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ABOUT THE INTERNATIONAL JOURNAL ON GREEN GROWTH AND DEVELOPMENT

The International Journal on Green Growth and Development is an effort to stir a debate around emerging 'green' concepts and development. The publication aims at building knowledge through stakeholder engagement on policy-relevant issues to understand the many facets of green growth and development. It is a step towards a forward-looking knowledge process for new opportunities linked with growth and sustainable development. The journal showcases new research through peer-reviewed articles, opinions, and innovative practices. The new journal builds on the previously published *Green Growth and Development Quarterly*.

The publication aims to cover the following topics:

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▸ Financing green growth
▸ Fiscal policies
▸ Business and green growth
▸ Post-growth thinking
▸ Policies on global and local environment
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▸ Natural resource management
▸ Integrated assessments
▸ Energy policy
▸ Engaging stakeholders
▸ Regional issues

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Green Fiscal Reform: A Brief Introduction

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Introduction

Pressure to progress on greenhouse gas (GHG) emission mitigation pledges submitted for the 2015 Paris Agreement on climate change, growing alarm about air pollution and other local environmental threats, recognition of the limitations of traditional environmental regulations, a preference for revenue-raising instruments given historically high fiscal pressures, and the window of opportunity created by lower energy prices, have all heightened the interest in green fiscal reforms. Although it could be defined more broadly, for the purposes of this editors' essay, 'green fiscal reform' refers to pricing policies—fuel taxes, emissions trading systems (ETS), targeted subsidies, removal of inefficient subsidies, etc.—that can achieve environmental goals while also having important revenue implications.

The essay proceeds as follows. We begin with some general context for green fiscal reform from an environmental, fiscal, and recent policy perspective. Next we briefly take stock of the general rationale for, and appropriate design of, green fiscal instruments. Following that, we briefly introduce the papers in this special issue. The essay finishes with some concluding thoughts.

Policy Context

Environmental Background

Green fiscal reform has a potentially critical role to play in addressing a wide range of negative externalities in the energy and industrial systems.

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Global climate change, caused by atmospheric accumulation of GHGs, is the central environmental problem. Global temperatures are projected to rise, in the absence of mitigating measures, by about 3–4 °C over pre-industrial levels by 2100, but with high tail risks (IPCC 2014). At the 21st Conference of the Parties (COP21), over 190 countries submitted (voluntary) GHG reduction pledges for the Paris Agreement, covering over 96 per cent of global emissions, and parties agreed on (legally binding) procedures for evaluating progress on, and updating, these pledges. A typical commitment is to reduce emissions in the order of 30 per cent by 2030, below emissions in some baseline year (see Table 1). Subsequently, on April 22, 2016 in New York, 175 Parties to the United Nations Framework Convention on Climate Change (UNFCCC) signed the Paris agreement. Among them were all key emitters, such as the United States, China, the European Union, Russia, India, Japan, and a wide number of developing nations, reaching a record for support in the history of international treaties. The remaining 22 countries have time until April 21, 2017, to sign the agreement. More importantly, 15 States also deposited their instruments of ratification during the signing ceremony, whereas two others did it in the following days.

The key practical challenge, however, is to analyse which policies are best suited for implementing mitigation pledges, as there is a general acceptance that ideally carbon pricing should be front and center.[2] The transition to a low carbon energy system cannot occur without a clear and stable long-term price signal, even though other fiscal instruments have proved to be quite effective in accelerating decarbonization of the global economy. For example, feed-in tariffs and similar support mechanisms have been the primary driver in boosting the market growth of renewable energy and are now used in 98 states, provinces, and countries worldwide.

At a more local level, outdoor air pollution—caused in part by fossil fuel combustion—causes estimated damages of about 1 per cent to the gross domestic product (GDP) of the United States and almost 4 per cent to GDP of China.[3] By far the main damage component is elevated risks of premature human mortality from exposure to fine particulates small enough to penetrate the lungs and bloodstream.

Premature deaths from outdoor air pollution were estimated at about 3.2 million worldwide in 2010 (Figure 1)[4], concentrated especially in East Asia (about 1.3 million) and South Asia (about 0.8 million). Again, fiscal policies can play a key role in ensuring that prices fully reflect both the supply and environmental and social costs of fuel use.

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[2] See <www.carbonpricingleadership.org/carbon-pricing-panel>.

[3] See NRC (2009), Muller and Mendelsohn (2012), and World Bank and State Environmental Protection Agency of China (2007).

[4] Estimated deaths from indoor air pollution in developing countries are even greater (3.8 million), though the scope for the use of fiscal policies is more limited here given the impracticality of taxing some of the fuels (e.g., biomass) and that even for coal, taxes may cause switching towards (equally harmful) biomass, at least until cleaner energy sources (e.g., charcoal, natural gas, electricity, or even processed coal that burns more cleanly), and better technologies, such as better ventilated stoves, are available.

Table 1: Mitigation pledges submitted for the Paris Agreement, selected large emitters

Country	Main mitigation pledge	Share of global emission, 2012[a]
China	CO_2 peaking around 2030, lower CO_2 intensity of GDP 60-65%.	25.9
US	Reduce GHGs to 26-28% below 2005 levels by 2025.	16.0
EU	Reduce GHGs 40% below 1990 levels by 2030.	11.9
India	Reduce GHG intensity of GDP 33-35% below 2005 level by 2030.	6.2
Russia	Reduce GHGs 25-30% below 1990 levels by 2030.	5.2
Japan	Reduce GHGs 25% below 2005 levels by 2030.	3.9
Korea	Reduce GHGs 37% below BAU in 2030.	1.9
Canada	Reduce GHGs 30% below 2005 levels by 2030.	1.7
Brazil	Reduce GHGs 37% below 2005 levels by 2025.	1.4
Mexico	Reduce GHGs 25% below BAU in 2030.	1.4
Indonesia	Reduce GHGs 29% below BAU in 2030.	1.4
Australia	Reduce GHGs 26-28% below 2005 levels by 2030	1.2

Source: UNFCCC (2015); EIA (2015)

Notes: [a] Refers to energy-related CO_2

Fiscal policies can be applied to a wide range of other environmental problems. For instance, the most effective way to manage urban traffic congestion is to charge motorists' fee (rising and falling during the course of the rush hour) for using busy roads (e.g., London, Milan, Singapore, and Stockholm have taken steps in this direction). Taxes or tradable quotas that charge fishermen for their catch (as pioneered in New Zealand) have proved effective in addressing overfishing and are far more efficient than regulatory approaches (e.g., restrictions on gear, the number of vessels, or fishing seasons). Payments for ecosystems services (as pioneered in Costa Rica) can target preservation or expansion of forestland in areas where environmental benefits (e.g., enhanced biodiversity, water protection) are greatest. And fiscal instruments are commonly used to charge for solid waste disposal and promote conservation and recycling of packaging materials and hazardous products.[5]

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[5]   For a discussion of country experiences see, for example, Ecotec Research and Consulting (2010), ch 12.

Figure 1: Premature deaths from exposure to outdoor air pollution, 2010
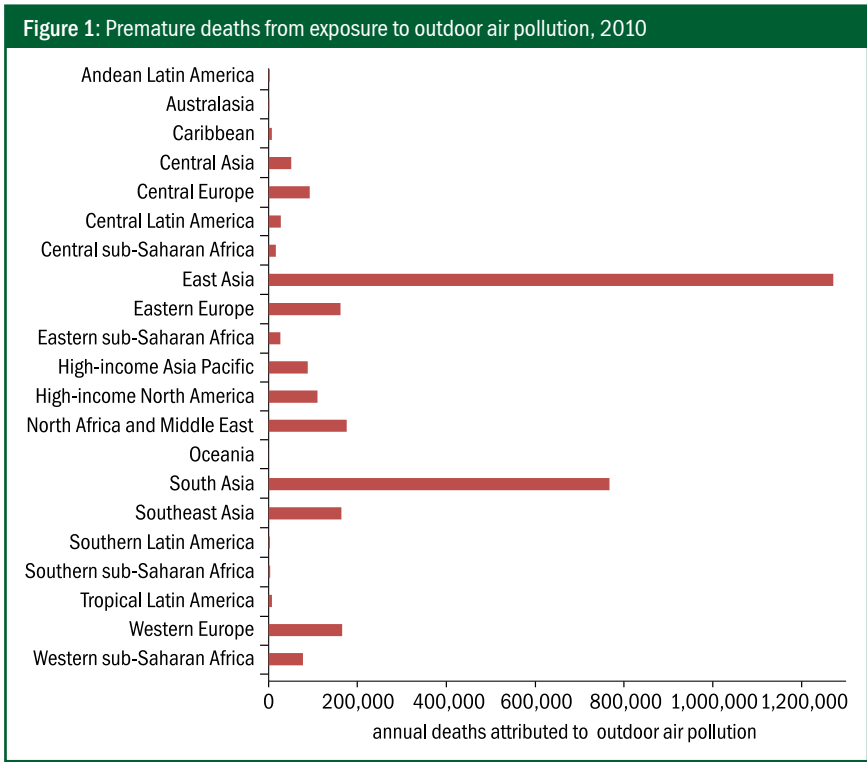
Broader Fiscal Background

Broader fiscal pressures remain at historically high levels. General government debt for advanced countries as a group is predicted to hover around 70 per cent of the GDP when compared with levels prior to the 2008 fiscal crisis of below 50 per cent of GDP, while average debt levels in emerging market and middle income countries are projected to double over the next five years, albeit from a much lower base (Figure 2).

Given this backdrop, green taxes may be especially timely from a finance ministry perspective. In fact, many countries already raise substantial revenues from energy and related taxes. For instance, on an average these taxes raise revenues of 2.6 per cent of GDP across the selected EU countries as shown in Figure 3, varying from about 1.5 per cent of GDP in Spain to about 4 per cent in Slovenia. The biggest component is energy taxes, meaning taxes levied on road fuels, heating oils, and (largely residential) electricity consumption accounting, on average, for almost 2 per cent of GDP, followed by vehicle taxes (0.6 per cent), and other sources, such as taxes levied on waste or water (0.1 per cent).

