities to substitute capital (e.g. pollution scrubbing equipment in vehicles) for pollution. Taxing fossil fuels, on the other hand, rather than carbon emissions is not as costly given the tight relationship between fossil fuel use and emissions. Taxing fuels in this case, however, would require some form of credit of carbon capture activities to be fully efficient.

[12] Taxes on emissions are also possible in the power sector. Chile has recently enacted a tax on emissions of particulate matter, nitrous oxides, and sulfur dioxide from thermal power plants 50 MW and above. The initial rate will be US $0.10 per ton of emissions with the rate to rise over time. De Marco, Currie, Eljuri and Arze (2014).

III. Case Studies of Environmental Fiscal Reforms

A. Overview

I provide four case studies in this section that span several key dimensions of policy for environmental fiscal reforms. Two of the case studies focus on carbon taxes (Mexico, British Columbia), while two case studies focus on subsidies to energy consumption or production (United States, Mexico). One case study looks at transport externalities (London). In addition to the case studies themselves, I've included some additional information in boxes that highlight some salient considerations for effective policy design.

B. British Columbia: Carbon Tax

As part of a broader package of tax reforms, the province of British Columbia enacted a broad-based carbon tax in 2008 at an initial rate of CAD $10 per metric ton of carbon dioxide. The rate was raised by CAD $5 per year until it reached a cap of CAD $30 (US $25.50) per ton where the rate remains as of this date.[13] The tax is a broad-based tax on the carbon emissions of all hydrocarbon fuels combusted in the province.[14] The tax is levied on final fuel use at the rates shown in Table 1. To put the tax in context, residents of British Columbia currently pay CAD $0.255 (US $0.217) per liter in provincial fuel excise taxes plus another $0.10 (US $0.085) in federal excise tax. So the carbon brought the total excise tax on gasoline from $0.355 (US $0.302)to $0.4217 (US $0.3584), an increase of one-fifth.[15]

Table 2. shows the actual and projected carbon tax payments as well as disposition of the proceeds over a seven year period. Carbon tax revenue has risen from CAD $306 million (US $260 million) in the first year of the tax to $1,120 million (US $952 million) in fiscal year 2013. Tax collections are projected to rise to over $1.2 billion (US $1.02 billion) in FY 2014 and 2015, representing just over five percent of projected tax revenue for FY 2015. The BC carbon tax is designed to be revenue neutral. In practice that has meant that all tax reductions

[13] All currency conversions to US dollars use exchange rates as of January 12, 2015.
[14] It also applies to methane and nitrous oxide emissions as noted by Carl and Fedor (2012).
[15] The provincial excise tax rate varies across the province. I am reporting the rate for the Vancouver area. Provincial excise tax variation is driven by public transit taxes levied on motor fuels. See British Columbia Ministry of Finance (2014) for more details. A federal goods and services tax of 5 percent is applied to the net retail price including all excise taxes (Antweiler and Gulati, 2012).

financed by the carbon tax must not fall short of carbon tax collections.[16] Between 2009 and 2013, refunds have exceeded revenue by as much as $260 million (US $221 million). As a share of carbon tax revenue the net revenue loss ranges from 2 to 35 percent.

Initially carbon tax financed tax reductions disproportionately benefitted individual taxpayers. Over time, the benefits have shifted to business tax breaks with a current business share of roughly 60 percent. Individual benefits are designed to offset any regressivity in the carbon tax. The two largest individual benefits are a low income climate action tax credit of $115.50 per adult plus $34.50 per child and a reduction of 5 percentage points in the first two personal income tax brackets over two years. In the first year of the carbon tax there was a one-time "climate action dividend" of $100 for every BC resident (Antweiler and Gulati, 2012). The low income tax credit phases out at the rate of 2 percent of family income above a threshold.

The general corporate income tax rate was reduced from 12 percent to 10 percent between 2008 and 2011 and subsequently raised back to 11 percent effective April 1, 2013. The small business corporate tax rate was cut from 4.5 percent to 2.5 percent in 2008 and the small business threshold raised from $400,000 to $500,000. Through Fiscal Year 2012 these were the main business tax benefits (along with small assorted property tax credits). Given the need to rebate increased amounts of carbon tax revenue as the tax rate peaked at $30 per metric ton, new tax credits were introduced (Harrison, 2013). Beginning in FY 2013, carbon tax revenue was used to finance part of a production services tax credit (total credit cost was $225 million in FY 2014) with the share of the credit financed with carbon tax revenue rising from 29 percent in FY 2014 to 70 percent in FY 2015. In addition, carbon tax revenue was allocated to a new film incentive tax credit and an interactive digital media tax credit as well as an R&D tax credit.[17]

Evidence is limited on the impact of the carbon tax on the economy of British Columbia. A simple comparison of per capita GDP growth in British Columbia relative to the rest of Canada

[16] Harrison (2013) notes as well that the Finance Minister's salary is reduced by 15 percent should rebated revenue fall short of carbon tax revenue.

[17] Harrison (2013) notes that many of these new tax credits previously existed. As a result, the net revenue neutrality of the carbon tax is increasingly a legalistic notion rather than actual fact.

shows that real per capita GDP grew faster than the rest of Canada at an annual rate of 1.4 percentage points between 2001 and 2007 while their growth rates were comparable between 2008 through 2013 (see Figure 2). A casual comparison would suggest that the carbon tax has lowered BC's economic growth rate relative to the rest of the country. A more comprehensive analysis would control for a variety of factors that affect provincial economies. To date, such an analysis has not been done. I carry out a preliminary analysis using a difference in difference approach comparing the province of British Columbia to other provinces and territories in Canada.

The difference in difference approach is based on the following regression equation:

(1) $$\ln(GDP)_{it} = \alpha + \beta_1 I(Year > 2007)_t + \beta_1 I(Year > 2007)_t * I(BC)_i + \gamma' X_{it} + \varepsilon_{it}.$$

The logarithm of per capita gross domestic product (in C$2007) in province *i* and year *t* is regressed on an indicator variable equal to one for years after 2007, the product of this indicator variable and an indicator variable for the province of British Columbia plus a vector of other control variables.

The coefficient β_1 measures the economy wide impact of changes in economic growth after 2007 while β_2 measures the differential post-2007 growth rate for British Columbia. After controlling for other possible province level impacts on economic growth, the coefficient β_2 can be interpreted as the impact of BC's carbon tax on economic growth in that province. The regression is run on annual data on the 13 provinces and territories over the time period from 1999 through 2013.

Table 3 reports regression results. The first column reports results from a regression on the post-2007 indicator variable alone and interacted with an indicator variable for British Columbia. The coefficient on the interaction term indicates a sharp negative impact of 8 percentage points on British Columbia's growth rate and is consistent with the casual comparison from the growth rate trends over time. This regression, however, ignores any underlying differences across provinces as well as pre-existing trends in growth rates as is suggested by the counterintuitive positive coefficient on the post-2007 indicator variable. The impact of the Great Recession is not being captured in this simple regression. The second column adds a common trend variable for the provinces and also includes province level fixed effects to control for unobserved time-invariant province level impacts on growth. Now the estimated coefficient on the post-2007 indicator variable is negative as expected albeit with a p-value of 0.12. The differential impact in British Columbia after the imposition of the carbon tax is positive but small (0.4 percentage points) and, based on the standard error of the coefficient estimate, we cannot reject a zero impact of the carbon tax on economic growth. In the third column I allow for province specific trends and also include the crude oil price and a price index for lumber given the importance of wood exports in Canada generally and British Columbia in particular.[18] The coefficient on the interaction between British Columbia and post-2007 continues to be small and statistically insignificant.

Summing up, there is no evidence that the carbon tax had a negative impact on economic growth in British Columbia. This is not surprising given how little of the province's electricity is generated with fossil fuels and the small impact on transportation fuel prices. The offsetting decreases in personal and corporate income tax rates also presumably dampened any negative economic impacts of the tax.

The evidence for the tax's impact on reducing the use of fossil fuels is more clear-cut. Data from Elgie and McClay (2013) updated in Elgie (2014) show that the use of fuels per capita subject to the carbon tax has declined by over 15 percent relative to 2007 while per capita fuel consumption in the rest of Canada is growing at a very modest rate (see figure 3 below).[19,20]

A number of features favor the imposition of a carbon tax in British Columbia. First, British Columbia has the second lowest per capita emissions in Canada with its abundance of hydropower (Harrison, 2013). Second, transportation is a significant source of emissions with its share higher than the Canadian average but transportation is already subject to substantial

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[18] Energy, wood and paper account for roughly 30 percent of Canada's exports (Statistics Canada, 2014). British Columbia in turn accounts for over one-third of wood and paper exports and roughly seven percent of energy exports. From the perspective of British Columbia, these two sectors account for over one-half of the province's exports (BCStats, 2014).

[19] Rivers and Schaufele (2013) find a similar impact on gasoline sales after accounting for other variables that affect gasoline consumption. They argue that the impact of the tax is substantially larger than a comparable increase in the *ex-tax* price of fuel and attribute the larger impact to the salience of the carbon tax.

