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A Conceptual Framework for Measuring the Effectiveness of Green Fiscal Reforms

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Article

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***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 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, labour market outcomes), and political feasibility. The paper views a number of green fiscal reforms throughout the world through these various dimensions.*

***Keywords**: Energy tax reform, Energy pricing, Green fiscal reforms, Greenhouse gas emissions, Transportation externalities*

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Introduction

The past two decades have seen the emergence of green fiscal reforms as an increasingly important element in fiscal reforms in many countries and subnational jurisdictions. This is quite remarkable given that environmental and public finance economists have only relatively recently focussed 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 stocktaking. 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. It provides some definitions, identifies the scope of analysis for the paper and sketches out a set of questions that provide the framework for analysis of given environmental fiscal reforms. The paper provides four case studies. The case studies were chosen to span a range of criteria: developed versus developing countries, national versus subnational policies, transport versus carbon tax versus subsidy reform on both the production and consumption side. It also identifies some lessons for effective environmental fiscal reforms and develops a template for assessing green fiscal reforms.

Objectives of Environmental Fiscal Reform

Environmental Fiscal Reforms: Scope

The Organisation for Economic Co-operation and Development (OECD) (2005) defines an environmental fiscal reform to include "a range of taxation and pricing measures which can raise fiscal revenues while furthering environmental goals". 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.[2] We can categorize these instruments conveniently in one of the four groups:

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'

[2] 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 programmes 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.

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 because it 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).[3]

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 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 allowances are allocated.[4] Clearly, a system of freely distributed allowances has substantial distributional implications and, as noted by Goulder *et al*. (1997) forgoes the opportunities for efficiency-enhancing reductions in existing distortionary tax rates.

Energy-related tax preferences: Fossil fuel combustion is associated with both greenhouse gas (GHG) emissions (a global pollutant) and sulphur dioxide, nitrous oxides, small particulate matter (e.g., PM2.5) 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 outcome in terms of improving environmental quality while raising revenue that can be used in socially productive ways.

Pricing of publicly 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

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3 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. The present report abstracts from this issue, given that the major departures from optimal taxation of pollution in the real world, such as optimally adjusting the tax rate away from social marginal damages, are likely to yield second-order benefits.

4 This assumes the freely allocated allowances and rebated revenues are treated similarly by the tax system.

phase out over the medium term inefficient fossil fuel subsidies that encourage wasteful consumption."[5] Figure 1 from Clements *et al.* (2013) shows global fossil fuel subsidies between 2007 and 2011. Subsidies peaked in 2011 at $492 billion[6] and, as the authors note, are closely correlated with world energy prices. According to Davis (2014), global subsidies to motor vehicle fuel consumption reached $110 billion in 2012. 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 per cent of fossil fuel subsidies to gasoline and diesel are received by the lowest income quintile in a number of African and Asian countries. Similarly, poor targeting for water subsidies has been documented in the literature (e.g., Angel-Urdinola and Wodon 2012; Barde and Lehmann 2014).

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 and 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.[7] Raising royalty rates for non-renewable resource extraction can result in 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 they are not included in the present report's catalogue of instruments for environmental fiscal reforms. The present report restricts attention to instruments that: (i) can lead to reduced environmental degradation; and (ii) provide revenue that can contribute to broader fiscal reforms. The historic ban in the United States on crude oil exports (recently removed), for example, depressed refinery acquisition costs for domestic crude thereby benefiting refineries and, potential consumers in the United States. Removing the ban does not directly lead to additional government revenues (except to the extent that allowing exports stimulates 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).