Figure 2: General government net debt

Debt, % GDP

- Advanced-actual
- Emerging market and middle income-actual
- Advanced-predicted
- Emerging market and middle income-predicted
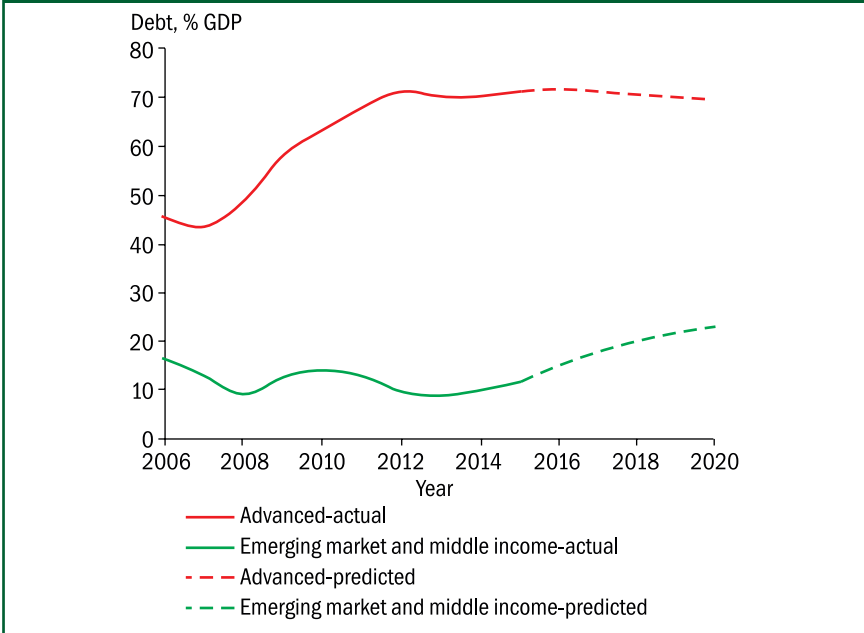
Source: IMF (2015), Tables A8, A16

Figure 3: Energy and related tax revenues, selected EU countries, 2012

Tax revenue as percentage of GDP

■ Energy   ■ Motor vehicles   ■ Other
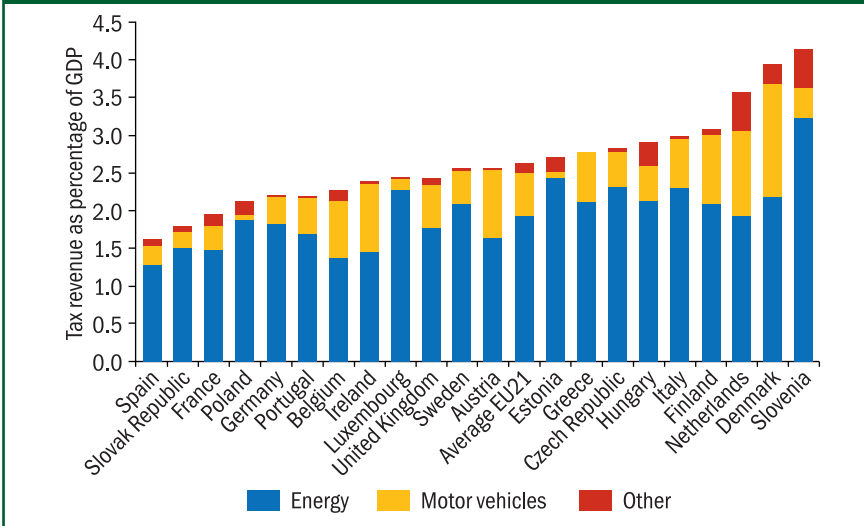
Source: OECD (2015)

However, these taxes are generally not well targeted from an environmental perspective. For example, coal is the dirtiest fuel from both a global warming and local air pollution perspective, yet (unlike road fuels) it has rarely been taxed.[6] While taxes levied on vehicle ownership often promote low CO_2 emission vehicles, they are less effective at reducing fuel use and emissions than fuel taxes, as the latter also encourage less driving. And even road fuel taxes are a very blunt instrument for addressing broader externalities from vehicle use, most notably traffic congestion, which is highly sensitive to where driving occurs and what time of day. Nationwide distance-based charging systems have been introduced in some European countries for trucks, and they have been considered (e.g., in the Netherlands and the UK) but not yet implemented, for light-duty vehicles.

Recent Policy Developments

As indicated in Figure 4, about 40 national governments and more than 20 subnational governments have introduced (or have legislated to introduce) some form of carbon pricing. Most of these schemes are emissions trading systems (ETSs) (e.g., in the EU scheme covering 31 countries, Korea, California, and some provinces in China) though 15 national and sub-national governments now have explicit carbon taxes (recent examples include Chile, France, Ireland, Mexico, and the UK). But this is only the beginning of a very long process—only 12 per cent of global GHGs are currently priced, reflecting the lack of national schemes in many large emitters, and limited sectoral coverage of existing schemes.[7] And current prices—often below $10 per tonne of CO_2—are well below those that will ultimately eventually be needed if the emission pledges for Paris are to be honoured.[8]

Another notable policy development, in many energy-producing countries, is the reform of energy subsidies traditionally arising from regulated prices (Table 2). These reforms have been facilitated by international price reductions (which have not been fully passed forward in lower domestic prices) and pressures (due to lower revenues from petroleum exports) to reduce the fiscal costs of domestic energy subsidies. For example, India has liberalized road fuel prices, Indonesia has abolished gasoline subsidies and capped diesel subsidies, Mexico will fully liberalize domestic fuel prices by 2018, and Saudi Arabia is substantially increasing domestic prices for road fuels, natural gas, and electricity. These reforms represent a welcome step in the direction of fully recovering supply costs in energy prices, though an even bigger challenge will be to go beyond this to factoring environmental costs into energy prices. Reforms of subsidy schemes

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[6] India, for example, has recently introduced a coal tax, though at relatively modest levels from an environmental perspective.

[7] Coverage will roughly double, if China makes good on its pledge to implement an ETS on industrial emissions in 2017.

[8] Meeting the Paris mitigation pledges through carbon pricing alone will likely require emissions prices in the order of $50-100 per tonne of CO_2 or more by 2030 (Parry 2016).

Figure 4: Carbon pricing: existing and soon to be implemented policies
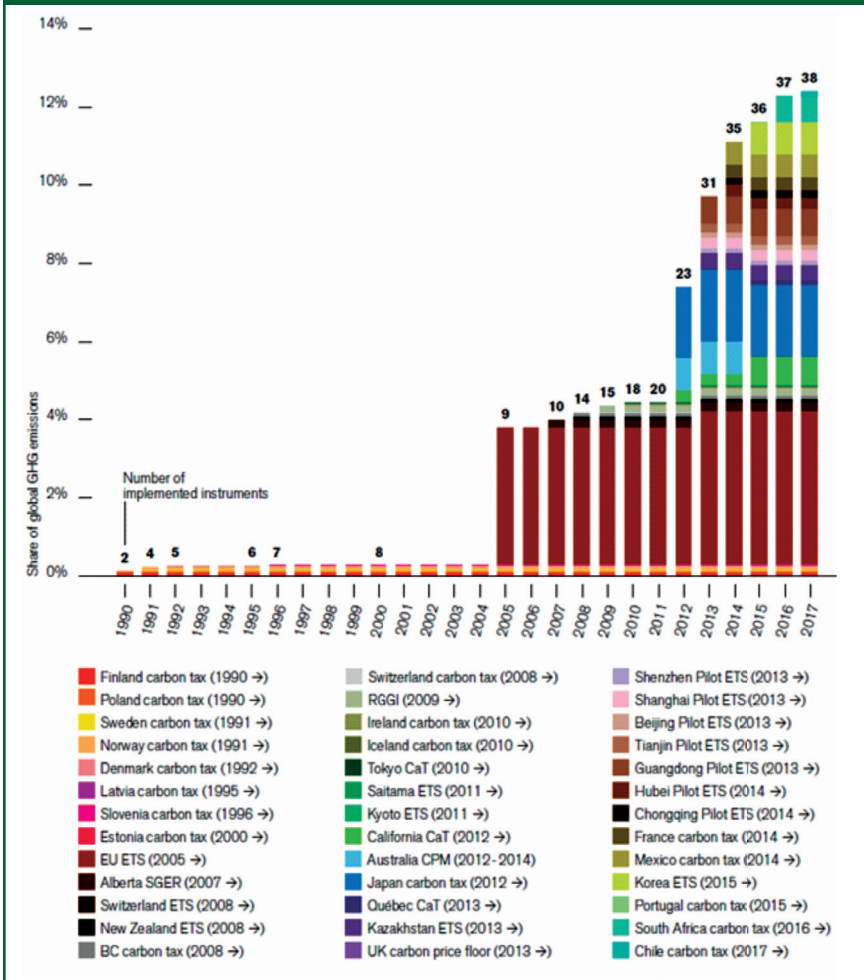
Source: WBG (2015), pp. 12

also free resources to be used to address human development priorities, such as health and education. In Kenya, for example, the government was able to improve the country's electricity network, crucial to improving both health and education conditions, due to the increased resources from subsidy removals.

Rationale and Design Basics for Green Fiscal Reform

Policy instruments for addressing environmental externalities fall into two main categories. The first consists of more traditional 'command and control' regulations

Table 2: Energy pricing reform: some recent examples

Angola	Liberalize domestic fuel prices by 2020
Egypt	Fuel and gas prices increased 40-78%, electricity prices 20-50% in 2014
Ghana	Petroleum prices liberalized 2015
Haiti	Gasoline, diesel, kerosene prices increased 6-896 in 2014, 9-1196 in 2015
India	Gasoline prices liberalized in 2010 and diesel prices in 2014
Indonesia	Abolished gasoline subsidies and capped diesel subsidies in 2015
Jordan	Automatic pricing mechanism in 2012, fuel subsidies zero in 2014
Kuwait	Raised diesel and kerosene prices 210% in 2015 (partially reversed)
Madagascar	Eliminating fuel subsidies and implementing automatic pricing in 2016
Malaysia	Prices for gasoline and diesel set monthly to reflect international prices
Mexico	Domestic fuel prices to be liberalized in 2018
Morocco	Gasoline, diesel, industrial fuel oil and LPG subsidies eliminated
Saudi Arabia	Gasoline price increased 50% in 2015, planned increases for diesel, gas, electricity
Sudan	Plan to eliminate fuel subsidies by 2019 (but fuel price riots in 2013)
UAE	Fuel price mechanism in 2015 and gasoline/diesel prices increased 25-30%
Yemen	Gasoline, diesel, kerosene prices increased 20, 50, 100% respectively in 2014

Source: International Monetary Fund (internal sources)

which might, for example, specify which technologies are to be used to reduce pollution. The second consists of the fiscal or market-based instruments, which are the focus here.

There are three main rationales for using fiscal instruments as the centerpiece of environmental policy, so long as—in each case—the design basics are right. In particular, these instruments:

• Are the most effective policies for exploiting opportunities for mitigating environmental externalities—so long as they are targeted at the right base;
• Achieve environmental protection at lowest overall cost to the economy—so long as the potential revenues are used productively; and
• Strike the right balance between environmental benefits and economic costs—so long as prices are aligned with marginal environmental damages.