[20] Provincial level data on greenhouse gas emissions are only available for 1990, 2005, and 2012 making it difficult to measure the impact of the carbon tax directly on emissions.

taxation, as noted above, and the carbon tax has a modest impact on final prices. Third, coal extraction, while a major economic activity for the province, is not subject to the carbon tax since the mined coal is largely exported out of the province. Harrison (2013) also notes that over time the rebated tax revenue has shifted from rebates to people based on their carbon tax burden to tax reductions that favor "more specific, and presumably more attentive, subpopulations" (p. 10). This suggests an emerging coalition to support maintaining the tax.

The evolution of public attitude towards the tax is demonstrated in Figure 4 from Harrison (2013). Significantly, attitudes towards the carbon tax have swung sharply from majority opposition to support since the middle of 2011. Harrison (2013) notes a few factors that may have contributed to this swing in public opinion including 1) growing acceptance that the tax was "here to stay"; 2) less media attention on the tax; and 3) a growing recognition that eliminating the tax would create a budget shortfall of roughly three percent that would be difficult to make up.

In summary, the following points emerge from this particular case study. First, British Columbia's carbon tax is a "textbook" example of an environmental fiscal reform in which a tax on a negative externality is used to reduce other taxes in the province. While the tax rate was not explicitly tied to an estimate of social marginal damages from greenhouse gas emissions, the ultimate tax rate CAD$30 per metric ton is consistent with the estimates of social marginal damages from U.S. Interagency Working Group on the Social Cost of Carbon (2013). It is a consumption based tax albeit imperfect in that it does not cover emissions embodied in imported goods (though it does apply to fuels imported from outside BC). It also builds on existing fuel excise taxes that address other externalities (local pollution and congestion) and so fall squarely in the framework of recommendations of the IMF on efficient energy pricing (Parry et al., 2014).

The revenues from the carbon tax account for roughly three percent of the province's budget and nearly six percent of provincial tax collections and have been rebated in a series of tax reductions and credits that exceed actual tax collections (BC Ministry of Finance, various years). Harrison (2013) reports some concerns that the increase in the tax rate over time was not matched by corresponding increases in tax reductions for low income households and some analysis of the changes in overall progressivity of the tax system over time would be instructive but has not yet been done. Casual analysis of the data suggest a shift in emphasis over time from equity to efficiency considerations though it would be inaccurate to say that equity is being ignored. Table 2 illustrates the shift. Individual benefits are generally directed (either directly or indirectly) to lower income households. The low income climate action tax credit, personal income tax bracket reductions, payments to Northern and rural homeowners along with senior credits accounted for nearly 70 percent of carbon tax revenue in the first year of the tax. By FY 2015 (projected), those payments account for about 45 percent of carbon tax revenue. Meanwhile business tax benefits rose from 33 percent of carbon tax revenue in 2009 to over 70 percent in the FY 2015 budget.[21] Finally, based on the analysis of Clements, et al. (2013), it does not appear that the province has pre-existing subsidies to fossil fuel production or consumption that would offset or otherwise undermine the carbon tax.

C. London: Congestion Charge

After several years of study and the election of a mayor who had campaigned on a platform that included the enactment of a congestion charge to address high levels of transport congestion, the city of London implemented the London Congestion Charge (LCC) in 2003 (Leape, 2006). The charge applies to all vehicles that drive in or park on city streets in the congestion charging zone during specified hours. As of November 2014, the daily rate for driving in the zone is £11.50 (£10.50 if paid with an auto-pay option).[22,23] Drivers may purchase daily (or longer) permits by registering and opting for an auto-pay option, by making an on-line payment, by SMS text message or by several other options. Video cameras in the congestion charging zone take photographs of license plates that are electronically read and compared at the end of the day to the list of permit holders. After a secondary check to ensure accuracy, Penalty Charge Notices (PCN's) are sent to owners of the cars observed driving in the

[21] The shares across personal and business tax benefits sum to more than one given the fact that carbon tax revenues fell short of tax reductions financed by the tax.

[22] Current information about the LCC is taken from the Transport for London (2014) website accessed on Nov. 29, 2014.

[23] Leape (2006) notes that the initial rates were chosen on the basis of economic modeling to maximize the net economic benefits of the charge.

congestion charging zone without a permit. Penalties for non-compliance are £130 (reduced to £65 if paid within two weeks).

Standard externality theory suggests the congestion charge should vary depending on the amount of congestion and the marginal congestion impact of additional drivers. The LCC does this to a very crude degree by only charging the fee between 7:00 am and 6:00 pm during weekdays. It also is limited to a specific geographic zone in downtown London.[24] The argument for a time invariant rate during the day is supported by traffic statistics which suggest that off-peak daytime travel speeds in central London were very similar to the morning and afternoon peak travel speeds (Leape, 2006, p. 161). The (approximately) constant travel speeds suggest a roughly constant marginal impact of additional drivers.[25] See the box below for an example of a time varying rate system.

Whether congestion pricing is a welfare improving policy depends on a comparison of the benefits from reduced congestion to the costs of implementing the policy. Early analyses suggest a reduction in traffic on the order of 30 percent during the congestion charging time (Leape, 2006). Subsequent assessments have noted an increase in congestion though, as Santos (2008) has noted, road work contributed to much of the increase in congestion. While net revenues from the congestion charge are positive, a benefit cost analysis would compare the benefits in reduced congestion and pollution against the costs of the program.

Prud'homme and Bocarejo (2005) estimate demand and cost curves for London and find that the major benefits are reduced congestion and increased speeds for bus users and modest environmental benefits in the form of reduced pollution. They estimate annual benefits on the order of €104 million. In contrast, the costs were €177 million annually. These are the administrative costs of running the congestion charge, not the congestion charge costs to drivers (the latter is a transfer and not a social cost). The authors conclude that the "London congestion charge, which is a great technical and political success, seems to be an economic failure. " (p. 279). Rouhani, Knittel and Niemeier (2014) note that the Prud'homme and

[24] Sharp discontinuities in charging whether geographically or temporally can lead to significant bunching near the policy change (a program notch). Such bunching can lead to large inefficiencies. See Blinder and Rosen (1984) and Sallee and Slemrod (2012) for discussion of notches in different contexts.

[25] It may be, however, that the value of time for drivers caught in congestion is higher during peak periods than during off-peak periods.

Bocarejo results are sensitive to parameter assumptions.[26] Moreover, they argue, the 2005 study ignored the opportunity costs of having roads in place. This includes construction and maintenance costs as well as the foregone rents from having land used for transport as opposed to other uses.[27] The opportunity cost of roads assumes the ability to eliminate roadways and not impact traffic materially. This is the case when there are substitutable roads (in Rouhani et al.'s terminology). With this fuller analysis and otherwise using Prud'homme and Bocarejo's assumptions, they find that when 16 percent of the roads in the central charging zone are substitutable, the net costs of the LCC fall by 25 percent. And if 33 percent of roads are substitutable, the LCC has positive net benefits on the order of €120 million annually.

Aside from periodic increases in the daily charge for driving or parking in the congestion charging zone, the program has made a number of other adjustments. Perhaps most notably the program offered a "Greener Vehicle Discount" which waived the congestion fee for hybrids and diesel cars. A surge in the use of these vehicles eroded revenue for the program and also, it was argued, led to an increase in particulate emissions. In its place a new Ultra Low Emission Discount (ULED) was offered beginning in 2013 for electric vehicles that run only on batteries and cars and vans that emit less than 75g/km of carbon dioxide and meet the Euro 5 emissions standard. Vehicles meeting these standards would be exempt from the fee.

While understandable from an environmental perspective, the ULED (and the predecessor discount for "greener vehicles") conflates congestion externalities with pollution externalities. As Prud'homme and Bacajero's study suggests, the vast bulk of the externality from driving in London is related to congestion and very little to pollution. On this basis, it makes little sense to exempt low or no pollution vehicles from the charge.[28]

Another noteworthy feature of the charge is the role that technology has played in reducing the costs of operating the program. Prior to the charge being put in place, there was great skepticism over the ability to implement a charging system. The pervasiveness and

[26] Also see Mackie (2005) and Raux (2005) who both argue that the LCC has positive net benefits when more reasonable assumptions are used in the Prud'homme and Bocarejo analysis.

[27] Rouhani et al. note that fuel taxes partially fund construction and maintenance but note that other funding sources are also used, thereby complicating the interpretation of fuel taxes as a use tax.

[28] Parry and Small (2009) also find that pollution is a small portion of the marginal external costs of driving. For London, they estimate that the congestion component accounts for roughly 90 percent of the total marginal external costs.

acceptance of video surveillance cameras in the United Kingdom has brought enforcement costs down dramatically. Moreover, there has been a shift over time with less and less reliance on retail establishments to purchase the permits (in fact, usage dropped to the point that they were phased out) and much greater reliance on on-line and auto-pay systems. The widespread introduction of video cameras in central business districts in the United States (and perhaps other countries) would likely be highly controversial given public views towards privacy. Also, the technology is not trivial in cost so it is not clear whether the success of the charge in London means that the system could be easily replicated in other cities.