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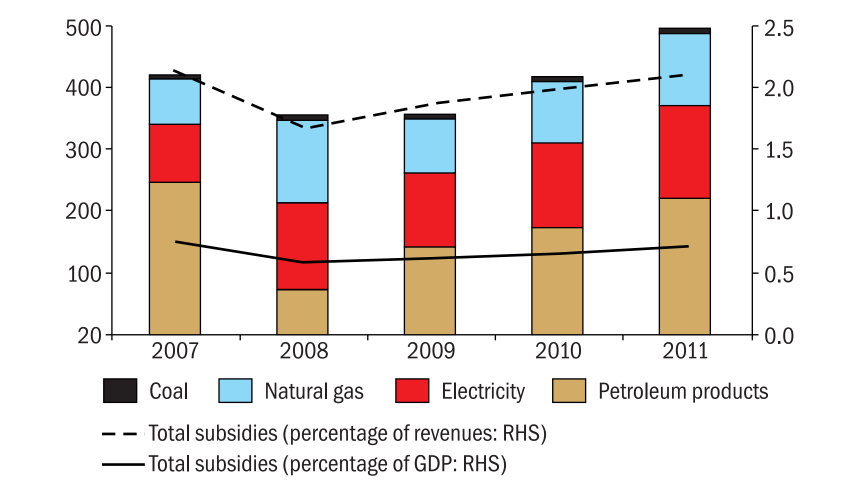
5 See IEA, OPEC, OECD and World Bank (2011) and International Energy Agency (2011) for recent updates and analyses of this commitment.

6 All dollar amounts are in United States dollars unless otherwise stipulated.

7 See Nigerian Natural Resource Charter (2012) for a case study application to Nigeria.

Figure 1: Pretax energy subsidies: 2007–11 (billions of United States dollars)



Source: Clements et al. (2013)

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 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 from the merits of any given environmental fiscal measures under consideration.[8] 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, among others. 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.

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.

Environmental goals: An environmental fiscal reform directly addresses some environmental problem. If the problem is one of local or global pollution—for

[8] 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.

example, emissions from automobiles in the first instance and GHGs in the second—then raising the price to more closely aligned 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 travelled 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 travelled (though this may change as technology for monitoring vehicle miles travelled improves, assuming public acceptability of the new technologies).

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 (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 labour taxes (see, for example, Ballard et al. 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 thus 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.

Framework for Assessing Environmental Fiscal Reforms

The present paper proposes 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 GHG emissions, a global pollutant. Removing fuel subsidies also addresses other externalities, including road congestion and accident externalities through the effect on vehicle miles travelled. 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).[9] 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, the present paper 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 United Nations Framework Convention on Climate Change (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, with the social costs of production and consumption. As will become apparent below, in the case studies, political leaders have generally struck a balance between equity and efficiency, using environmental

9 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 *et al*. (2013), p. 6 for a fuller description of the methodology.

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.[10] 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 positive. British Columbia's carbon tax is structured to avoid raising net new revenue. As discussed below, reform in British Columbia 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, as 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 the United States, they argued that roughly 80–90 per cent of domestic GHG 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

10 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 point of extraction or import of coal reduces compliance costs dramatically. In the United States, for example, there are just over 1,200 coal mines (United States 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.[11]

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.[12] For other pollutants, where and how the tax is imposed, can affect the efficiency of the tax. In principle—'in principle' because there does not appear to be a tailpipe emissions tax anywhere—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. 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.[13,14]

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 behaviour as much as possible. Congestion and accident externalities are not caused by fuel consumption per se,

[11] 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.

[12] 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 the wellhead does not entirely address the problem since methane has a 100 year global warming potential that is 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).

[13] 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, 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.

[14] Taxes on emissions are also possible in the power sector. Chile has recently enacted a tax on emissions of particulate matter, nitrous oxides, and sulphur dioxide from thermal power plants 50 MW and above. The initial rate will be $0.10 per tonne of emissions with the rate to rise over time. De Marco *et al*. (2014).

but by the miles driven. A first best congestion tax would be levied on vehicle miles travelled 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 alternative of using fuel taxes as proxies combined with vehicle bans in the central business district may approximate the first best option, but would 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 congestion-adjusted vehicle miles travelled tax with a carbon tax would be a first-best approach to addressing driving related externalities.