We elaborate a bit on these basic, but nonetheless very important, points.

Environmental Effectiveness

Table 3 illustrates the effectiveness of different environmental policy instruments,

Table 3: Comparing CO$_2$ mitigation opportunities provided by alternative policies

Policy Instrument	Power generation — lowering CO$_2$ per kWh		Reducing electricity use		Transportation		Homes/industry
	Shift to renewables	Shift from coal to gas and from these fuels to nuclear	higher efficiency	reduced product use	Higher fuel economy	Reduced driving	Reduced fuel demand
(1) Carbon tax (or emissions trading equivalent)	✓	✓	✓	✓	✓	✓	✓
(2) Renewable subsidy	✓	–	–	–	–	–	–
(3) CO$_2$ per kWh standard	✓	✓	(✓)	(✓)	–	–	–
(4) Efficiency standards for buildings, appliances, etc.	–	–	✓	x	–	–	–
(5) Vehicle fuel efficiency standard	–	–	–	–	✓	x	–
(6) Combination of (3), (4), (5)	✓	✓	✓	x	✓	x	–
(7) Electricity tax	–	–	✓	✓	–	–	–
(8) Motor fuel tax	–	–	–	–	✓	✓	–
(9) Simple vehicle ownership tax	–	–	–	–	–	(✓)	–

Source: Authors

Note: √ denotes an emissions reduction opportunity exploited by a particular policy; (√) denotes where an opportunity is only partially exploited by the policy; – denotes an opportunity not exploited; and × denotes where a policy increases rather than reduces emissions (through the rebound effect).

using the example of (energy-related) CO_2 mitigation. As indicated by the column headings, the major (near term) possibilities for reducing emissions from a typically large CO_2 emitting country can be categorized as: (i) Switching from fossil fuels to renewables in power generation; (ii) Shifting from coal to natural gas in power generation, and from these fuels to nuclear; (iii) Reducing electricity demand by increasing efficiency of products, reducing the capital that use electricity (lighting, space heating and cooling, household appliances, industrial machinery, etc.), and by reducing use of these products; (iv) Reducing transportation fuel use through higher fuel economy and less vehicle use; and (v) Reducing direct use of fuels (e.g., natural gas, home heating oil) by firms and industry.[9]

A tax on the carbon content of fossil fuels promotes all seven of these responses—indicated by the seven √s in the first row of Table 3—as the tax is passed forward into higher prices for fossil fuels, electricity, and so on. A subsidy for renewable power generation fuels, in contrast, promotes only one of the responses.

A CO_2 per kilowatt hour (kWh) standard for the power sector promotes all responses for lowering the emissions intensity of power generation (though it has a relatively weak impact on electricity demand as there is no pass through of tax revenues into prices). Efficiency standards for electricity-using products and capital promote only one response, while slightly offsetting these gains through lowering unit energy costs and increasing product usage—the 'rebound effect'. A combination of regulations is more effective—for example, a CO_2 per kWh standard for power generation and comprehensive efficiency standards for electricity using products and vehicles would promote four responses in Table 3, though this package still misses some opportunities, and perversely affects others through rebound effects.

The superior effectiveness of carbon taxes or tax-like policies over other instruments hinges critically on directly, and comprehensively, targeting the source of the externality, in this case emissions, or carbon content of fuels. If, for example, the tax is levied on electricity consumption, or a subset of fossil fuels, many of the key behavioural responses for reducing emissions are not exploited (Table 3).

Fortunately, directly taxing the source of the externality is administratively quite feasible, at least for some of the major environmental problems. Carbon taxes can be imposed upstream in the fossil fuel supply chain in proportion to carbon content—a straightforward extension of road fuel excises, which are well established in most countries and among the easiest of all taxes to administer. Similarly, the practicalities of taxing local air pollution from coal (the most polluting fuel) are manageable—either through charging for emissions out of the smokestack or through upfront taxes on coal use combined with rebates for firms demonstrating use of mitigating technologies (e.g., flue gas

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9   Another possibility, though more for the medium to longer term, is capture and storage of carbon emissions at large industrial sources, which might be promoted through rebates.

desulphurization technologies). And to take another example, road congestion taxes can be collected electronically, through debiting of on-board smart cards or home billing based on driving patters tracked by Global Positioning Systems.

Cost Effectiveness and Fiscal Considerations

As regards cost effectiveness, it was traditionally thought that, by providing all sources with the same incremental incentive to reduce environmental harm, fiscal instruments would achieve a given level of environmental protection at lowest cost to the economy (e.g., Baumol and Oates 1971; Kneese and Bower 1968)—in contrast, regulatory approaches typically violate least cost principles to the extent they result in differential incremental incentives for mitigation across different firms, sectors, and programmes.

However, matters are more complicated because environmental policies also interact with pre-existing sources of distortion in the economy, most importantly distortions created by the broader fiscal system.[10] Taxes on labour and capital distort economies by discouraging work effort, discouraging investments in human and physical capital, shifting economic activity to the informal sector, encouraging excessive spending on tax-preferred goods, such as housing and fringe benefits, and so on. To the extent that environmental policies contract economic activity (e.g., through raising energy costs) they tend to reduce the overall level of employment, investment, and so on, which results (given large tax wedges) in significant additional efficiency costs in factor markets. However, using environmental tax revenues to lower the burden of taxes on labour and capital produces offsetting economic efficiency benefits. In fact fiscal considerations can, up to a point, reinforce the case for green taxes, if the revenues cut an especially distortive tax. But the most important point is that if revenues are not used efficiently this can increase, quite considerably, the overall costs of environmental taxes for the economy, undermining the case for green fiscal instruments. If revenues are used for additional (general or environmental) spending this should, therefore, generate comparable economic efficiency benefits to those from cutting distortionary taxes.

Efficient revenue use is obviously very important when a large amount of revenues are at stake, which is clearly the case for energy price reform. At a global level, revenue gains from 'getting energy prices right'—that is, moving from existing prices to prices that fully cover supply costs, environmental costs (e.g., air pollution and global warming), and taxes applied to general consumer goods—have been estimated at about \$3.0 trillion (4 per cent of global GDP) for 2013 (Figure 5). Revenue gains are particularly large in Emerging and Developing Asia and the Commonwealth of Independent States (where health problems from local air pollution are especially severe) and the Middle East and North Africa where petroleum, natural gas, and electricity prices are well below efficient levels.

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[10] See, for example, Goulder *et al*. (1999), Parry and Bento (2000).

Figure 5: Revenue gains from getting energy prices right, 2013
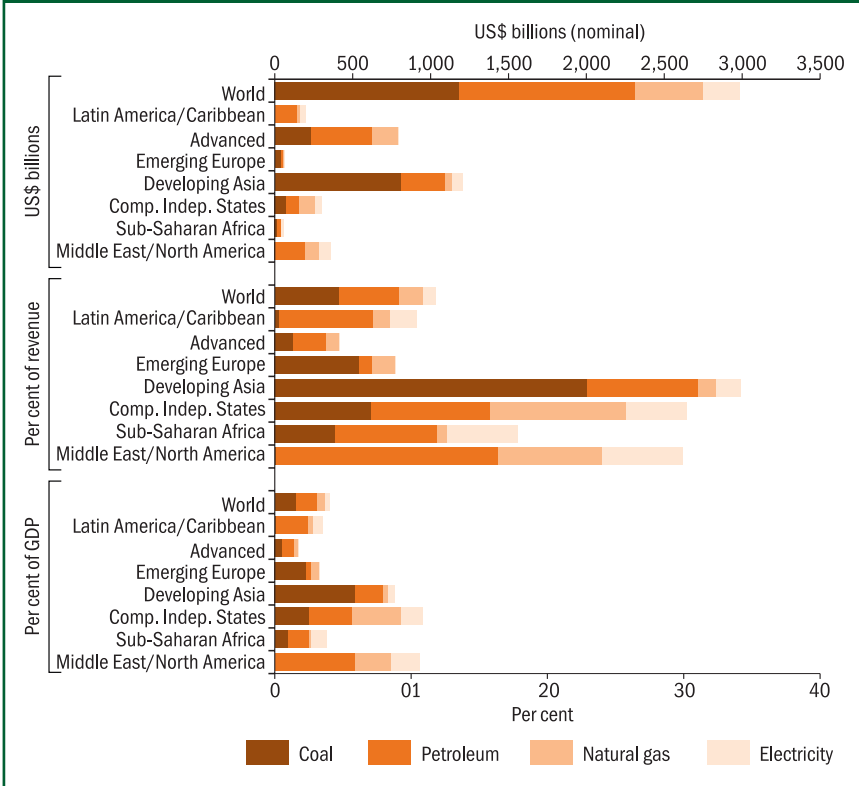
Source: Coady *et al*. (2015)

Notes: Figure shows revenues gains due to raising energy prices from current levels to levels that cover supply costs, environmental costs, and taxes applied to general consumer goods (where current prices already exceeding this level revenue gains are set to zero). Commonwealth of Independent States comprises certain former Soviet Union republics. Middle East and North Africa includes Afghanistan and Pakistan.

Potential revenues from other applications of green fiscal instruments can be significant, but are not on the same scale as those from full reform of energy pricing. For example, just like energy, water is pervasively mispriced, though usually the main issue is undercharging for supply costs, depreciation, and maintenance of infrastructure, rather than undercharging for environmental costs. Figure 6 shows recent estimates of water subsidies, which totaled $456 billion worldwide in 2012, or about 0.6 per cent of global GDP, with subsidies varying across regions by between 0.3 and 1.8 per cent.