Box: Congestion Charges in Developing Countries

Singapore's Electronic Road Pricing (ERP) Scheme: The city of Singapore replaced its pioneering congestion pricing scheme called the Area Pricing Scheme with the Electronic Road Pricing (ERP) scheme in 1998. Vehicles are equipped with in-vehicle units that communicate with responder gantries on arterial roads, expressways, and cordon areas in the central business area. Vehicles are charged each time they pass through an ERP gantry based on rates that are set to maintain designated optimal speed ranges. Rates are reviewed and adjusted based on a quarterly review of traffic speeds.

The use of in-vehicle units that communicate with responder gantries provides great flexibility in pricing. Rates can be raised during particularly congested times in those areas where congestion is especially acute. Rates at the eleven Shenton Way-Chinatown gantries peak at S$2.50 (US $1.88) between 8:30 and 9:00 am while travel is free through the nine Orchard gantries. In the afternoon, the pattern changes with the Orchard and Shenton Way gantry rates both peaking at S$2.00 (US $1.50) and S$3.00 (US $2.25) just after 6:00 pm.[29] The gantries prominently display the current congestion price and historic and prospective rates are also available on-line.

Vehicles are charged on the basis of when they enter the restricted zone and on the basis of their Passenger Car Unit (PCU). Cars, taxis, and "light goods" vehicles are deemed 1 PCU. Motorcycles are 0.5 PCU, heavy goods vehicles and buses are 1.5 PCUs and very heavy

[29] Rates were downloaded from http://www.onemotoring.com.sg/publish/onemotoring/en/on_the_roads/ERP_Rates.html on Dec. 3, 2014. The rates quoted above were for passenger cars and in effect from November 3, 2014 through February 1, 2015.

goods vehicles and large buses are 2 PCUs. Thus large trucks are charged at twice the rate of cars which, in turn, are charged at twice the rate of motorcycles. Failure to have a functioning transponder unit is the assessed toll plus an administrative fee of S$10 (US $7.50). To avoid vehicles speeding up or slowing down to pass through a gantry just before (or after) it has shifted to (or from) a lower to a higher rate, the rate is graduated over a 5 minute window. Anas and Lindsey (2011) cite studies that suggest the ERP has been successful at managing congesting but note that no cost benefit analysis has been undertaken of the system.

Another area of assessment pertains to the use of revenue from the charge. The bulk of revenue is used to support the development and enhancement of public transport (buses) in the congestion charge zone. This has two potential benefits. First, the flat rate nature of the congestion charge makes it regressive. So moneys spent on public transport are likely to undo some of that regressivity given the relation between public transit use and income. While this is not the most efficient way to undo the charge's regressivity, options are limited given the requirement to earmark LCC revenue to public transportation services. Second, the incremental benefits of a policy of enhanced public transit on top of the congestion charge in London are not clear. Basso and Silva (2014) find that congestion pricing in London provides the highest social benefits (the sum of changes in consumer surplus and bus and congestion pricing revenue net of bus and congestion operating costs adjusted by the marginal cost of public funds) among single policy choices where the possible policies are bus fare differentiation (lower prices during peak periods than off-peak periods), subsidized bus service, congestion pricing, and dedicated bus lanes. Their analysis shows a very modest increase in social benefits when dedicated bus lanes and/or subsidized transit are added to the mix.[30,31]

The Basso and Silva illustrate an important point about the role of indicators in assessing policies. If private benefits to commuters (as measured by change in consumer surplus) is the

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[30] The authors find much higher social benefits from dedicated bus lanes in Santiago Chile but finds in both London and Santiago that there is little benefit from multiple transit policies once the highest net benefit policy has been put in place (congestion pricing in London and dedicated bus lanes in Santiago).

[31] Consumer surplus, however, rises the most from dedicated bus lanes. While social benefits are higher with congestion pricing, there is a significant transfer from drivers to others through the congestion tolls collected. Note also that the policies differ in their distributional implications among commuters among the various policies. Low-income commuters benefit the most from subsidized transit and the least from congestion pricing.

indicator of interest, then dedicated bus lanes would be preferred to congestion pricing. Also, note that Basso and Silva's consumer surplus measure treats commuter surplus the same across income groups. But since high income consumers value the time savings more, they will get greater consumer surplus from reductions in congestion. Hence an unweighted aggregate consumer surplus measure is, in effect, disproportionately reflects benefits to higher income commuters. Weighting the individual consumer surplus gains in some fashion that put greater weight on lower income commuters will, presumably, increase the benefits of subsidized transit relative to congestion pricing. Similarly a focus on distribution across income groups of commuters also makes subsidized transit more attractive from a policy perspective.

Anas and Lindsey (2011) note a number of factors that have led to the LCC's political acceptability. First, London suffered from severe traffic congestion in the inner city. Second there was a comprehensive and well-functioning public transport system in place that could serve as an alternative mode of transportation into the congestion charging zone. Third, the geography of roads in and around London, including the Inner Ring Road, helped to create a natural boundary for the charging zone. The factors that contributed to the LCC being successful speak to the importance of assessing the local traffic situation before turning to congestion charging to address traffic problems. Cities with weak or non-existent public transportation systems, for example, are unlikely to find congestion charging either successful at reducing congestion or politically acceptable. Administrative costs in the London system appear to be high relative to benefits (c.f. Prud'homme and Bocarejo, 2005) though other charging approaches may be less costly.

D. Mexico: Carbon tax and Reforms to Retail Energy Markets

Mexico has embarked on a remarkable path of energy and climate reform that has the potential to fundamentally transform the energy landscape in the country. Beginning in 2012, Mexico enacted national climate change legislation with the goal of reducing greenhouse gas emissions by 30 percent by 2020 and 50 percent by 2050 (Vance, 2012). The subsequent election of Enrique Peña Nieto in 2012 ushered in further and more far reaching reforms to energy markets in Mexico and provides the underpinnings of a green fiscal reform. Peña Nieto's reforms include opening up oil exploration and production to foreign investors and liberalizing retail markets.[32] The following year, the president's submitted budget for 2014 introduced a carbon tax as part of a broader package of tax reforms that addressed various social problems including pollution and obesity. These three interrelated reforms will contribute significantly to a green restructuring of Mexico's fiscal system. These are on top of other initiatives to address energy consumption and greenhouse gas emissions including an appliance rebate program discussed in a side box.

Box: Mexico's Cash For Cooler's Program

Mexico implemented an appliance purchase program ("Cash for Coolers") between March 2009 and December 2012 with the goal of reducing energy consumption and greenhouse gas emissions. According to Davis, Fuchs and Gertler (2014), the program was, in part, a response to various reports that indicated high potential savings and possible negative cost emission reductions. Program participants received direct cash payments in return for disposing of an old air conditioner or refrigerator (at least ten years old) and replacing it with a new appliance meeting certain size and energy-efficiency standards. Cash payments ranged from $30 to $170 depending on historic energy consumption. Most participating households were eligible for the highest payment which represented roughly forty percent of the cost of a replacement appliance.

Despite predictions of substantial electricity savings from the program, Davis et al. found average savings for refrigerator replacement of roughly 8 percent (about one-quarter estimated savings from one study) and *increased* electricity consumption from replacement air conditioners. For refrigerators, the overly optimistic ex ante estimates of energy savings appear to have been based on older refrigerators being replaced than actually occurred. For air conditioners, the surprising result of higher energy consumption appears to have been the result of a *rebound effect*.

A rebound effect can occur when an appliance user replaces an inefficient with an efficient appliance. The more efficient appliance lowers the cost of obtaining a given level of cooling; this in turn leads to increased demand for cooling services. Rebound is a simple manifestation of the economic phenomenon of downward sloping demand curves. When the price of a good or service falls, demand generally rises. If the increase in demand is sufficiently large, the reduction in energy consumption arising from the improved energy efficiency can be more than offset by the increase in consumption

[32] Goldwyn, Brown and Cayten (2014) provides a detailed political and institutional analysis of the reform.

arising from higher demand. When this occurs, energy consumption rises. Even if demand does not go up, rebound can undermine the energy savings arising from improved efficiency.[33]

How consumers respond to energy efficiency programs such as the Mexico program is extremely important for evaluating the program's effectiveness. Davis et al. find that the program cost per kilowatt hour of electricity saved (in 2010 USD) was $0.25 (compared to an average price of electricity of $0.096 per kWh) and the cost per ton of carbon dioxide avoided was $457. For air conditioners, the program cost is not defined since electricity consumption (and emissions) rose in response to the program.

The analysis here shows in a very stark way how the composition of program participants as well as the phenomenon of rebound can undercut savings from an energy efficiency program and, as the case of air conditioning shows, possibly work at cross purposes with the program's goals. This study also illustrates the importance of carrying out ex post evaluations of government policies to reduce energy consumption.[34]

The carbon tax levies a tax on the sale and import of fossil fuels based on carbon content relative to natural gas (Borda, 2013). Table 4 shows the carbon tax rates initially proposed by President Peña Nieto and the rates subsequently enacted by the Mexican Congress. The initial proposal taxed all fossil fuels at the effective rate of MEX $70.68 per ton of carbon dioxide (US $5.35).[35] Based on the President's budget submission to the Congress the tax would have raised MEX $20.4 billion (US $1.5 billion) in 2014 (Mexico Ministry of Finance, 2013a). Mexico's final budget adjusted the carbon tax rates and levied rates relative to the carbon content of natural gas. Thus natural gas was not subject to taxation and rates for

[33] Note that higher efficiency increases consumer welfare whether energy consumption falls or not. With rebound, some of the welfare gains come in the form of increased enjoyment of the services of the appliances rather than in reduced energy bills.