Case Studies of Environmental Fiscal Reforms

Overview

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

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 tonne of carbon dioxide. The rate was raised by CAD$5 per year until it reached a cap of CAD$30 (US $25.50) per tonne where the rate remains as of this date.[15] The tax is a broad-based tax on the carbon emissions of all hydrocarbon fuels combusted in the province.[16]

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 litre in provincial fuel excise taxes plus another CAD$0.10 (US$0.085) in federal

15 All currency conversions to United States dollars use exchange rates as of January 12, 2015.

16 It also applies to methane and nitrous oxide emissions as noted by Carl and Fedor (2012).

Table 1: British Columbia selected carbon tax rates by fuel

Fuel type	Units for tax	Tax rate (July 1, 2012)
Gasoline	¢/litre	6.67
Diesel (light fuel oil)	¢/litre	7.67
Jet fuel	¢/litre	7.83
Natural gas	¢/cubic metre	5.7
Propane	¢/litre	4.62
Coal - high heat value	$/tonne	62.31
Coal - low heat value	$/tonne	53.31

Source: British Columbia Ministry of Finance (2014)

excise tax. So the carbon brought the total excise tax on gasoline from CAD$0.355 (US$0.302) to CAD$0.4217 (US$0.3584), an increase of one-fifth.[17]

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 CAD$1,120 million (US$952 million) in fiscal year 2013. Tax collections are projected to rise to over CAD$1.2 billion (US$1.02 billion) in FY 2014 and 2015, representing just over 5 per cent of projected tax revenue for FY 2015. The British Columbia carbon tax is designed to be revenue neutral. In practice, it has meant that all tax reductions financed by the carbon tax must not fall short of carbon tax collections.[18]

Between 2009 and 2013, refunds have exceeded revenue by as much as CAD$260 million (US$221 million). As a share of carbon tax revenue, the net revenue loss ranges from 2 to 35 per cent.

Initially, carbon tax financed tax reductions, disproportionately benefited individual taxpayers. Over time, the benefits have shifted to business tax breaks with a current business share of roughly 60 per cent. 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 CAD$115.50 per adult plus CAD$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 CAD$100 for every resident of British Columbia (Antweiler and Gulati 2012). The low income tax credit phases out at the rate of 2 per cent of family income above a threshold.

17 The provincial excise tax rate varies across the province. The rate for the Vancouver area was reported. 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 per cent is applied to the net retail price including all excise taxes (Antweiler and Gulati 2012).

18 Harrison (2013) notes that the Finance Minister’s salary is reduced by 15 per cent should rebated revenue fall short of carbon tax revenue.

Table 2: British Columbia carbon tax revenue and disposition (millions of Canadian dollars)

	FY2009	FY2010	FY2011	FY2012	FY2013	FY2014*	FY2015*
Carbon tax revenue	306	542	741	959	1 120	1 212	1 228
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 tonne	$10	$15	$20	$25	$30	$30	$30

*Forecast

Source: British Columbia Ministry of Finance (various years)

The general corporate income tax rate was reduced from 12 per cent to 10 per cent between 2008 and 2011 and subsequently raised back to 11 per cent with effect from April 1, 2013. The small business corporate tax rate was cut from 4.5 per cent to 2.5 per cent in 2008, and the small business threshold raised from CAD$400,000 to CAD$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 CAD$30 per metric tonne, 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 CAD$225 million in FY 2014) with the share of the credit financed with carbon tax revenue rising from 29 per cent in FY 2014 to 70 per cent 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.[19]

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 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 (Figure 2). A casual comparison would suggest that the carbon tax has lowered the economic growth rate in British Columbia relative to the rest of the country. A more comprehensive analysis would include statistical controls to disentangle the various social and economic drivers of provincial economies. To date, such an analysis has not been done. A preliminary analysis using a difference in difference approach comparing the province of British Columbia to other provinces and territories in Canada is undertaken below.