Balancing Benefits and Costs

According to the traditional analysis of efficient environmental taxation, the tax level that maximizes environmental benefits net of mitigation costs equals

Figure 6: Public water subsidies by region, 2012
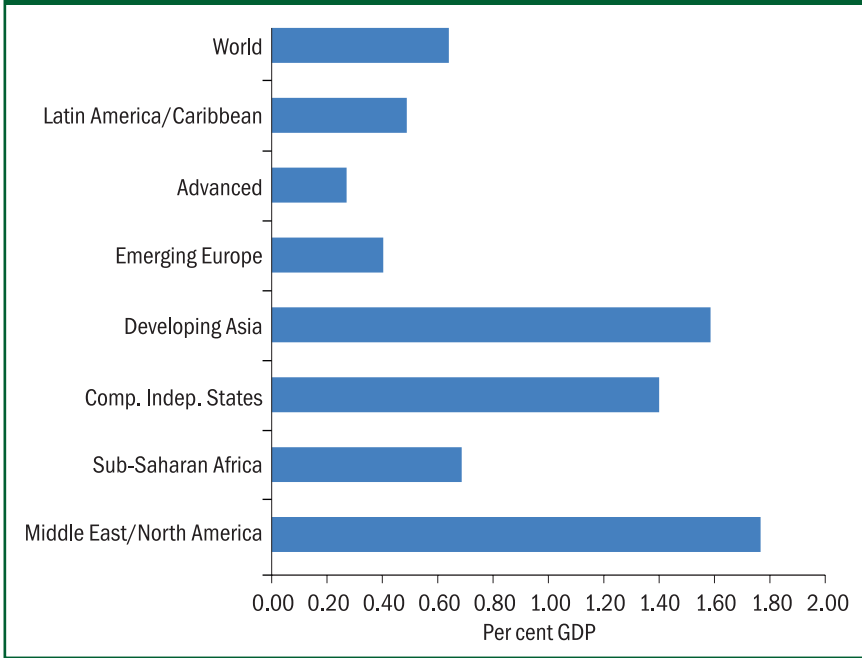
(marginal) environmental damages—the 'Pigouvian Rule'. As just noted, fiscal considerations may enhance the case for green taxes, though for practical purposes this may not warrant setting higher tax rates given uncertainty over the fiscal parameters needed for this adjustment, that any mark-up above the Pigouvian rule declines with the level of mitigation (due to erosion of the tax base), and the difficulty of conveying the technicalities to policymakers and stakeholders.

The Pigouvian rule is more naturally implemented under a tax than a regulatory approach or ETS (which impose prices implicitly or indirectly). And for some problems, such as global warming and air pollution, it seems reasonable to measure Pigouvian taxes assuming constant marginal damages (estimated at current tax levels).[11]

Apart from global warming, country-specific data is needed to quantify Pigouvian tax levels. For example, the efficient charge for local air pollution

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[11] For air pollution, the relation between fatalities and pollution concentrations appears to be approximately linear in the relevant range for corrective taxes (Parry *et al.* 2014), pp. 38–39. For global warming, damages depend on the accumulated stock of greenhouse gases in the atmosphere and one country's emissions in one year add a negligible amount to this stock (Pizer 2002).

damages varies considerably across countries with local emission rates (which depend on fuel quality and deployment of control technologies), population density in proximity to emissions sources, the health status of exposed populations, and the valuation of health risk (the latter varies considerably with per capita income).

Figure 7 illustrates some estimates of Pigouvian taxes on coal for selected countries in 2010, expressed in $ per gigajoule (GJ) of energy. The orange bars indicate carbon damages (based on a CO_2 damage value of $35 per tonne) which amount to $3.3 per GJ, or about two-thirds of the average world coal price in 2010. The blue bars are the air pollution damages which can greatly exceed (at current air emissions rates) the carbon damages in some cases (e.g., densely populated countries like China) though in other cases (e.g., Australia) air pollution damages are far more moderate. The black diamonds in the figure indicate current taxes which are essentially zero or slightly negative in some cases.[12] Therefore, the overall pattern is one of pervasive and substantial undercharging for coal use.

Key Themes of Papers from the Special Issue

Most of the issues and themes discussed in the previous sections of this introductory paper are further analysed and deepened in the articles of this special issue. The paper by Gilbert Metcalf, develops a template for assessing the effectiveness (strengths and weaknesses) of green fiscal reform and suggests that policy choices should be assessed based on their: (i) Fiscal potential; (ii) Opportunities for economic efficiency gains; (iii) Distributional impacts; (iv) Macroeconomic impacts; and (v) Political economy concerns. The template is applied to various case studies from developed and developing countries. One notable theme from these studies in the macroeconomic context is that environmental improvement need not come at a high cost to economic growth.

In the first paper, Gunnar S Eskeland and Haakon Lindstad demonstrate the use of imperfect, though powerful, instruments (e.g., fuel taxes, tax/subsidy schemes or 'feebates', emission standards, congestion tolls) in managing air quality, greenhouse gases, and congestion from transport systems requires carefully designed combinations of policy instruments. With examples from cars to maritime shipping, the paper highlights common themes in environmental improvements beyond technology improvements, such as larger shipments and higher utilization of network capacity.

Rita Pandey and Meeta Keswani Mehra review the best practices associated with the choice and design of fiscal policy instruments in the context of promoting renewable energy technologies. The paper outlines an analytical framework identifying the characteristics of drivers and barriers in innovation of renewable

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[12]   The EU ETS, which implicitly prices coal emissions at about $1 per GJ is not included here, nor is the UK carbon tax floor.

Figure 7: Corrective taxes on coal use, selected countries, 2010

Corrective coal tax, $/GJ

■ Carbon ■ Local pollution ♦ Current tax
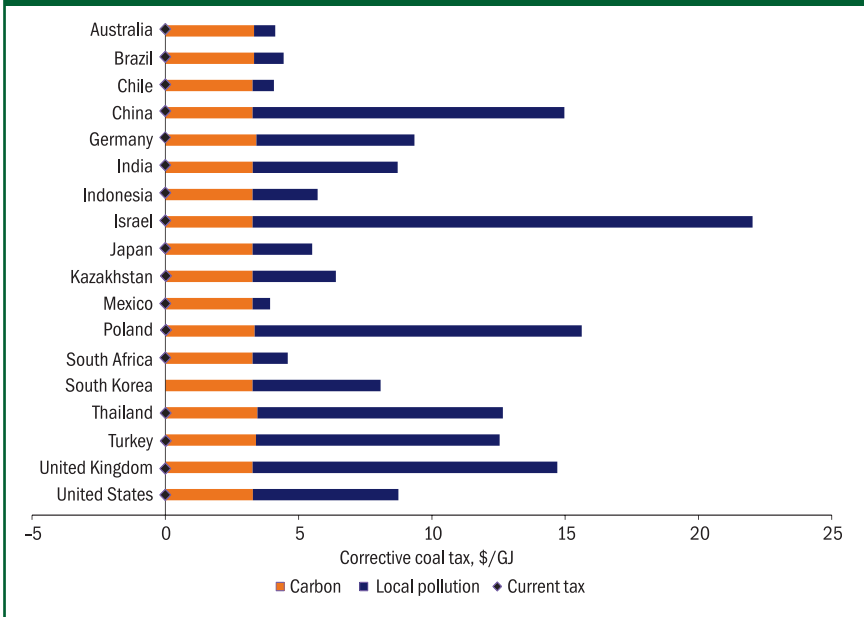
technologies; sequencing of various steps involved in promoting innovation; and various policy tools in the context of each barrier that accelerate the process and enhance the outcomes. The paper identifies main lessons from some country cases for future design and implementation of renewables policies.

Sirini Withana examines how obstacles to green fiscal reforms, such as concerns about economic and social impacts, might be overcome through targeted measures for vulnerable groups, use of revenues, and complementary tools, drawing on lessons from a wide variety of experiences in both advanced and developing countries. The article highlights the potential importance of a comprehensive, consultative, pragmatic approach to green fiscal reforms, and to build broad political and public support to ensure success.

The paper by Kai Schlegelmilch and Amani Joas develop a conceptual framework for understanding the revenue potential of green fiscal instruments and central to this is the tax base, tax rate, and the price responsiveness of the tax base. The study further examines the effect of green fiscal instruments on general revenues, the administrative costs of green fiscal reforms, compensatory spending, and use of revenues for cutting broader taxes and funding environmentally related public goods.

Some Final Thoughts

It is an exciting time to study green fiscal reform, given the diverse range of pressing environmental problems where fiscal incentives can play a key role, including biodiversity loss, excessive exploitation of forests and fisheries, allocation of scarce water resources, air and water pollution, climate change, crowding of transportation infrastructure, disposal of solid and municipal waste, and so on. Moreover, there is growing interest in green fiscal reform among environmental, finance, and other ministries, across advanced and emerging market countries alike.

The principles of sound policy responses are increasingly accepted, most importantly ensuring that environmental costs are appropriately priced for market and non-market goods. The challenges lie in the practicalities of getting it done: assessing the efficient level of environmental charges; evaluating policies in terms of their effectiveness, fiscal impacts, and economic impacts; accompanying measures for related market failures, such as inadequate innovation; the next best alternatives when fully efficient pricing is not viable; and so on.

Successful fiscal policy reforms also often require adequate complementary measures due to their potential distributional and macro-economic impacts particularly on certain segments of society, such as businesses in carbon-intensive industries and low-income households. Removing government subsidies on fossil fuels, for example, could lead to higher energy prices and weaker purchasing power for households. Therefore, complementary measures to offset negative distributional impacts are often needed.

We hope this special issue stimulates further discussion and study of green fiscal reforms, which are central for addressing some of key challenges facing policymakers in the 21st century.

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Environmental Taxation in Transport

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Abstract: *For the purpose of providing public goods (e.g., air quality, congestion management, and greenhouse gas mitigation), the transportation sector employs—and should employ—imperfect policy instruments, such as fuel taxes, feebates, emission standards, and tolls. Then, policymakers need knowledge of the sector and how it can be more environment-friendly. With examples from cars to maritime shipping, common themes in environmental improvements beyond technology improvements—exploitation of scale economy, capacity utilization, and slower speeds—have been highlighted. Imperfect instruments ask for awareness of a broader set of environmental responses. Fuel taxes will, to some extent, succeed in eliciting responses, such as scale economy, capacity utilization, slowdown, and mode change from air to surface, from road to rail, and from rail to sea. Standards often work narrowly through technology and new acquisitions, such as individual vehicles or vessels.*

Keywords: *Congestion, Emission reduction, Environment, Greenhouse gases, Mitigation, Accidents, Public goods, Road pricing, Taxation, Transport sector, Scale, Capacity utilization*

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Introduction

Public Goods, such as Local Air Quality, and their Link to Transport Activities

Environmental goods and services are often 'pure public goods', meaning that they are available to all.[3] This implies that they may need policy intervention (from government, typically) to be protected or provided at efficient levels. This overall framework—using the concept of pure public goods to place environmental protection in the body of welfare economics—suggests that analysis and intervention start with the cross-sectoral coordination of powers that relate to public goods (e.g., air quality), as in a city council or environment ministry (see Table 1). In the following sections, we stretch the idea of the 'environment' so that traffic accidents, congestion, and road wear can be included as public goods. The risk of accidents is, for example, influenced by non-rivalrous and non-excludable conditions, such as the general quality of infrastructure, cars, and drivers. We still allow ourselves to use traditional terms/phrases, such as 'polluting', 'emissions', 'abatement', and 'beneficiaries of environmental improvements', since they are most closely aligned with established analytical tools and our examples. In Table 1, for example, we use the term 'benefit domain' for an airshed and the people benefiting from air quality improvements within its geographical boundary.