[34] To quote Allcott and Greenstone (2012), "We believe that there is great potential for a new body of credible empirical work in [assessing energy efficiency programs], both because the questions are so important and because there are significant unexploited opportunities for randomized control trials and quasi-experimental designs that have advanced knowledge in other domains."

[35] Throughout I use an exchange rate of 13.2 pesos to the US dollar. This is approximately the exchange rate at the beginning of 2014. The exchange rate as of late November, 2014 is closer to 13.6 pesos to the dollar. Data taken from Federal Reserve Bank of St. Louis (2014).

taxed fuels ranged from US \$0.43 to US \$3.44 per ton CO_2.[36] The budget that was ultimately passed by the Mexican Congress projected revenues in 2014 of MEX \$14.6 billion (US \$1.1 billion) (Mexico Ministry of Finance, 2013b. The 2015 budget renames the carbon tax as a tax on fossil fuels and budgets MEX\$ 9.87 billion pesos (US\$0.72 billion) in collections – less than one percent of total federal tax collections. Given that the tax is quite modest, it is not surprising that its impact on emissions is small. According to Belausteguigoitia (2014) the carbon tax is expected to reduce carbon dioxide emissions by 1.6 million metric tons in 2014 (0.33 percent of Mexico's total emissions) with the bulk of the emissions reductions coming from gasoline.

In addition to the imposition of the carbon tax in 2014, Mexico has instituted a number of law changes affecting PEMEX, the national energy company, and has changed the way gasoline prices are set. Historically, gasoline prices have been set on the basis of an estimate of PEMEX production, distribution, and retailing costs. If world oil prices rise, the result is a subsidy to the retail price of gasoline based on an opportunity cost approach to measuring pre-tax energy subsidies.[37] Figure 5 shows the subsidy per liter of regular unleaded gasoline in Mexico since 2005. The graph shows the difference between the ex-tax price of gasoline in Mexico (in US dollars per liter) and the Argus spot price for gasoline in Houston.[38] A spot price higher than the Mexico ex tax price indicates a Mexican price below the world trading price (e.g. a subsidy under the price gap methodology). The subsidy peaks in 2008 at US\$0.32 per liter, falls to just under \$0.19 in 2009 and then rises in 2011 and 2012 to over \$0.34 per liter before falling again.[39] Note that the pricing reforms do not go into effect until 2015 and the graph shows recent quarterly data after the vertical dashed line in the graph illustrating the impact of lower recent oil prices. Monthly adjustments will be made to gasoline prices with full

[36] Based on energy data from U.S. Energy Information Administration (2014b), natural gas accounts for roughly 30 percent of Mexico's energy related carbon dioxide emissions. Thus Mexico's carbon tax applies to a little over two-thirds of the country's fossil fuel related emissions.

[37] This is an example of the price gap methodology as used, for example by Clements, et al. (2013) and Davis (2014).

[38] Following the methodology of Clements, et al. (2013), I adjust the ex-tax price by US\$0.20 to account for transport, distribution, and retailing based on the fact that Mexico is a net importer of refined products (U.S. Energy Information Administration, 2014c).

[39] These numbers are consistent with estimates in Plante and Jordan (2013).

decontrol of retail gasoline prices envisioned by 2018 (Lajous, 2014; Goldwyn, Brown and Cayten, 2014).

Belausteguigoitia (2014) estimates that the phase out of gasoline and diesel subsidies will reduce carbon dioxide emissions by 5.4 million tons. Combined with the carbon tax, total emissions would drop by 7 million tons, roughly one-sixth of Mexico's commitment to reduce emissions by 30 percent by 2020. The revenue implications will be significant as well. While carbon tax revenues are modest – on the order of 0.8 percent of tax revenues in the 2014 budget, the phase-out of gasoline and diesel subsidies has substantial implications for Mexico's budget. PEMEX revenue accounts for 17 percent of federal income in the 2014 budget. Subsidies to motor vehicle fuels directly impact PEMEX's net revenue.[40] At a subsidy rate of MEX $2 per liter, PEMEX revenues are reduced by roughly MEX $140 billion (based on 2012 motor vehicle fuel consumption). This is an order of magnitude larger than budgeted carbon tax revenues in 2014.[41]

Together the carbon tax and retail pricing reforms could account for roughly 10 percent of tax revenue once the retail pricing reforms are fully phased in. This would be a very substantial green fiscal reform for Mexico. Mexico is undergoing a broader set of tax reforms (Price Waterhouse Coopers, 2013) and it is not possible to assess the distributional implications of the full reform when the energy market reforms are added to other tax reforms. While the energy price reforms and carbon tax raise the price of energy, other tax reforms are targeted more at higher income households (higher tax rates on top brackets, for example) illustrating the shared burden of revenue raising tax increases across the income distribution. A complete assessment would consider the impact of the overall reforms that went into effect starting in 2014 across the income distribution.

The low carbon price suggests little potential impact on emissions. It may be, however that the retail pricing reforms have a larger impact, at least in the short run. A quantitative

[40] The fiscal impact of the subsidies is not straightforward. At one level, the burden of the subsidies falls on PEMEX given a fixed revenue contribution for the state-owned company to the federal budget. In this case, one can argue that the subsidy erodes funds available for internal investment. But how the need for investment funds impacts the federal budget deliberations and required PEMEX revenue contribution to the budget is not clear. In the end, money is fungible.

[41] Road transport fuel consumption data from International Energy Agency (2014a) converted from millions of tonnes equivalent (mtoe) to liters at a conversion rate of 8.53 barrels per metric ton and 159 liters per barrel.

analysis along the lines of the diff-in-diff analysis presented above of the BC carbon tax impact on economic growth can be undertaken once sufficient time has passed. Simple distributional impacts of the retail pricing reform can also be undertaken using national survey data on household income and expenditures to assess price impacts across different income groups.

E. United States: Tax Expenditures for Energy Production

The United States provides a good example of the opportunities for tax reforms that ensure energy producers are treated in a similar fashion as other U.S. firms while raising revenue that can be used to finance tax reforms. President Obama's Fiscal Year 2015 Budget Submission to Congress (2015) proposed $48 billion over ten years (2015 – 2024) in revenues from reforming energy tax preferences in the federal income tax as part of a $250 billion reserve that his budget sets aside to pay for business tax reforms in the federal tax code. While the political atmosphere in Washington is not conducive at the moment to a political deal for fundamental tax reform, the proposal illustrates the potential for environmental fiscal reforms.

The bulk of provisions in the President's proposal are energy specific provisions that depart from normal tax treatment under an income tax. The three major departures from standard practice under an income tax are 1) the use of percentage depletion; 2) expensing of intangible drilling costs; and 3) accelerated depreciation of certain exploration and development costs for a mine or well. The box provides information on the U.S. federal tax treatment of these three costs.[42]

Box: Tax Treatment of Energy Costs: Theory and Practice in the United States

Capital investments to develop oil and gas production sites fall into one of three categories for federal tax purposes. Costs incurred in finding and acquiring the rights to oil or gas are treated as depletable property and, under a standard income tax, should be written off over the life of the oil or gas site. These include exploration costs to identify promising sites as well as the cost of up-front (or bonus) bids to acquire sites. Once a site is identified and purchased, its oil or gas enters a firm's proven reserves. As natural resources are extracted from booked reserves, the value of those reserves is diminished. Cost depletion – analogous to the tax treatment of inventories in manufacturing – allows a firm to write off depletable costs as the reserve is drawn down. As a simple example imagine a field that contains two million barrels of proven reserves of oil with exploration and purchase costs of $10

[42] See Metcalf (2009a) for more details on energy tax provisions and their impact on capital investment.

million. Under cost depletion, the firm is allowed to write off the $10 million cost as oil is drilled. Thus if the firm pumps 100,000 barrels of oil from the field in the first year, it would be allowed cost depletion of $500,000 since the amount pumped equals 5 percent of the proven reserves.

As an alternative to cost depletion, independent oil, gas, and coal producers are allowed to take percentage depletion.[43] Rather than take a depletion deduction based on actual costs, the firm is allowed to take a certain percentage of revenue as a deduction. The current rate for percentage depletion is 15 percent for oil and gas and 10 percent for coal (up to a limit). Continuing with the example above, assume an independent firm owns this oil reserve and sells the 100,000 barrels of oil pumped in the first year for $60 per barrel. Assuming no taxable income limitations, the firm could take a deduction for 15 percent of the revenue from the sale of the oil or $900,000. If the firm were to sell the entire reserve of oil at $60 per barrel its cumulative depletion allowance would be $18 million, eighty percent greater than the depletable costs of the field.

Once a property has been identified, the firm incurs significant costs to develop the site. These costs, which might include site improvement, construction costs, wages, drilling mud, fuel, and other expenses, are called intangible drilling costs (or IDCs). Intangible drilling costs are all costs for which no salvage value is possible. Typically non-capital costs associated with developing a capital asset are depreciated over the life of the asset under the uniform capitalization rules of the federal income tax. In the energy sector intangible drilling costs may be expensed by independent producers. Integrated producers may expense 70 percent of IDCs and write the remainder off over a five year period. The last capital expense category is the drilling equipment itself. This is written off over a seven year period using double declining balance depreciation rules.