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

(1) $ln(GDP)_{it} = \alpha + \beta\_1\ (Year>2007)_t + \beta\_2\ I\ (Year>2007)_t * I(BC)_i + \ \gamma'\ X_{it} + \varepsilon_{it}.$

The logarithm of per capita gross domestic product (CAD$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 measures the economy wide impact of changes in economic growth after 2007, while measures the differential post-2007 growth rate for British Columbia. After controlling for other possible province level impacts on economic growth, the coefficient can be interpreted as the impact of British Columbia'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

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

Figure 2: Real per capita GDP growth in British Columbia and the rest of Canada before and after carbon tax enactment

Source: Author's calculations

1999 through 2013. Table 3 reports the regression results. The first column reports results from a regression on the post-2007 indicator variable alone 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—a zero impact of the carbon tax on economic growth cannot be rejected. The third column allows for province specific trends and also includes crude oil price and a price index for lumber, given the importance of wood exports in Canada generally and British Columbia in particular.[20] The coefficient on the interaction between British Columbia and post-2007 continues to be small and statistically insignificant.

[20] Energy, wood, and paper account for roughly 30 per cent of Canada's exports (Statistics Canada 2014). British Columbia in turn accounts for over one-third of wood and paper exports and roughly 7 per cent of energy exports. From the perspective of British Columbia, these two sectors account for over one-half of the province's exports (BC Stats 2014).

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

Notes: Dependent variable is the natural logarithm (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

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 dampen 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 per cent relative to 2007, while per capita fuel consumption in the rest of Canada is growing at a very modest rate (Figure 3).[21,22] A number of features favour the imposition of a carbon tax in British Columbia. First, British Columbia has the second lowest per capita emissions in Canada with abundant hydropower (Harrison 2013). Second,

21 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.

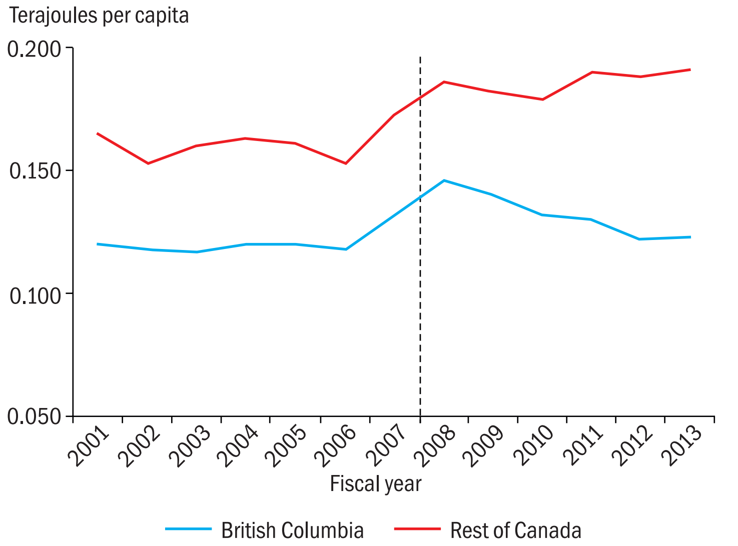
22 Provincial level data on GHG emissions are only available for 1990, 2005, and 2012 making it difficult to measure the impact of the carbon tax directly on emissions.

transportation is a significant source of emissions with its share higher than the Canadian average, but transportation is already subject to substantial 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, tax cuts financed by the carbon tax have shifted from rebates to people based on their carbon tax burden to tax reductions that favour "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: (i) growing acceptance that the tax was "here to stay"; (ii) less media attention on the tax; and (iii) a growing recognition that eliminating the tax would create a budget shortfall of roughly 3 per cent that would be difficult to make up.