The Taxation of Fuels as a Policy Lever to Supply Environmental Goods and Services

Table 1 illustrates that there are several dimensions that make fuel taxes imperfect from the point of view of public goods provision (or protection), with the imperfections varying in importance across the public goods. Two points stand out. First, location and time are important. For public goods, such as local air quality and congestion, one may want to introduce urban toll rings or other instruments to supplement fuel taxes and differentiate discouragement of fuel use by location and time of day, season, and perhaps air quality status. Second, abatement and technology may be critical. For air quality, one may want cleaner cars and fuels in other ways than what can be achieved by fuel taxes. Provision of public goods may also ask for raising variable costs in a way that is dependent on location and the characteristics of a vehicle, as is the case for road wear and Germany's odometer-based fee, or with lower urban tolls for emission-free cars, as in Norway.

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[3]   As used herein, the phrase 'pure public goods' implies that an individual's enjoyment of something (e.g., air quality improvements) is not diminished by someone else enjoying it too (non-rivalry) and cannot easily be excluded or charged for (non-excludability, see Samuelson, 1954). Since a public good, such as air quality, can also be thought of as air pollution, though with the opposite sign, the term is interchangeable with 'public bad', with emission reductions representing a 'public good' provision and emissions representing a 'public bad' provision (Kolstad 2011).

In many cases, a fuel tax is applied because of how it works through an average of conditions, generally discouraging the scale of the transportation activity and enticing responses along the lines of fuel efficiency. Both of these often coincide when supporting environmental goals, though, as explained above, also fail to produce desirable responses.[4]

Table 1: Environmental public goods, their benefit domain, and indicatively the role of transportation

Public Good Benefit Domain			Important Contributor (Example/Typical)	
Public Good	Geographic/ Jurisdiction	Time	Transport	Other
Air quality	From city to valley to neighbouring states	Hours to weeks	Road vehicles (diesel especially); vessels near or in port towns	Power generation, manufacturing and waste burning
Water quality	Bay or river to system of rivers and lakes	Weeks to decades; also more accidental in nature	Maritime shipping, tank cleaning, spills and ballast water	Industry, households and agriculture
Greenhouse gases	Global only	Cumulative and centuries	Road, aviation, and maritime shipping	Power generation, cattle, cement, and all fuel burning
Noise	Very local to suburban level	Spontaneous	Road vehicles and aviation	Construction, household sources, sound systems
Accidents	Local and national in prevention policies	Spontaneous, though strategies may work over decades	Road and rail	Agriculture, industry, and homes
Congestion	Local	Hours	Road vehicles	None
Road wear	Local/national	Cumulative/ decadal	Heavy vehicles; and studded tires	None

As an example, Parry *et al.* (2014) (see Figure 1) suggested that environmental taxes be applied to automotive fuels in lieu of five public goods: carbon dioxide or greenhouse gas (GHG) mitigation, air quality, traffic accident prevention, congestion management, and (for diesel) road wear.

A point that we shall develop is that a fuel tax in lieu of a number of public goods will depend not only on its underlying priority (e.g., whether air pollution is harming many people), but also on average emission factors per litre, depending on fuel specifics and whether emissions standards and other instruments are applied.

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[4]   Several researchers have discussed how imperfect fuel charges or driving regulations work when implemented with other environmental policy instruments (see Eskeland 1994, Parry and Strand 2011, Small 2011, Barrahona *et al.* 2015).

Figure 1: Suggested road fuel taxes in lieu of five public goods
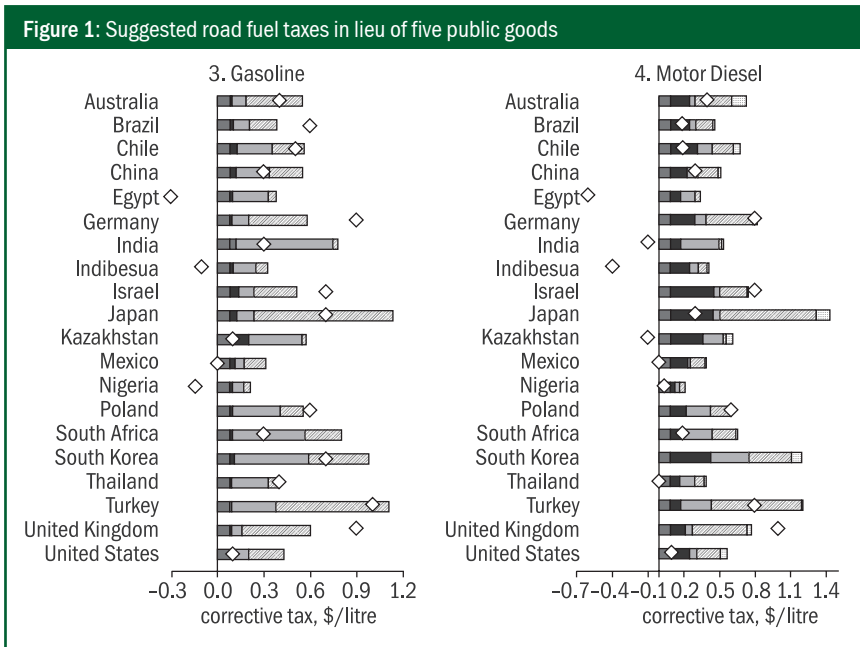
Note: Applied taxes, and in some cases a subsidy, are more often than not lower than suggested, indicating potential for low-cost environmental improvements.

Transport Activities: Their Role in Our Economies

Figure 2 shows—for a select set of countries—the share of domestic transport in total energy consumption by country (see annexure 1 for more complete data). We can see that domestic transport tends to be:

- In the range between a fifth and a third of total energy consumption;
- Lower for poor, agriculturally-based countries;
- Lower for small countries, and countries with an extensive coastline and large coastal population; and
- Dominated by road transport.

In addition to domestic transport, transnational movements exist, dominated by maritime shipping of cargo and passenger aviation, each representing 2–3 per cent of global GHG emissions (Buhaug *et al*., 2009). Figure 3 shifts attention to globalization, transport, and some observations of development over time and shows that the growth in international trade is much smaller in tonnes moved than in dollar value. This means that movement of high-value light items (e.g., garments and electronics) has expanded much more than movement of low-value cargo that costs a lot of energy to move per dollar (e.g., ore, oil, coal, and grain). In fact, tonnes moved have increased in almost exact proportion to world output, or GDP.

Figure 2: Domestic transport's share in total domestic energy consumption for selected countries
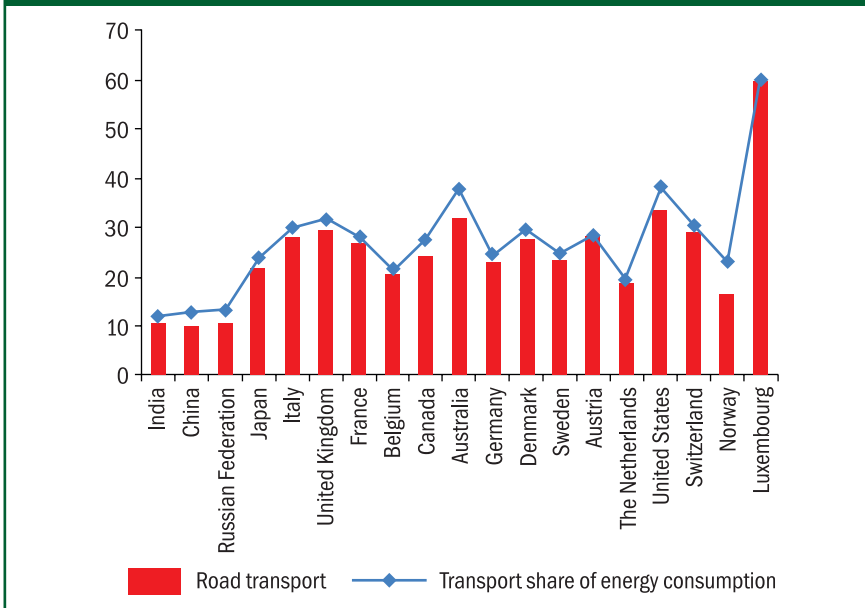
Road transport — ◆ — Transport share of energy consumption

Figure 2 also shows that tonne miles (nautical miles), which is a measure of total transportation work, increases in just about the same proportion as tonnes moved, meaning that the average freight distance has been constant. In this transport-weighted sense, the world has not expanded. Finally, Figure 2 illustrates that to the extent that fuel use in transport is a good proxy for relevant environmental public goods (for GHGs, it is just about perfect), it has increased by even less—150 per cent compared to 250 per cent. As we shall see later, the average fuel consumption (and CO_2, or more broadly GHG emissions) per tonne mile of transportation work falls with various factors, such as lower speeds, larger vessels, and slender hulls, as well as technology. So the combined effect of these has been to reduce fuel consumption per tonne mile produced in this period. We shall show that this potential continues to be sizeable.

Environmental Quality: First Declining and then Improving with Income?

Transport tends to rise with income. In consumption, transport is either a normal or a luxury good, and transport is also an input into production. Given this tendency, one should not be surprised to see environmental concerns rising with income growth. All that is required is for some of the environmental phenomena to show capacity constraints that require collectively induced abatement at high (not

low) levels of transport activities. This will lead to higher willingness to pay for environmental improvements. Whether or not it halts or even reverses deterioration of environmental public goods depends on three factors: (i) income dependence in demand for public goods, (ii) the cost of environmental improvements, and (iii) whether institutions for collective action and policy formation are sufficiently responsive and effective.