Table 5 shows the Administration's revenue estimates over a ten year period for the major provisions that benefit oil, gas, and coal that are not available to other industries.[44] The two major provisions are the repeal of expensing of intangible drilling costs and percentage depletion. Additional revenues come from treating royalties for owners of coal mineral rights as ordinary income.   Overall, aligning the tax treatment of fossil fuel extraction with the tax

[43] Independent producers are defined as producers who do not engage in refining or retail operations to a substantial degree.

[44] The Administration proposal also includes repealing the domestic manufacturing deduction for fossil fuels with a ten year budget estimate of just under $15 billion. Since the deduction is maintained for other manufacturing activities in the United States, I have not included it in this analysis to keep the focus on tax provisions that specifically benefit fossil fuel extraction.

treatment of other firms would raise over $33 billion over a ten year period. Unlike previous budget submissions where the Administration has included these revenues as part of its budget, this year's budget submission sets these revenues aside as part of the $250 billion revenue pool to ensure the long-run revenue neutrality of a business tax reform. Presumably these revenues which come from closing loopholes, broadening the tax base, and tax simplification would be used to pay for lower corporate and non-corporate income tax rates.

The tax code also provides various incentives for non-fossil fuel energy investment and production. In particular production tax credits for various renewable electricity production (including wind) and investment tax credits for solar electricity generation incentivize renewable energy investment and production. The argument for these incentives is that the failure to price fossil fuels at their full social cost (including the damages from greenhouse gas emissions) tilts the investment playing field towards fossil fuel investments. Providing subsidies for non-fossil investments is a second-best response in the absence of a carbon price in fossil fuel prices.[45]

Table 6. from Metcalf (2009a) reports effective tax rates on different forms of energy investments as of 2009. An effective tax rate is a summary measure of all the provisions in a tax code that affect the return on a capital investment. In particular it incorporates provisions such as accelerated depreciation and expensing (immediate full deduction), production and investment tax credits and reduced tax rates. Following the terminology in Congressional Budget Office (2005), the effective tax rate is defined as $(\rho - r)/\rho$ where ρ is the real before-tax return on the marginal investment for a particular capital asset category and r the real return paid to investors. Thus, if savers are prepared to accept seven percent on an investment after tax (r) and the project must earn ten percent in order to cover depreciation, taxes, and required payments to investors (ρ), the effective tax rate is (10 – 7)/10 = 30 percent.

[45] Subsidies are a second-best response since they lower the overall cost of energy and so increase demand for polluting and non-polluting energy alike. Acemoglu, Aghion, Bursztyn and Hemous (2012) argue that even when a carbon pricing is possible, directed subsidies may be optimal to complement the carbon price and spur technological development. The point, in brief, is that a very high carbon tax may be required to induce the same amount of clean energy innovation as a modest subsidy. The high carbon tax, however, would have significant efficiency distortions in the presence of pre-existing taxes.

Effective tax rates focus on the marginal cost of funding investments rather than on project cost. In particular, they focus on the cost of a break-even investment. Because they summarize the many provisions of the tax code that affect the returns to capital investment, effective tax rates are frequently used to consider how the tax system affects capital investment. The first column of Table 6 reports effective tax rates for different types of energy investments. Effective tax rates for wind and solar generated electricity are significantly lower than the rates for coal and natural gas fired generating plants. This reflects, in large measure, the production and investment tax credits that wind and solar have received.[46] Looking at petroleum, the ability of non-integrated drilling firms to utilize percentage depletion reduces their effective tax rate dramatically relative to integrated firms. Variation in depreciation schedules, for the most part, explain the differential effective tax rates for different types of natural gas pipelines.

The second column removes all production and investment tax credits. This narrows the difference among electric generation sources. To the extent that the tax credit is a substitute for carbon pricing policies, this narrowing of the effective tax rate is welfare reducing. The third column removes all preferential depreciation schedules (both accelerated depreciation and expensing) in which case effective tax rates are the same except for wind and solar which benefit here from the tax credits.

Measuring the economic impact of these policies is not entirely straightforward. Metcalf (2007) did a rough calculation of the impact of U.S. subsidies to oil production and estimated a lowering of world oil prices on the order of 0.4 percent. While the U.S. share of world production today is larger than when that estimate was made (13.4 percent in 2013 versus 8.5 percent in 2004), Metcalf's 2007 analysis used an estimate of the value of subsidies that was quite high (10 percent of oil value versus a GAO estimate of roughly 2 percent).[47] Given the U.S. export ban on crude oil, however, it is possible that the domestic price pressure

[46] The production and investment tax credits are subject to two-year reauthorization and have faced periodic uncertainty over their reauthorization. Metcalf (2009a) shows that this policy uncertainty has impacted overall wind and solar investment. As of December 3, 2014, Congress had not yet reauthorized wind production tax credits that had lapsed at the beginning of the year. The current House proposal would reauthorize them retroactively through 2014, in other words for the next three weeks. It is not yet clear how this will all play out politically.

[47] See footnote 41 in Metcalf (2007) for further details.

is greater. But this pressure is eased, to some extent, by the ability of refiners to export refined product (e.g. gasoline and diesel). To date, there has not been a comprehensive economic analysis of the impact of tax subsidies to oil and natural gas production that addresses these issues.

The various tax incentives for renewable electricity production, especially when combined with state-level renewable portfolio programs, have contributed to a boom in solar and wind installations in the United States. This has impacted the dispatch of electricity and, in some cases led to extremely low – and even negative – dispatch prices for electricity in some instances (U.S. Energy Information Administration, 2014a).

The main impact of these policies is to shift investment decisions away from unsubsidized (or lightly subsidized) investments towards more heavily subsidized investments. For oil and natural gas investments, this has an unambiguous efficiency cost. For solar and wind, the redirected investments are an indirect way of addressing the fact that fossil fuel production investments don't account for the social marginal damages of greenhouse gas emissions (as well as other production or consumption related externalities).

The first best policy approach would remove all investment preferences from all fuels (including renewable fuels) and replace with Pigouvian taxes for local and global pollutants associated with each fuel's use. In the absence of such a policy, a second best approach would be to remove the tax preferences for fossil fuels and implement a technology neutral investment or production tax credit for all carbon free energy sources.[48]

Summing up, the United States has a complex set of tax provisions that affect energy investment in the production, transmission, distribution, and refining stages. It is difficult to rationalize many of these provisions on the grounds of economic efficiency, concerns with externalities, or distribution. The one exception is the set of investment and production tax credits for renewable energy production. These credits act as a counterweight to the failure to

[48] This is an approach that forms the basis of a Discussion Draft on energy tax reform put forward in December 2013 by the Staff of the U.S. Senate Committee on Finance. See the draft and other supporting documents at http://www.finance.senate.gov/newsroom/chairman/release/?id=3a90679c-f8d0-4cb6-b775-ca559f91ebb4.

price greenhouse gas emissions from the use of fossil fuels. But they are a distinctly inferior policy choice.[49]

IV. Lessons for Effective Environmental Fiscal Reforms

Economic theory is clear on the process for designing efficient environmental policies: eliminate energy production and consumption subsidies and use a Pigouvian fee to send appropriate signals through the market on the optimal use of different energy sources. Beyond that policy prescription, a number of choices remain: use of revenues, costs of administration, monitoring and oversight and other practical issues. Different countries and sub-national jurisdictions have successfully implemented environmental fiscal reforms with different political and economic forces driving results. A few broad lessons do stand out. First, transparency in the use of revenues appears to have contributed to the success of some environmental fiscal reforms. The very explicit commitment to budget neutrality in the British Columbia carbon tax as well as the London Congestion Charge helped proponents of these policies build a coalition to support enactment. The British Columbia example is particularly instructive as the policy was designed to return revenue through a combination of tax reductions that gave money to individuals and to business owners. In addition, BC made a one-time payment to BC residents and instituted a special payment to residents in areas with especially high heating costs. Similarly the use of revenue in London to support public transportation contributes to a political narrative that viable alternatives to driving in the central part of London are available and in fact being made more abundant.

Second, it is important to clearly articulate the problem that the policy is addressing and bringing strong political will to bear. The ability to enact a congestion charge in London was made easier by the strong commitment of London's first independent mayor to the policy as well as the extreme congestion in the central part of the city. The problem was very clear and the proposed instrument was an obvious and direct solution to the problem. Similarly in Mexico, a strong political commitment to addressing carbon emissions – a commitment that predates the current president – contributed to the adoption of the (albeit modest) carbon tax.

[49] Metcalf (2009b) discusses the problem with using subsidies.

The structural problems with PEMEX, meanwhile, raised the political urgency of reforming the state owned company. Given the need for revenue, both for the Mexican budget as well as for PEMEX capital investment, reforming retail pricing was an essential step to take and one recognized by all.