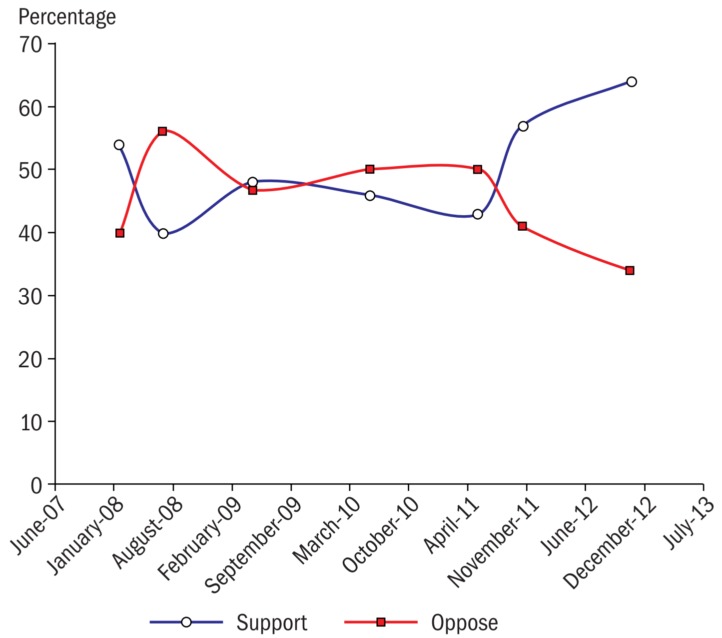
In summary, the following points emerge from this particular case study. First, British Columbia's carbon tax is a textbook example of an environmental fiscal reform in which a tax on a negative externality is used to reduce other taxes in the province. While the tax rate was not explicitly tied to an estimate of social marginal damages from GHG emissions, the ultimate tax rate CAD$30 per metric tonne is consistent with the estimates of social marginal damages from the United States, 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 British Columbia). It also builds on existing fuel excise taxes that address other externalities (e.g., local pollution and congestion) and so falls squarely in the framework of recommendations of the International Monetary Fund (IMF) on efficient energy pricing (Parry *et al*. 2014). The revenues from the carbon tax account for roughly 3 per cent of the province's budget and nearly 6 per cent of provincial tax collections and have been rebated in a series of tax reductions and credits that exceed actual tax collections (British Columbia 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 suggests 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 per cent of carbon tax revenue in the first year of the tax.

Figure 3: Sales of fuels subject to British Columbia carbon tax



Source: Author's own graph based on Elgie (2014)

Figure 4: Public attitudes towards the British Columbia carbon tax



Source: Harrison (2013)

By FY 2015 (projected), those payments account for about 45 per cent of carbon tax revenue. Meanwhile, business tax benefits rose from 33 per cent of carbon tax revenue in 2009 to over 70 per cent in the FY 2015 budget.[23] 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.

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).[24,25] Drivers may purchase daily (or longer) permits by registering and opting for an auto-pay option, by making an online 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 (PCNs) are sent to owners of the cars observed driving in the 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 a.m. and 6:00 p.m. during weekdays. It also is limited to a specific geographic zone in downtown London.[26] 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). The (approximately) constant travel speeds suggest a roughly constant marginal impact of additional drivers.[27] See Box 1 for an example of a time varying rate system.

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

24 Current information about the LCC is taken from the Transport for London (2014) website, accessed on November 29, 2014.

25 Leape (2006) notes that the initial rates were chosen on the basis of economic modelling to maximize the net economic benefits of the charge.

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

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

Box 1: 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 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 8:30–9:00 a.m. 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 p.m.* The gantries prominently display the current congestion price and historic and prospective rates are also available online.

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 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 five minute window. Anas and Lindsey (2011) cite studies that suggest the ERP has been successful at managing congestion but note that no cost benefit analysis has been undertaken of the system.

* Rates were downloaded from www.onemotoring.com.sg/publish/onemotoring/en/on_the_roads/ERP_Rates.html on December 3, 2014. The rates quoted above were for passenger cars with effect from November 3, 2014 to February 1, 2015.

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 per cent 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 of the order of €104 million. In contrast, the costs were €177 million annually earlier. 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 *et al*. (2014) notes that the Prud'homme and Bocarejo results are sensitive to parameter assumptions.[28] Moreover, they argue, that 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.[29] 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 (2014) terminology). With this fuller analysis, and otherwise using Prud'homme and Bocarejo's (2005) assumptions, they find that when 16 per cent of the roads in the central charging zone are substitutable, the net costs of the LCC fall by 25 per cent. And if 33 per cent 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 programme has made a number of other adjustments. Perhaps most notably the programme 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 programme and, it was argued, that it also 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 (2005) 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.[30]

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

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28 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 (2005) analysis.