In some cases, institutions and abatement are fairly effective—lead was finally removed from gasoline for public health reasons and public-health-weighted air quality improved. In such a case, recommended environmental taxation of

Figure 3: World trade, maritime transport, and other indicators (1979–2012)

World Trade 1,200% increase 1970 ->2012

——— World Trade 1.4 -> 18 billion USD

——— Maritime freight work 12,500 -> 46,000 billion tonne nm

– – – Global GDP 16 -> 55 billion USD

· · · · Maritime transport 2.6 -> 9.2 billion tonne

– – – Energy usage 4.9 -> 13.3 billion TOE

· · · · Maritime fuel 120 -> 300 million tonne

——— Population 3.7 -> 7 billion
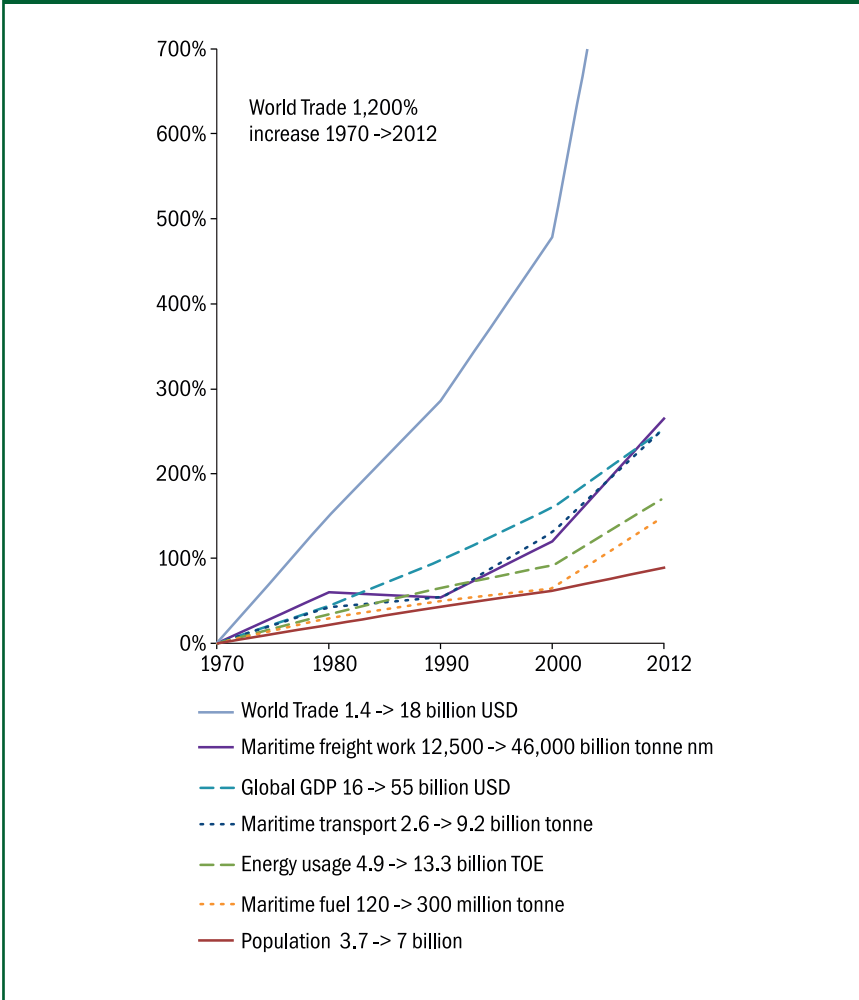
Sources: UNCTAD (2014), IEA (2014), Lindstad (2013) and authors' own calculations.
Abbreviation: TOE = tonnes of oil equivalent

gasoline per litre may decline when the health-weighted emission factor per litre of gasoline declines.

The hypothesis which states that with income growth, environmental quality will first decline then improve is called the Environmental Kuznetz Curve. In the case of transport related public goods, such as air quality and traffic safety, it is both possible and probable to see these public goods initially deteriorate with income growth and then improve. Transport quantity and quality may continue to rise throughout and fuel tax rates may decline if policy instruments and abatement options are sufficiently effective.

The Analytical Foundation of Environmental Taxation

The textbook proposition that environmental problems are best addressed through market-based instruments, such as tradable quotas or emission taxes, is a sophisticated one that is often misunderstood.[5]

A key idea is that persons and companies try to avoid costs to the extent they can. If emissions are priced uniformly per gram weighted by damage, people and companies will try to reduce emissions up to the point where their marginal abatement costs are equal to that price:

(1) $t_{el} = c_e^h = c_e^i$

Where c_e^h is the marginal cost of emission reductions (or marginal abatement costs) for all individuals, firms or sectors h and i. The equality thus ensured across persons, firms, sectors, and abatement alternatives constitutes cost-effective provision of public goods or protection of the environment.

Even when they are cost-effective, such protection of the environment has a cost to persons and firms, and thus to society, and should be justified by environmental benefits. A disciplined route to optimal provision of public goods is the Samuelson condition (1954). Taking the example of a local public good, it asks the emission tax t_{el} (e for emissions, l for a local public good, like air quality) to be set at a level equal to the sum across individuals of marginal benefits of environmental improvements, as follows:

(2) $t_{el} = \sum_{(h=1)}^{n} b_{el}^h = n_l \, b_{el}$

Here, b_{el}^h is the marginal benefit locally (e.g., in a city) to an individual h from being exposed to reduced emissions in the individual's area, and expresses the

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same sum with an average for all the individuals in the city. Equation (2) represents a collective demand—willingness to pay—for environmental quality, and through the tax, it asks everyone who can help provide environmental improvement to respond so that demand equals supply.

Fuel Taxation

Alternatively, when the emission tax is levied not on grams of weighted emissions but per litre, the following applies:

$$(3) \quad t_{eql} = \sum_{(h=1)}^{n} b_{el}^{h} = n_l \, b_{el} \, e_{ql}$$

Here $_{eql}$ is an appropriate average emission coefficient per litre, q, for grams of locally damaging emissions. Benefits must take into account the fact that the fuel tax may have to apply uniformly across locations where benefits differ, for instance, averaged between emissions in a rural area where benefits of air quality improvements are zero and an urban area where benefits are positive.

In this exposition, we have omitted two issues. First, we did not bring in the possibility of a positive 'shadow price' of public revenue. In doing so, we essentially, in equations (1) to (3), assume that income has the same value in private and in public hands, so the transfer to the government is not valued in itself (polluters may of course be public, too). Second, though we could have used the idea of revenue neutral reform to justify not examining the shadow price of public revenue, we would have fallen short on the analysis of which other taxes should be reduced if environmental taxes are raised.[6]

We thus omit, here, the debates of 'double dividends' from 'green tax' reform. Our focus is on what environmental taxes can do for environmental improvements—the first dividend only. Green taxes can raise substantial revenue, not the least when levied on fuels. But this should not distract attention from the fact that good environmental policies reduce emissions and damages, and thus welcome a shrinking tax base if it is shrinking for the right reasons.

The consequences of revenue neutral green tax reform—a fruitful approach both in terms of analytics and reform communication—depends on which other taxes are reduced and whether to emphasize efficiency gains (e.g., reducing taxes on labour, savings, or business, since these are costly in terms of distortions) or incidence (e.g., reducing taxes on the poor to protect the vulnerable). Both topics are beyond the scope of this paper.

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[6] Several studies have explored the role of a government revenue constraint, as well as revenue neutral reform, tax interactions, and environmental tax incidence (e.g., see Sandmo 1975, Goulder 1995, Goulder *et al.* 1999, Bovenberg 1999).

With these shortcomings in mind, an important message can be derived from equations (1) to (3): a general consequence of using market-based instruments, such as tradable quotas or taxes, to attain environmental improvements is the equalization of marginal costs of environmental improvements across polluters (or providers of public goods), leading to cost-effective environmental improvements.

Abatement Options Different from Reduced Transport or Fuel Use

Pollution and other problems are neither (in general) proportional to output nor to fuel use. Tax approaches, such as a tax on fuel use, are employed in part because they are simple in terms of monitoring, enforcement, and collection, and will thus incentivize some of the responses sought for the environment, but not others. Tax approaches may even lead to some undesirable responses. In contrast, for the textbook case, with an emission tax based on continuous or cumulative monitoring of individual emissions, all desirable responses are actually incentivized in an optimal combination.

In the case of a fuel tax, one must ask how fuel reductions from fuel taxes shall be combined with abatement that is induced by other means, for example, emission standards that reduce emissions of locally damaging air pollutants per litre of fuel or per vehicle kilometre (Eskeland 1994):

$$(4) \ \frac{t_{eq}}{e_{\bar{q}l}} = c'_{\bar{e}}$$

Here, $c'_{\bar{e}}$ is the marginal cost of emission reductions from tightening emission standards or in other ways along the technical-control cost curve (e.g., see the Mexico City example). Simply put, a cost-effective pollution control programme views the demand for polluting fuels—or polluting trips [the left hand side of (4)]—as a supply curve for emission reductions, comparable to and competing with the technical-control cost curve (the right hand side). Therefore, the cost-effective programme sets the tax rate on fuels, per unit of emissions, equal to the marginal abatement costs, as shown in the fourth equation.

In Figure 4, panel A displays the idea that a public good, such as air quality, can be provided in part by consumption reduction when travel is produced by consumption of fuel. In panel B, such an output reduction is attained with a fuel tax or an output or input tax, assumed equivalent in this case. In panel C, we have assumed that an abatement option (that is different from output reduction) is to change the technology (a filter, say, an electric engine, or a catalytic converter) to reduce the emission coefficient per litre of fuel. Such a change may be imposed by regulation, such as an emission standard. In panel D, an optimal combination of output reduction and abatement is employed, which can be induced either by a skillful combination of a fuel tax and an emission standard or by a textbook-emission tax based on monitored annual emissions.

Figure 4: When demand reduction or abatement or a combination offers emission reduction

(a) No intervention
Consumer surplus = (A–B)

(b) Pollution tax on output
Consumer surplus = A

(c) Mandated abatement
Consumer surplus = (A–B)

(d) A pollution tax
(or output tax and abatement)
Consumer surplus = A
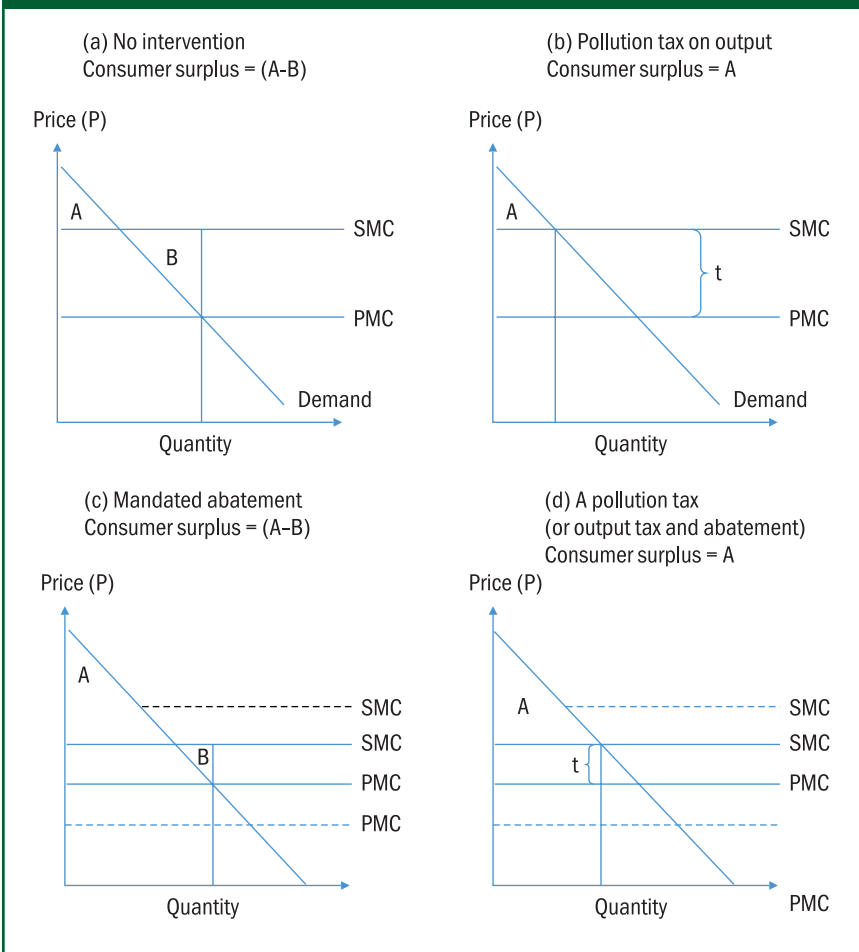
Source: Author's own calculations

Several Public Goods: Local Air Quality and Global Greenhouse Gas Emissions

We can, in the same spirit, include taxes that reflect global benefits of GHG reductions, multiplied by seven billion plus individuals (and their descendants) who will benefit, so that a litre of gasoline is taxed at the sum of two rates:

$$(5)\ t_{eq} = t_{eql} + t_{eqg} = n_l\, b_{el}\, e_{ql} + n_g b_{eg}\, e_{qg}$$

Here, b_{eg} is the average per capita global benefit of GHG emission reductions, and $n_g b_{eg}\, e_{qg}$ is the social cost of carbon expressed per litre of gasoline.