A third lesson is that environmental fiscal reforms need not adversely affect economic growth. While it is too soon to tell how the Mexican reforms will affect the economy, the evidence from British Columbia suggests no adverse effect on economic growth in the province. London has benefited from declines in congestion that generated benefits, by most academic accounts, that well exceed the cost of the program. Experience suggests, however, that political estimates of gains from reforms may overstate the benefits. Careful assessment of reforms with precise characterization of the appropriate counterfactual is important and there is considerable scope for using well designed randomized control trials and other experiments to measure the impact of reforms. This is especially important for reforms that are designed to improve energy efficiency and turnover of old energy-inefficient capital stocks.

A fourth lesson is that there is no consensus on the importance of using environmental revenue for efficiency versus equity. British Columbia returned revenue to contribute to efficiency and equity enhancements. London used revenue for public transit improvements, thereby contributing both to efficiency and, possibly, to scale economies and equity. While the US proposals to eliminate fossil fuel subsidies have not progressed, one view as articulated in the President's most recent budget submission, is that the revenues from these reforms could be used to help pay for tax reform, including a reduction in corporate income tax rates.

Finally, it is important not to conflate or confuse policy goals. Allowing "Greener" vehicles to avoid paying the congestion charge in London contributed to higher congestion in the city thereby undermining the goals of the program. The existence of two different externalities (congestion and pollution) calls for two policy instruments (a congestion charge for driving in the central city and a pollution charge). Using one instrument for both problems leads to benefits on one margin (lower pollution) while exacerbating problems on the other margin (more congestion).

Table 7 provides a conceptual framework for assessing green fiscal reforms. While suggestive – and to some extent qualitative – it provides guidance on a number of key indicators that policy makers need to consider when planning green fiscal reforms. First – and foremost – is the environmental impact of the reform. How much is pollution reduced by the initiative? Answering this question requires a counterfactual. What would pollution have been in the absence of the program? Evidence from randomized control trials (RCTs), quasi-experimental analyses including difference in difference regression frameworks may be helpful for carrying out this assessment. While ex ante assessments are instructive, it is important, where possible, to build in ex post assessments and allow for the possibility of adjustments to the policy to improve its environmental integrity. Closely related to environmental impact is environmental cost effectiveness. Just because a policy reduces pollution does not mean it is worth doing At the minimum an assessment of a program's cost effectiveness gives a benchmark for considering whether the program is worth undertaking. If, for example, a congestion charging scheme saves time at a marginal cost of $500 per hour saved, one would need to conclude that this is either an overly stringent plan or has unintended impacts that are driving up cost (or blunting congestion mitigation).

Fiscal impacts are a second area of consideration. How much revenue will the program raise or costs? What are the plans for using the revenue (or for financing the cost)? Should green revenues be earmarked for green expenditures? From a purely economic perspective, earmarking revenues to environmental programs is rarely optimal; better to spend the revenues where the marginal social benefit is highest. Politically, however, earmarking may be important perhaps for building coalitions to support green fiscal initiatives.

Assessing the efficiency and distributional implications of the initiative is important, both for better understanding economic implications of the program and for equity reasons. Distributional analyses can be carried out at various levels of sophistication and precision. Simple analyses of fuel tax reform, for example, have focused on the share of spending on various energy products by the lowest income quintile (cf. chapter 14 in International Energy Agency, 2011). In cases where the cost of intermediate goods is affected by fiscal reforms, first order distributional analyses can be done using data on consumer expenditures and input-output tables can be used to trace through the impact of higher prices of inputs into final good prices (see, for example, Metcalf, 1999). In the case of broader-based fiscal reforms, computable general equilibrium (CGE) modeling can be used to assess impacts both across income groups and across regions of a country as in, for example, Rausch, Metcalf, Reilly and Paltsev (2011).

Modeling the economic impacts of reforms (impacts on economic growth rates, labor market changes, etc.) can be done through CGE modeling or through careful econometric analysis. The regression framework for assessing the impact of British Columbia's carbon tax on growth rates in the case study section above illustrates how this latter approach can be utilized.

Understanding possible barriers to reform is essential for a successful green fiscal reform. Is there appropriate capacity in place to carry out a reform? Is there a need for regulatory reform or other changes to the enabling environment to avoid unintended consequences from a desired reform? Indicators may exist to help outside experts assess the potential for reform. Those may be fruitfully supplemented by careful case studies and qualitative assessments.

V. Conclusion

Environmental fiscal reforms have moved from the realm of academic thought to real world application. Increasingly they are part of the mainstream political discourse during fiscal negotiations. This makes perfect sense given the potential benefits along a number of dimensions. First, the environmental benefits are obvious from using fiscal policy to address local and global externalities. Second, environmental revenues provide fiscal flexibility to policy makers as they address broader fiscal reform issues that often include difficult revenue raising or spending reduction choices. Third, a package of environmental and non-environmental reforms can be designed to optimize efficiency as well as equity considerations. This is especially important given distributional concerns about many environmental policy initiatives when viewed in isolation.

Assessing the effectiveness of a green fiscal reform requires a conceptual framework for analysis. The framework put forward here starts with the environmental principle of full social costing of economic activities. This means eliminating subsidies to environmentally degrading activities and using policies so that final consumer prices reflect the full social cost of producing or using a good or service. Since a number of policies can lead to this socially desirable outcome (taxes, cap and trade systems, regulation), those policy choices should be assessed on the basis of their: 1) fiscal potential; 2) opportunities for efficiency gains; 3) distributional impacts; 4) macroeconomic impacts; and 5) political economy concerns.

While there are costs – as well as benefits – to any fiscal reform, environmental or otherwise, the reforms highlighted here also make clear that environmental improvement need not come at high cost to economic growth. Indeed it is not clear that there is any growth cost to well-designed environmental fiscal reforms. It is hoped that the framework sketched out in this paper will help policy makers assess proposed reforms and design reforms that are optimal given particular country and regions circumstances.

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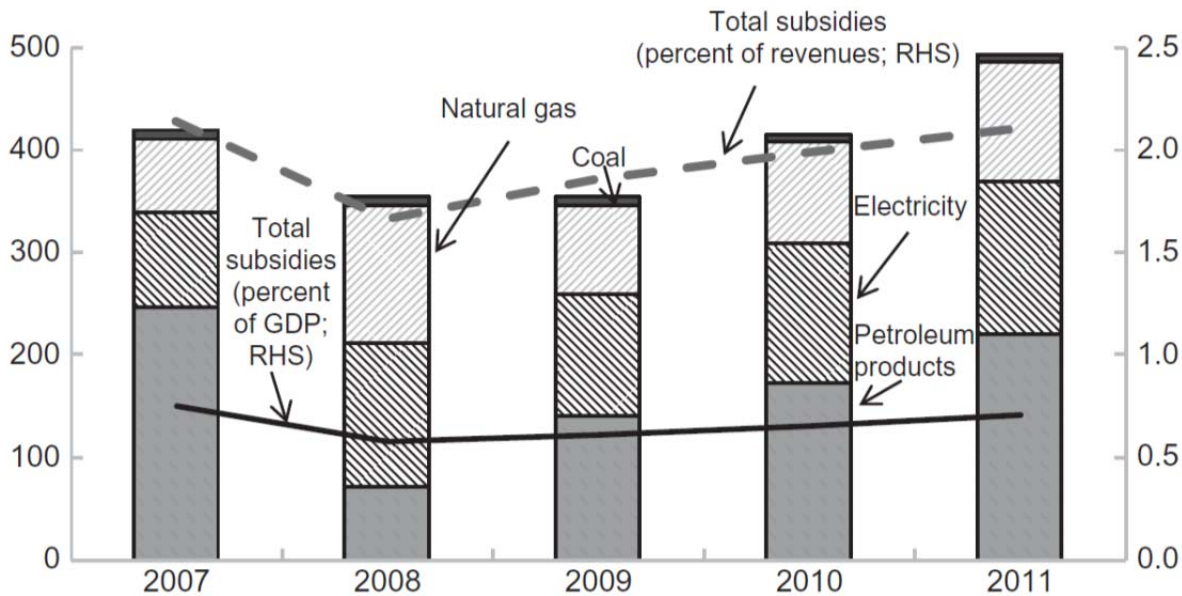
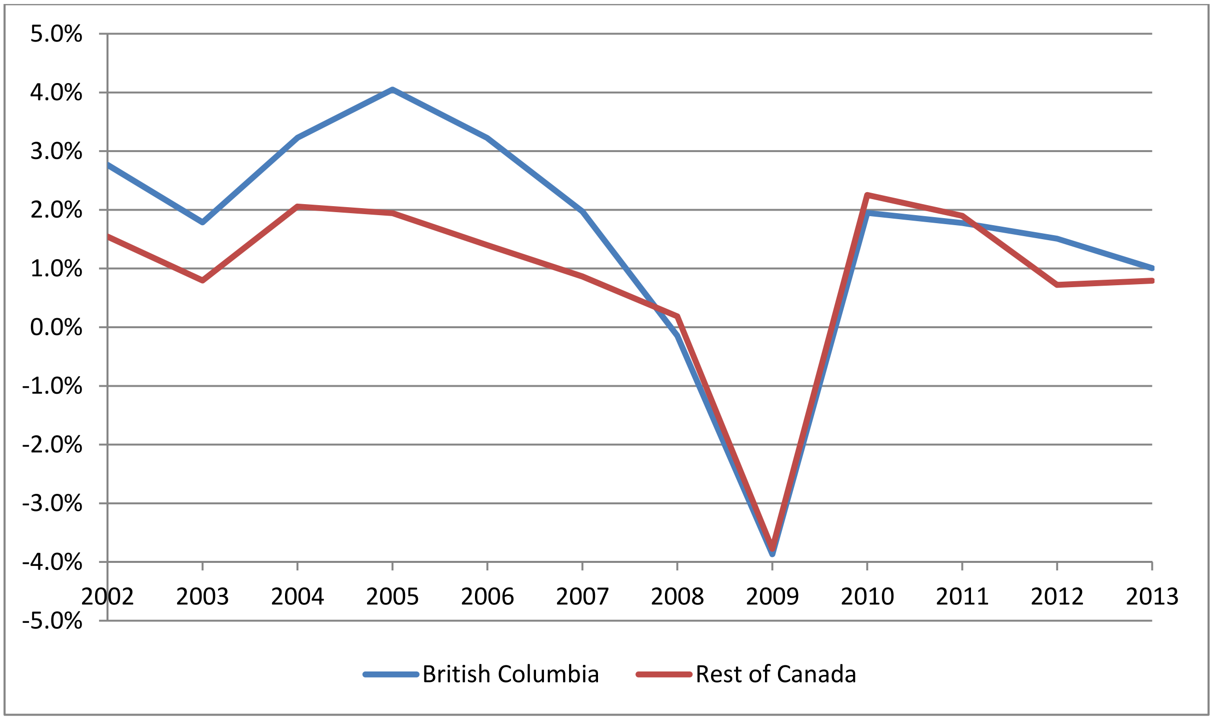
Figure 1. Pretax Energy Subsidies: 2007 – 2011 (US$ Billions)