29 Rouhani *et al*. (2014) notes that fuel taxes partially fund construction and maintenance but also notes that other funding sources are also used, thereby complicating the interpretation of fuel taxes as a use tax.

30 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 per cent of the total marginal external costs.

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.

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 money spent on public transport is likely to undo some 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.[31,32]

Basso and Silva (2014) 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 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 in the same way, across income groups. But since high income consumers value time savings more, they will get greater consumer surplus from reductions in congestion. Hence, an unweighted aggregate consumer surplus measure disproportionately reflects benefits to higher income commuters. Weighting the individual consumer surplus gains in some fashion that puts greater weight on lower income commuters will, presumably, increase the benefits of subsidized transit relative to congestion pricing. Similarly, a focus

[31] The authors find much higher social benefits from dedicated bus lanes in Santiago, Chile, but find that in both London and Santiago 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).

[32] 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.

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 (Prud'homme & Bocarejo 2005) though other charging approaches may be less costly.

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 GHG emissions by 30 per cent by 2020 and 50 per cent 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 provided 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.[33] The following year, the budget submitted by the president for 2014 introduced a carbon tax as part of a broader package of tax reforms that addressed various social problems, including pollution. 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 GHG emissions, including an appliance rebate programme discussed in Box 2.

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 tonne of carbon dioxide (US$5.35).[34] 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).

[33] Goldwyn *et al*. (2014) provide a detailed political and institutional analysis of the reform.

[34] Throughout, an exchange rate of 13.2 pesos to the United States dollar is used. 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 is taken from the Federal Reserve Bank of St Louis (2014).

Table 4: Mexico's carbon tax

Fossil fuel	Initial rate	Enacted rate	Units	Mexican pesos /tonne CO_2	United States dollars/tonne CO_2
Natural gas	11.94	0.00	¢/m3	0.00	0.00
Propane	10.50	5.91	¢/litre	39.78	2.93
Butane	12.86	7.76	¢/litre	42.10	3.10
Gasoline	16.21	10.38	¢/litre	45.26	3.33
Jet fuel and kerosene	18.71	12.40	¢/litre	46.84	3.44
Diesel oil	19.17	12.59	¢/litre	46.42	3.41
Fuel oil (heavy & regular)	20.74	13.45	¢/litre	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

All rate amounts are in Mexican pesos unless otherwise indicated.

Source: Belausteguigoitia (2014)

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 taxed fuels ranged from US$0.43 to US$3.44 per tonne CO_2.[35] 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 1 per cent 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 tonnes in 2014 (0.33 per cent 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 Petróleos Mexicanos (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

[35] Based on energy data from the United States Energy Information Administration (2014b), natural gas accounts for roughly 30 per cent 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.

Box 2: Mexico's cash for coolers programme

Mexico implemented an appliance purchase programme ('cash for coolers') between March 2009 and December 2012 with the goal of reducing energy consumption and GHG emissions. According to Davis *et al*. (2014), the programme was, in part, a response to various reports that indicated high potential savings and possible negative cost emission reductions. Programme 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 40 per cent of the cost of a replacement appliance.

Despite predictions of substantial electricity savings from the programme, Davis *et al*. found average savings for refrigerator replacement of roughly 8 per cent (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 a larger number of 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 arising from higher demand. When this occurs, energy consumption rises. Even if the demand does not go up, rebound can undermine the energy savings arising from improved efficiency.[a]

How consumers respond to energy efficiency programmes, such as the Mexico programme, is extremely important for evaluating the program's effectiveness. Davis *et al*. (2014) find that the programme cost per kilowatt hour of electricity saved (in 2010 United States dollars) was $0.25 (compared to an average price of electricity of $0.096 per kWh), and the cost per tonne of carbon dioxide avoided was $457. For air conditioners, the programme cost is not defined since electricity consumption (and emissions) rises in response to the programme.

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

[a] 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.