Gasoline, here, is only an example, of course, but the basic idea is that a fuel, such as gasoline, will be taxed for several reasons in lieu of different public goods, often with different geographical domains (and jurisdictional domains, perhaps, as with local and global). Averaging marginal damages per litre for uses and users within the bounds given for tax differentiation will be necessary.

Three Examples of Tax Policy Instruments in Transport

In this section, we present three examples from transport: (i) road, (ii) passengers, and (iii) maritime shipping and cargo, to illustrate considerations in practice of using fiscal instruments for environmental purposes, as well as seeing how they will be supplemented.

Air Quality in Mexico City: Fuel Taxes Combined with Emission Standards

Road vehicles have been an important target of air quality policies for many decades, and quite impressive advances have been made in terms of emissions that are harmful to public health locally. Key successes have been the removal of sulphur and lead in fuels, and reducing trace elements of incomplete combustion with improved ignition systems and catalytic converters. The latter relates more to a car's characteristics than to its fuel consumption, thus it is not easily attained with fuel taxation designs. Lead and sulphur removals can in principle be enhanced with taxes depending on fuel characteristics, though there have often been important arguments for regulatory approaches (e.g., concern for misfuelling).

Many of the modifications that can make cars and fuels less polluting may require policy instruments other than fuel taxes. To be simplistic, one can think differently about those policy instruments that can make cars and fuels cleaner, and those policy instruments that discourage car use and fuel use. Figure 5, is from a study that made this point (Eskeland 1994). Eskeland highlighted that policy instruments that make cars and fuels cleaner—often taking the shape of emission standards applied to new car models when sold or also to cars in use through mandatory inspection and maintenance programmes—should be complemented with a gasoline/ diesel tax to manage the scale of the polluting activity of driving. The study estimated that a given air quality target for Mexico City would be about 30 per cent less expensive (in welfare terms) if one included demand-management instruments, such as gasoline taxes, in the toolbox of policy instruments since the most expensive technical controls would not need to be used (see Eskeland and Feyzioglu 1997b).

The example illuminates some other points. First, many emission-reducing initiatives entail a fixed cost at the point of manufacture or retrofit, which yields emission-reduction benefits proportional to the vehicle's annual usage. This has the implication that policy instruments which target high-use vehicles first (e.g., taxis before cars in ordinary family use) are more cost-effective. Second,

Figure 5: Supply curve for emission reductions in Mexico City, with and without an optimally matching gasoline tax
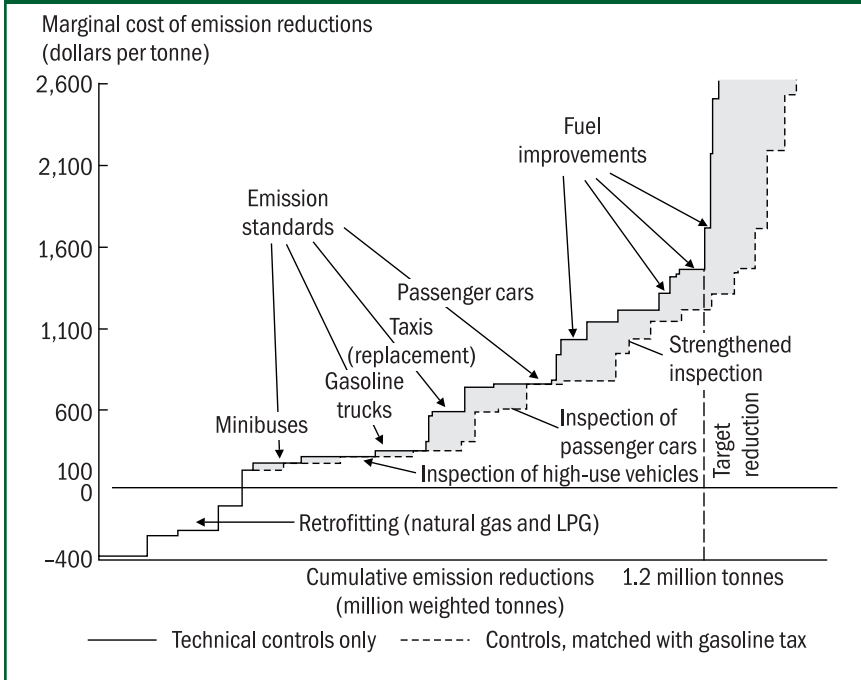
larger vehicles often offer low-emission transport more cheaply, so public transport is enhanced. In the Mexico City control-cost curve, taxis, minibuses, and buses demonstrated these points (see Figure 4). Third, policies that can be phased in with the speed of vehicle purchases (including replacements) will be easier and cheaper than policies trying to move faster. Finally, if old, polluting vehicles can be transferred to non-polluted rural areas, this may be a better option than policies leading to scrappage.

An important observation is that such knowledge is not needed by policymakers in the theoretical textbook case when an emission tax is available, since a tax levied on emissions continuously measured would make vehicles and trips and abatement opportunities self-select along such lines.

When one moves from emissions of air pollutants to GHGs, another point surfaces: there are greater emissions from GHGs when compared to local air pollutants which are strictly proportional to the fuel consumed. Thus, for GHG emissions, fuel taxes alone will provide complete incentives. These need to take into account differences across fuels, which is easily built into GHG-motivated fuel taxation systems.

In contrast to GHG mitigation, air quality controls may be worth more in certain urban locations and times than in others—a differentiation that generally cannot

be built into fuel prices. Thus, for air quality and congestion, tolls may be suitable as supplementary policy instruments. Norwegian toll rings allow electric cars to pass for free, conveying that such differentiation is possible. It would, however, be more sensible to make electric cars pay for road use and congestion, even if they should pay less or nothing for air pollutant emissions. There is also a discussion about whether electric cars in hydro-based Norway should be held accountable for a fossil share in European electricity generation (Eskeland 2012).

Finally, the Mexico City example also demonstrated the value of market-based instruments in discouraging environmentally damaging driving activity. We have already discussed how a fuel tax can reduce polluting trips and the scale of a polluting activity. This recommendation was in contrast to a driving restriction *hoy no circula* (today, not driving), which used license plate numbers to ban driving, i.e., allowing a car to run only one workday per week. Such a driving restriction is unable to select the least important trips. It also has the disadvantage that it raises the value of an additional car. Many Mexico City households made such acquisitions and the regulation increased driving. The driving restriction reversed the traditional flow of used cars registered in the capital being exported to the rest of the country, resulting in more pollution.[7]

Carbon Leaner Cars, with Fiscal Instruments

Figure 6 shows the average CO_2 intensity—CO_2 grammes per vehicle kilometre (vkm)—for new cars sold in European countries from 2001 to 2011. European countries generally have quite high fuel taxes, often including a 'carbon tax', which is a suitable instrument according to textbook environmental economics. European countries have, in addition to fuel taxes, set specific goals for a car fleet to become 'carbon-leaner', and the figure shows that cars have indeed become leaner over the period.

Since 2006, the policy instrument in Norway has been a specific tax levied in the 'new car tax schedule (*engangsavgiften*) for each gram of CO_2 per vehicle kilometre (vkm). The tax resembles a feebate, combining a rebate for CO_2 lean cars and a tax for cars with high CO_2/vkm.[8] The feebate works together with

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[7] Several researchers (e.g., Eskeland and Feyzioglu 1997a, Davis 2008, Barrahona *et al.* 2015) have performed analyses on driving restrictions, including the beneficial effects when they are designed to accelerate vehicle turnover towards cleaner cars, as attempted in Santiago, Chile.

[8] Policies in some EU countries and the US Corporate Average Fuel Economy (CAFE) standards have had similar features. These approaches reduce fuel consumption per vehicle kilometre, but they do not reduce driving. Thus, they risk a 'rebound' in driving because variable user costs decline, unless fuel taxes are raised. Small (2011) analysed tighter fuel efficiency standards in the United States (or steeper feebates, similar to the Norwegian system) as compared to higher fuel taxes and found that fuel taxes offer fuel and emission reductions at a lower welfare cost. Eskeland and Mideksa (2008) explored why fuel economy standards often appear in real world policies, emphasizing transition and political commitment.

Figure 6: Decline in the average CO_2 intensity for new car sales in Europe
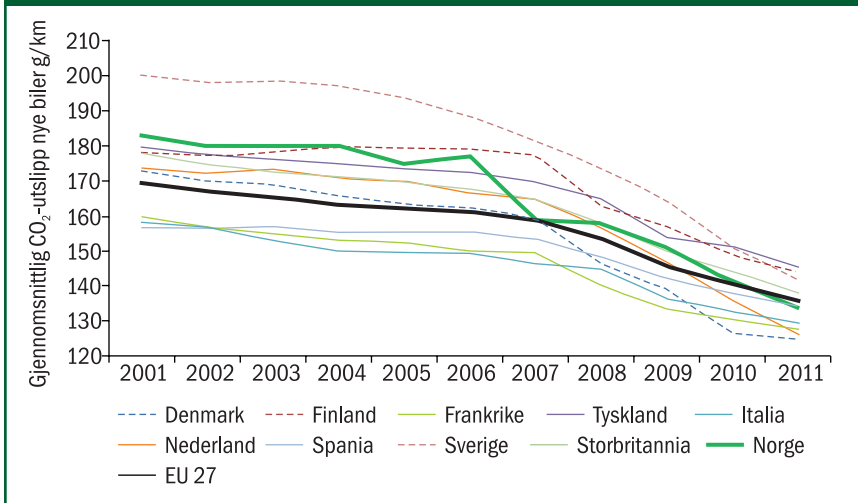
Source: Eskeland (1994).