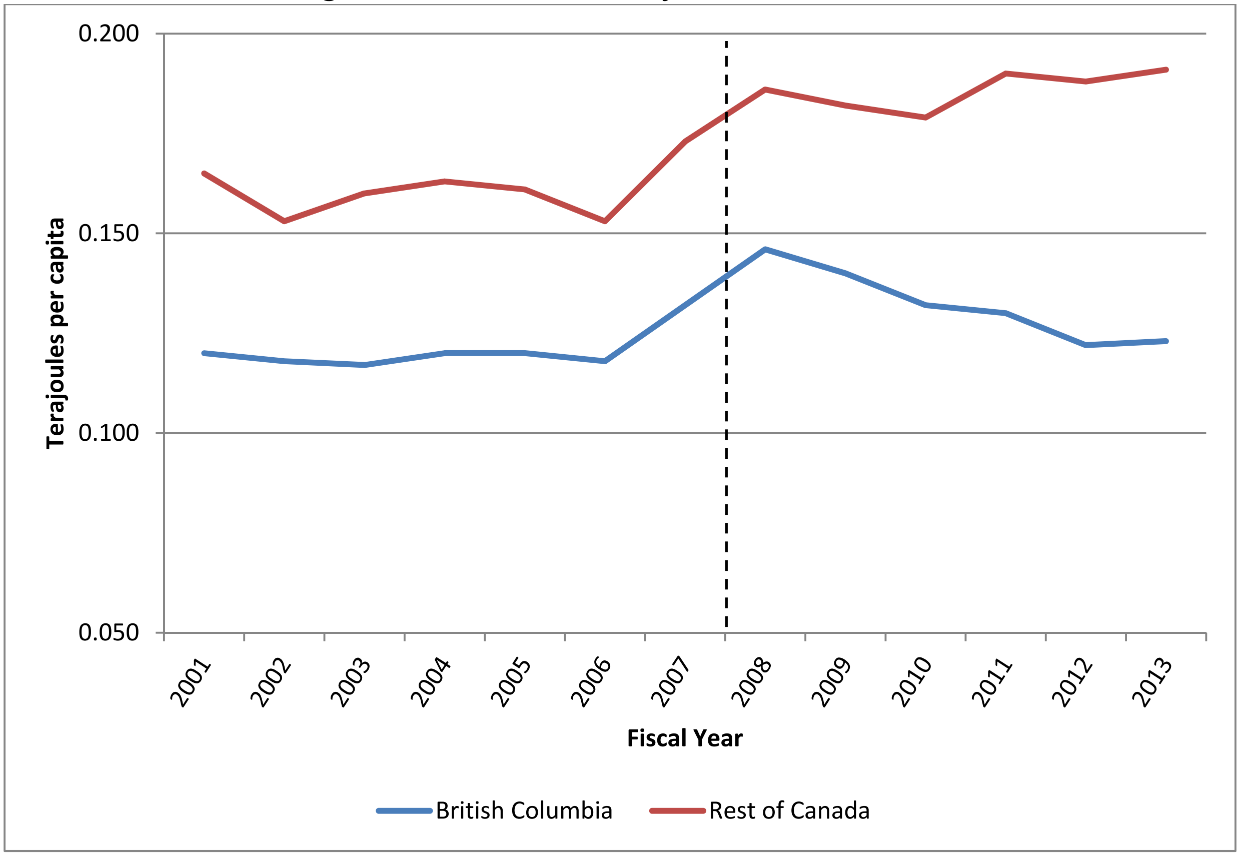
Source: Clements, et al. (2013)

Figure 2. Real Per Capita GDP Growth in British Columbia and Rest of Canada Before and After Carbon Tax Enactment