[b] 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 programmes) 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."

pre-tax energy subsidies.[36] Figure 5 shows the subsidy per litre of regular unleaded gasoline in Mexico since 2005. The graph shows the difference between the ex-tax price of gasoline in Mexico (in United States dollars per litre) and the Argus spot price for gasoline in Houston.[37] 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 $0.32 per litre, falls to just under $0.19 in 2009 and then rises in 2011 and 2012 to over $0.34 per litre before falling again.[38] 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 decontrol of retail gasoline prices envisioned by 2018 (Lajous 2014; Goldwyn *et al.* 2014). Belausteguigoitia (2014) has estimated that the phase out of gasoline and diesel subsidies will reduce carbon dioxide emissions by 5.4 million tonnes.

Combined with the carbon tax, total emissions would drop by 7 million tonnes, roughly one-sixth of Mexico's commitment to reduce emissions by 30 per cent by 2020. The revenue implications will be significant as well. While carbon tax revenues are modest—on the order of 0.8 per cent 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 per cent of federal income in the 2014 budget. Subsidies to motor vehicle fuels directly impact PEMEX's net revenue.[39] At a subsidy rate of MEX$2 per litre, PEMEX revenues are reduced by roughly MEX$140 billion (based on 2012 motor vehicle fuel consumption). This is an order of magnitude larger than the budgeted carbon tax revenues in 2014.[40]

Together, the carbon tax and retail pricing reforms could account for roughly 10 per cent 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

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

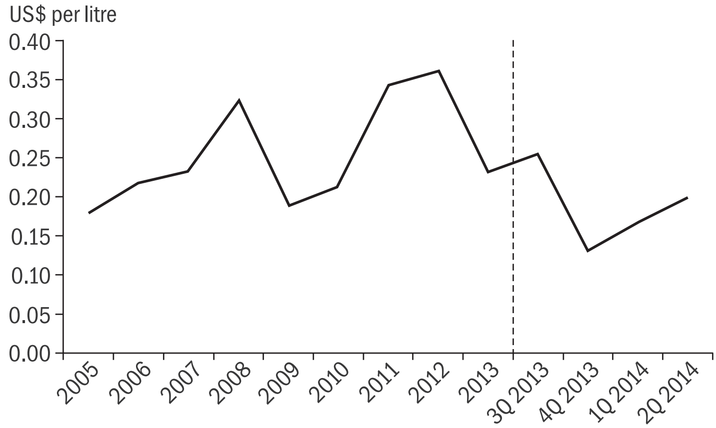
37 Following the methodology of Clements *et al*. (2013), I adjust the ex-tax price by US$0.20 to account for transport, distribution, and retailing based on the fact that Mexico is a net importer of refined products (US Energy Information Administration 2014c).

38 These numbers are consistent with other estimates (Plante and Jordan 2013).

39 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.

40 Road transport fuel consumption data from International Energy Agency (2014a) converted from millions of tonnes equivalent (mtoe) to litres at a conversion rate of 8.53 barrels per metric tonne and 159 litres per barrel.

Figure 5: Subsidy per litre for regular unleaded gasoline in Mexico



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

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 analysis along the lines of the difference-in-difference analysis presented above of the British Columbia 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.

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 firms in the United States while raising revenue that can be used to finance tax reforms. President Obama's Fiscal Year 2015 Budget Submission to Congress (United States Office of Management and Budget, 2015) proposed \$48 billion over ten years (2015–24) 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: (i) the use of percentage depletion; (ii) expensing of intangible drilling costs; and (iii) accelerated depreciation of certain exploration and development costs for a mine or well. Box 3 provides information on the United States federal tax treatment of these three costs.[41]

Table 5 shows the Obama 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.[42] 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 treatment of other firms would raise over $33 billion over a ten year period.

Unlike previous budget submissions, which have 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 GHG 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.[43]

Metcalf (2010) reports effective tax rates on different forms of energy investments as of 2009 (see Table 6). 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

41 See Metcalf (2010) for more details on energy tax provisions and their impact on capital investment.

42 The Obama 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."

43 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 et al.(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.

Box 3: 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 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 a cost depletion of $500,000 since the amount pumped equals 5 per cent of the proven reserves.

As an alternative to cost depletion, independent oil, gas, and coal producers are allowed to take percentage depletion.[4] 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 per cent for oil and gas and 10 per cent 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 per cent 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, 80 per cent 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 (IDCs). IDCs 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, IDCs may be expensed by independent producers. Integrated producers may expense 70 per cent 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.

expensing (immediate full deduction), production and investment tax credits, and reduced tax rates. Following the terminology used by the Congressional Budget Office (2005), the effective tax rate is defined as $(\rho - r)/\rho$, where ρ is the real pre-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 7 per cent on an investment after tax (r) and the project must earn 10 per cent in order to cover depreciation, taxes, and required payments to investors (ρ), the effective tax rate is $(10 - 7)/10 = .3$ or 30 per cent.

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

Table 5: Ten year revenue estimates for energy tax reforms (millions of United States dollars)

Tax proposal	Revenue impact
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: United States, Office of Management and Budget (2015). Revenue estimates for fiscal years 2015 through 2024.

Table 6: Effective tax rates in the United States tax code (percentage)

	Current law	No tax credits	Economic depreciation
	(1)	(2)	(3)
1. 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 (2010)

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.[44] 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, explains 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 United States subsidies to oil production and estimated a lowering of world oil prices on the order of 0.4 per cent. While the United States share of world production today is larger than when that estimate was made (13.4 per cent in 2013 versus 8.5 per cent in 2004), Metcalf's 2007 analysis used an estimate of the value of subsidies that was quite high (10 per cent of oil value versus a Government Accounting Office estimate of roughly 2 per cent).[45] Given US's export ban on crude oil at the time of the analysis, however, it is possible that the domestic price pressure was greater. But this pressure was 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 programmes, 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 (United States 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

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44 The production and investment tax credits are subject to two-year reauthorization and have faced periodic uncertainty over their reauthorization. Metcalf (2010) 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 have reauthorized them retroactively through 2014, in other words for the next three weeks. Subsequently, Congress reauthorized the tax credits though errors in the language inadvertently omitted certain minor renewable energy sources from credit eligibility; Congress as of 2016 is struggling to correct that error.

45 See footnote 41 in Metcalf (2007) for further details.

investments do not account for the social marginal damages of GHG 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 them 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.[46]

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 price GHG emissions from the use of fossil fuels. But they are a distinctly inferior policy choice.[47]

Lessons for Effective Environmental Fiscal Reforms

Economic theory is clear on the process for designing efficient environmental policies: eliminating energy production and consumption subsidies and using 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 subnational 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, British Columbia made a one-time payment to residents of British Columbia 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.

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46 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 United States 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>.

47 Metcalf (2009) discusses the problem with using subsidies.

Second, it is important to clearly articulate the problem that the policy is addressing. 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. 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 that was 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, which well exceed the cost of the programme. 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 United States 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 programme. 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 policymakers 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 programme? 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 programme's cost effectiveness gives a benchmark for considering whether the programme 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 programme raise or cost? 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 programmes is rarely optimal; it is 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 programme 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 *et al.* (2011).

Modelling the economic impacts of reforms (e.g., impacts on economic growth rates and labour market changes, among others) can be done through CGE modelling 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

Table 7: Framework for assessing green fiscal reform

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 Programme 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 programmes 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), labour supply, employment, etc.	Economic data on national income, employment Subnational data allows for more disaggregated analysis
Barriers to reform	Qualitative capacity measures	Indicators (e.G., World bank "doing business indicators", mif/bnef climatescope)? Interviews or case studies?

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.

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 policymakers 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 (e.g., taxes, cap and trade systems, regulation), the policy choices should be assessed on the basis of their: (i) fiscal potential; (ii) opportunities for efficiency gains; (iii) distributional impacts; (iv) macroeconomic impacts; and (v) 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 a 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 policymakers assess proposed reforms and design reforms that are optimal for particular country and regional circumstances.

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