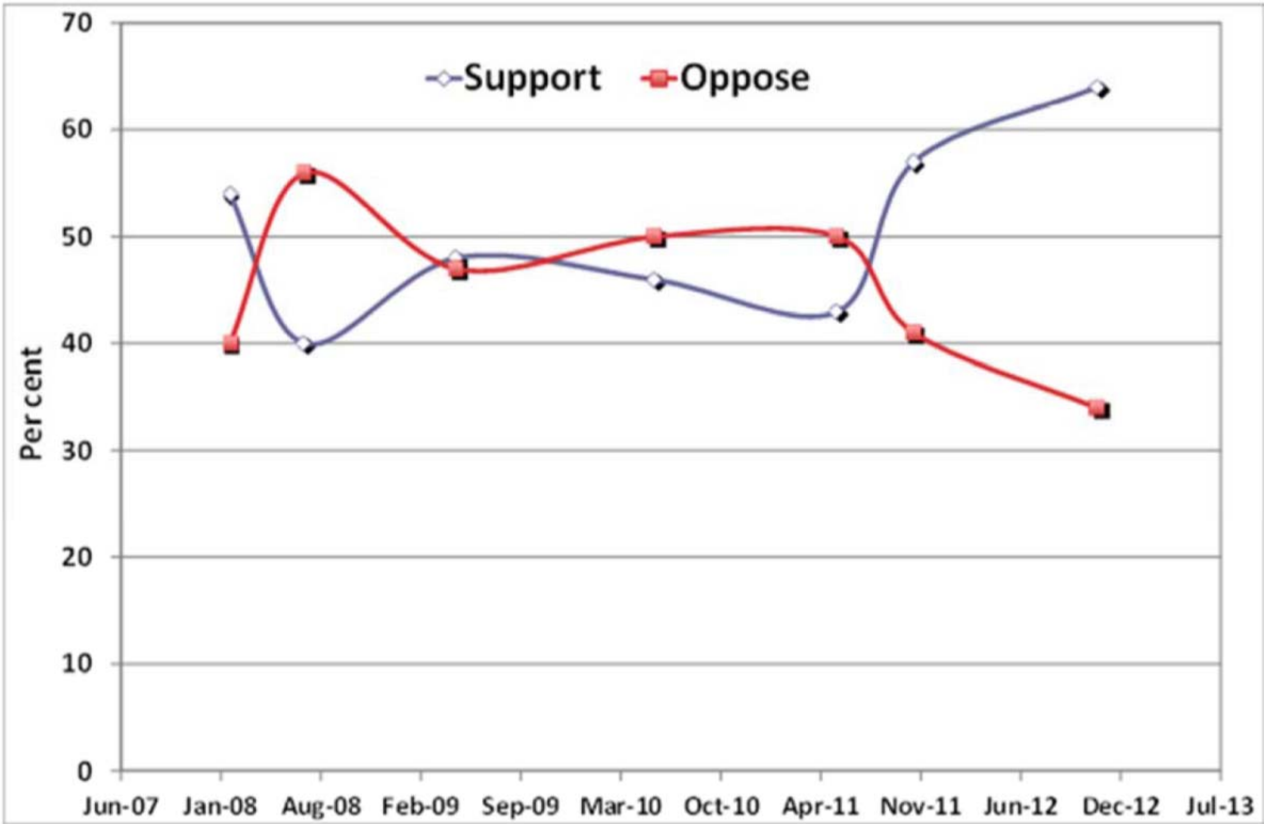
Source: Author's Calculations

Figure 3. Sales of Fuels Subject to BC Carbon Tax



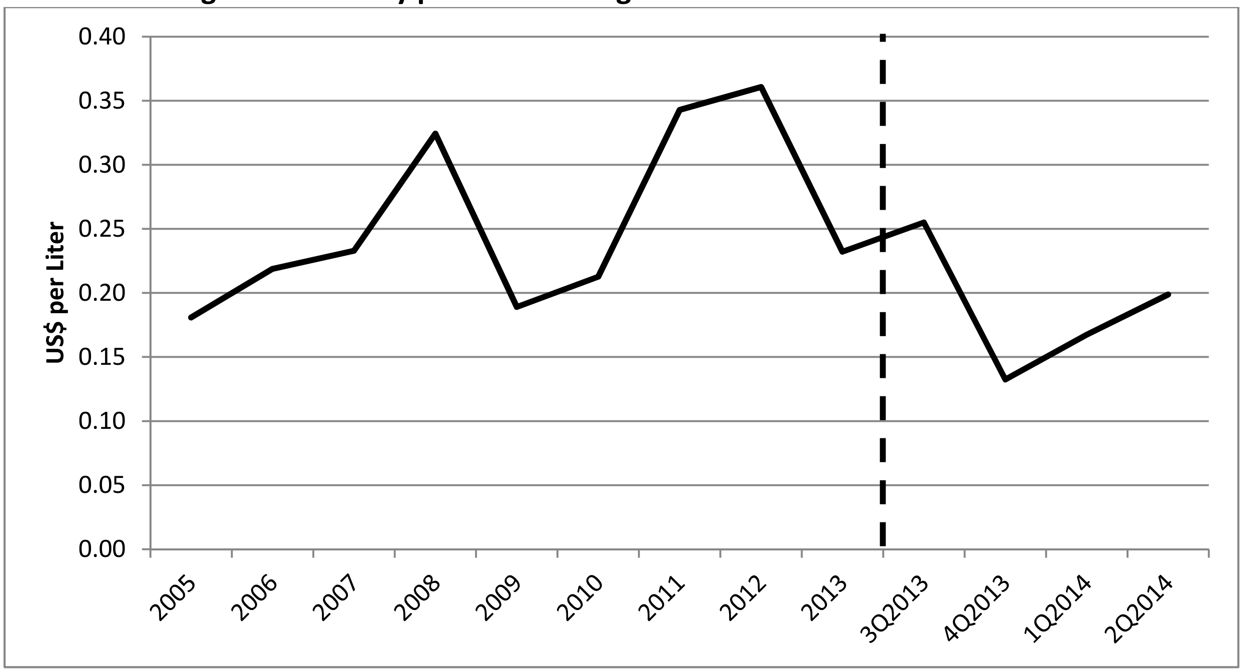
Source: Elgie (2014)

Figure 4. Public Attitudes Towards the British Columbia Carbon Tax



Source: Harrison (2013)

Figure 5. Subsidy per Liter for Regular Unleaded Gasoline in Mexico



Source: International Energy Agency (2014b) and author's calculations

Table 1. British Columbia Selected Carbon Tax Rates by Fuel

	Units For Tax	Tax Rate July 1, 2012
Gasoline	¢/liter	6.67
Diesel (light fuel oil)	¢/liter	7.67
Jet Fuel	¢/liter	7.83
Natural Gas	¢/cubic meter	5.7
Propane	¢/liter	4.62
Coal - high heat value	$/tonne	62.31
Coal - low heat value	$/tonne	53.31
Source: British Columbia Ministry of Finance (2014)		

Table 2. British Columbia Carbon Tax Revenue and Disposition (CAD $ millions)

	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014*	FY 2015*
Carbon Tax Revenue	306	542	741	959	1120	1212	1228
Individual Benefits							
Low Income Climate Action Tax Credit	106	153	165	184	195	194	194
Income Tax Bracket Reductions	107	206	207	220	235	237	250
Northern and Rural Homeowner Payment			19	66	67	69	71
Seniors' Home Renovation and Other Credits					49	22	35
Total Personal Tax Benefits	**213**	**359**	**391**	**470**	**546**	**522**	**550**
Business Benefits							
Corporate Income Tax Reduction	65	152	271	381	450	200	202
Small Business Corporate Tax Reduction	35	164	144	220	281	240	221
Industrial Property Tax Credits		54	58	68	68	43	23
Farm Property Tax Credits			1	2	2	2	2
Interactive Digital Media Tax Credit					26	63	50
Scientific Research and Experimental Development Tax Credit							99
Film Incentive Tax Credit						88	80
Production Services Tax Credit						66	198
Other Tax Credits					7	8	11
Total Business Tax Benefits	**100**	**370**	**474**	**671**	**834**	**710**	**886**
Net Revenue	**-7**	**-187**	**-124**	**-182**	**-260**	**-20**	**-208**
Individual Share of Benefits	68%	49%	45%	41%	40%	42%	38%
Business Share of Benefits	32%	51%	55%	59%	60%	58%	62%
Tax Rate per metric ton	$10	$15	$20	$25	$30	$30	$30

* Forecast.
Source: British Columbia Ministry of Finance (various years).

Table 3. Economic Impact of British Columbia Carbon Tax

	(1)	(2)	(3)
BC*(Year > 2007)	-0.081	0.004	0.002
	(0.081)	(0.021)	(0.035)
Year > 2007	0.102**	-0.053	-0.067
	(0.020)	(0.031)	(0.042)
Crude Oil Price			0.002**
			(0.001)
Lumber Price Index			-0.003*
			(0.001)
Lumber Price Index*BC			0.002***
			(0.001)
Constant	10.708***	-28.766***	-18.173***
	(0.081)	(5.742)	(4.275)
Province Fixed Effect Included	No	Yes	Yes
Trend Included	No	Yes	No
Province Specific Trend Included	No	No	Yes
Observations	195	195	195
R-squared	0.030	0.963	0.975

Dependent variable is the ln of per capita real GDP. BC is an indicator variable for British Columbia.

Robust standard errors in parentheses. Standard errors are clustered at the province level.
*** p<0.01, ** p<0.05, * p<0.1

Table 4. Mexico's Carbon Tax

				Carbon Price	
Fossil Fuel	*Initial Rate*	*Enacted Rate*	*Units*	*MEX $/ton CO2*	*US$/ton CO2*
Natural Gas	11.94	0.00	¢/m3	0.00	0.00
Propane	10.50	5.91	¢/liter	39.78	2.93
Butane	12.86	7.76	¢/liter	42.10	3.10
Gasoline	16.21	10.38	¢/liter	45.26	3.33
Jet Fuel & Kerosene	18.71	12.40	¢/liter	46.84	3.44
Diesel Oil	19.17	12.59	¢/liter	46.42	3.41
Fuel Oil (Heavy & Regular)	20.74	13.45	¢/liter	45.84	3.37
Petroleum Coke	189.85	15.60	$/ton	5.80	0.43
Mineral Coal	178.33	27.54	$/ton	10.92	0.80
Other Carbon Fuels	Fuel Specific			39.80	2.93
Source: Belausteguigoitia (2014). All rate amounts are in Mexican pesos unless otherwise indicated.					

Table 5. Ten Year Revenue Estimates for Energy Tax Reforms

Tax Proposal	Revenue Impact ($ millions)
Repeal expensing of intangible drilling costs	14,350
Repeal percentage depletion for oil and natural gas wells	13,030
Increase geological and geophysical amortization period for independent producers to seven years	3,081
Repeal percentage depletion for coal	2,052
Repeal expensing of exploration and development costs for coal	679
Repeal capital gains tax treatment for coal royalties	508
Total	33,700
Source: Office of Management and Budget (2015). Revenue estimates for fiscal years 2015 through 2024.	

Table 6. Effective Tax Rates in U.S. Tax Code

	Current Law	No Tax Credits	Economic Depreciation
	(1)	(2)	(3)
I. Electric Utilities			
Generation			
Coal (PC)	38.9%	38.9%	39.3%
Gas	34.4%	34.4%	39.3%
Wind	-163.8%	12.8%	-13.7%
Solar Thermal	-244.7%	12.8%	-26.5%
2. Petroleum			
Oil Drilling (non-integrated firms)	-13.5%	-13.5%	39.3%
Oil Drilling (integrated firms)	15.2%	15.2%	39.3%
Refining	19.1%	19.1%	39.3%
3. Natural Gas			
Gathering Pipelines	15.4%	15.4%	39.3%
Other Pipelines	27.0%	27.0%	39.3%
Source: Metcalf (2009a)			

Table 7. Framework for Assessing Green Fiscal Reforms

Indicators	***Metric***	***Data Needs***
Environmental Impact	• reduction in externality generating activity	• emissions data • economic performance data
Environmental Cost Effectiveness	• cost per unit of externality reduction	• emissions data • program cost data
Fiscal Potential	• revenue potential • expenditure requirement	• social marginal damages of pollution (e.g. GHG emissions, congestion, accident externalities, local pollution) • cost of green spending programs • budget data
Efficiency Gains	• deadweight loss reduction from removing subsidies to fossil fuels • deadweight loss reduction from taxing externalities at optimal rate	see above
Equity Gains	• quantitative (or qualitative) measures of changes in income distribution (e.g. distributional tables, Suits Index)	• household spending and tax data, where available • input-output tables, where available, to track price changes through economy
Economic Impacts	• impact on economic growth (GDP), labor supply, employment, etc.	• economic data on national income, employment • sub-national data allows for more disaggregated analysis
Barriers to Reform	• qualitative, perhaps • capacity measures?	• indicators (e.g. World Bank "Doing Business Indicators", MIF/BNEF Climatescope)? • interviews or case studies?