Note: Calculations are based on -0.8 elasticity of demand for gasoline

specific levies on effect (horse powers or kilowatts) and weight, collectively stimulating leaner cars, though the latter two components appear lacking or weak in environmental underpinning. As Figure 6 indicates, Norway has had a more rapid reduction in CO_2 per vkm than the others, about 27 per cent (from 183 to 134 grams per vehicle km) against Europe's 20 per cent. Further analysis shows that this slimming is at similar rates within each car segment, with only minor shifts between segments (e.g., from sport utility to medium-size vehicles).[9]

Figure 7 shows the prices of car models offered in Norway in 2012 (blue dots) plotted against their CO_2 intensities (grammes per vkm in registration documents). The green curve shows the sum of the new-car taxes; the purple curve shows the CO_2 tax element. As can be seen, the taxes, in sum, contribute to CO_2 intensive qualities being more expensive, but they are also expensive for non-tax reasons.

Figure 8 shows how the distribution of sold cars shifted to the left from 2008 to 2012 in Norway (a small market with imported cars only) under the influence of a rising tax rate for CO_2/vkm and technological change exogenous to Norway. We can see that the whole distribution of car sales has shifted towards the leaner left and also that some electric vehicles have entered the market. Electric vehicles have in Norway not only been considered non-emitting, but oddly enough been given additional stimulus, such as VAT exemption and bus-lane privileges.

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9   Norwegian cars are larger, heavier, and with higher shares of four wheel-drive than the European average (Figenbaum *et al.* 2013).

Figure 7: Car model price with tax and CO_2/vkm
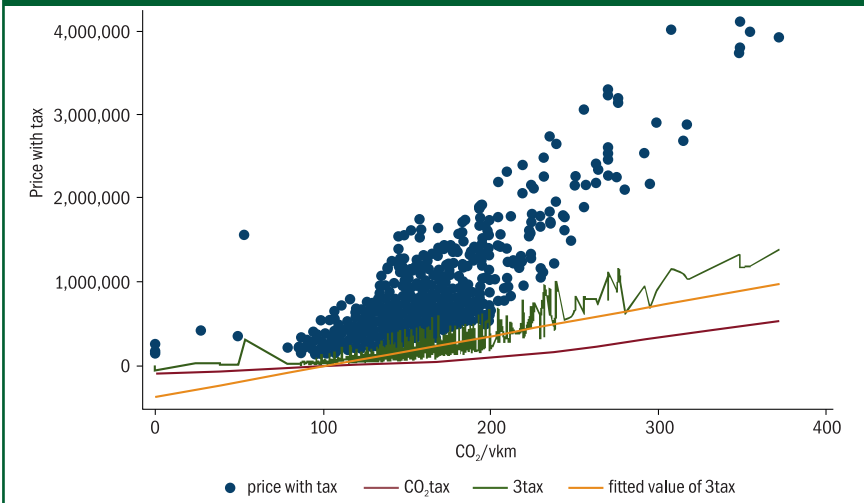
Source: Figenbaum *et al.* (2013)

Note: With CO_2 intensity along x axis, the dots show the price of car models offered. The three tax elements are CO_2, weight, and horsepower. The sum of the three tax components (3tax and fitted 3tax) increase in CO_2 more steeply than the CO_2 tax components, and car prices tend to increase even more steeply

Figure 8: Distribution of cars sold sorted by CO_2 intensity (grams per vehicle kilometre) for 2008 and 2012 under heavy and increasing taxation of CO_2/vkm in new car registrations.
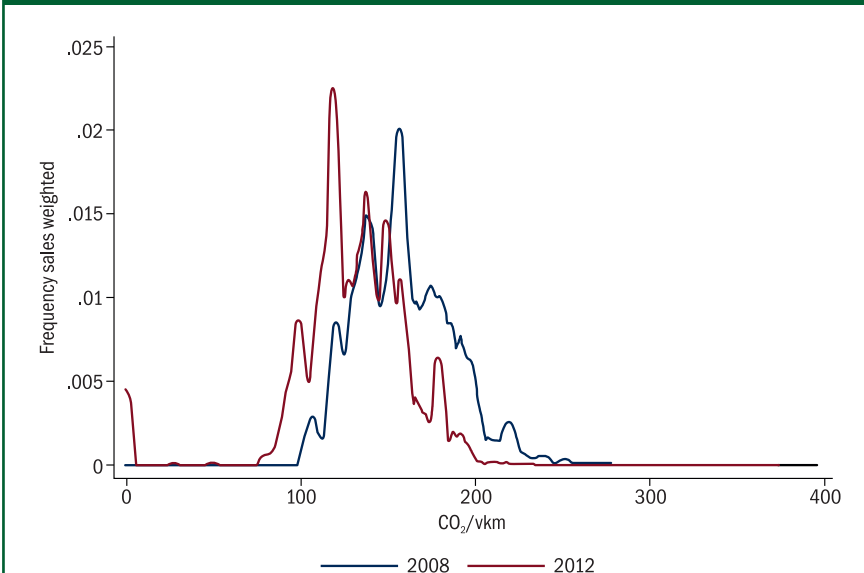
Source: Figenbaum *et al.* (2013), and data from OFV (Office of Road Traffic).

While these reductions in CO_2 intensity are noticeable, the policy instruments in use are heavy handed. Welfare costs are associated with asking people to buy leaner cars that are costlier to build or offer less in terms of some quality dimension. A welfare analysis which recognizes that certain desirable quality characteristics are costlier to deliver with lower CO_2 intensity (e.g., four wheel drive, acceleration, range and size) is illustrated in Figure 9. Assuming that government revenue is worth the same as private revenue, the welfare cost of raising the tax rate is measured as areas E plus B. These calculations assume an elasticity of CO_2 with respect to a price of minus 20 per cent. Consequently, a tax increase of 50 per cent causes a CO_2 slimming of 10 per cent. This calibration seems reasonable based on years of experience in Norway, though the trend and time delay probably gives a greater change over time.[10]

Quite generally, GHGs, and especially CO_2 (the most important GHG from automobiles), are proportional to fuel use, independent of location and many other parameters that are important for other environmental problems. For this reason, fuel taxes alone, reflecting the CO_2 content of fuels (or tradable quotas), come very near to being suitable, stand-alone policy instruments.

Nevertheless, the practical world of policy has shown interest in other instruments, such as fuel economy standards and the now evolving feebates, for new vehicles in the European Union (EU). The literature points out that such strategy may be finding some support in consumer myopia or asymmetric information (e.g., propositions that people give insufficient weight or credence to future fuel savings when buying durables, such as cars). In Norway, as in Europe more generally, these vehicle-oriented instruments work in conjunction with taxes on transportation fuels. The combined effect of these instruments in Norway is much higher than what can be justified in order to match the pressure on CO_2 in other areas. The effect in Norway is many times the quota price in Europe and far exceeds the frequently applied benchmark of $35 (unless otherwise specified, all dollar amounts are in United States dollars) per tonne CO_2 (Parry *et al*. 2014) Thus, while this is a powerful way to reduce emissions, the level itself is presently much too high to be justified by cost considerations of cost-effectiveness.[11]

The feebate structure for new car sales in Norway is applied jointly with tolls on highways, urban toll rings and taxes on fuels. While some of these have

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[10] As an illustration of the welfare cost of suppressing CO_2, and using new car sales in European countries over ten years, an elasticity of CO_2 intensity in cars with respect to per capita income was estimated at 25 per cent, correcting for the trend but not beyond this for policy and technological changes.

[11] Eskeland and Mideksa (2008) discussed fuel efficiency standards, including whether their future targets provide more commitment for politicians than do fuel taxes. Modifying assets over time with standards and feebates may work more favourably in dynamic, political economic terms because such modification moves individuals toward less fuel intensive assets while simultaneously transferring less income than would be the case for fuel taxes.

Figure 9: Schematic treatment of the welfare costs of using taxes to get carbon leaner cars
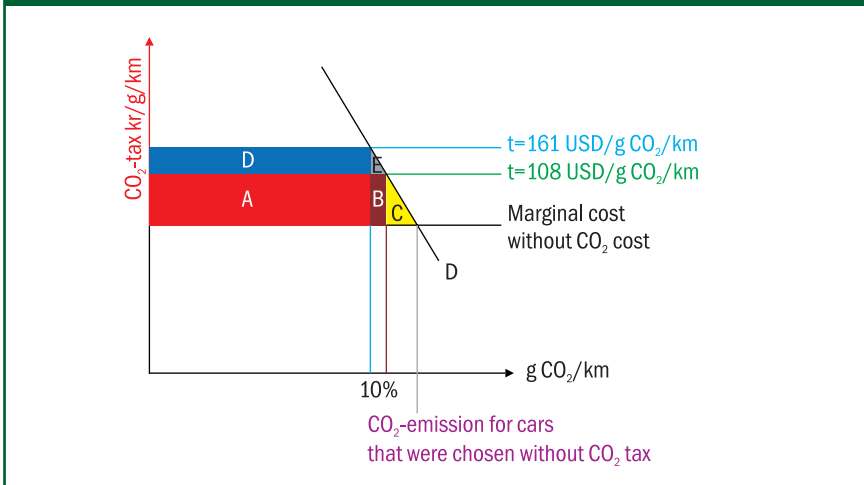
Source: Figenbaum et al. (2013).
Note: The estimates are based on the assumption that resources have the same value in the hands of government as they do in the hands of households.

environmental goals attached to them, their motivation and design also bears evidence of revenue goals and redistributive goals.

Maritime Shipping: Slowing Down, Sizing Up, and Reshaping Vessels

The shape and value of environmental taxation depends on the extent to which the sector can change its ways—or only its activity levels—in response to the taxes. We explore this topic utilizing the example of maritime transport as measured in transportation work—that is, cargo tonne-miles or tonne kilometres globally (Figure 10). As revealed in Figure 10, maritime shipping is dominant in global cargo movements; aviation is less than two tenths of one per cent of cargo tonne-kilometres.

Figure 11 gives an important hint that the strong dominance of maritime shipping is due to its lower energy cost per unit of transportation work performed, in tonne-miles or tonne-kilometres. The figure also shows that the cost-effectiveness ranking and differences for lighter goods, that is, costs per cubic metre transport times kilometres, is similar but with smaller differences. The figure also shows a strong role for scale economies in 'lot size' and 'vehicle size'. The only exceptions to the rule that energy consumption (or CO_2 grams per tonne-km) declines with lot size are related to large differences in speed: aviation is much faster than road haulage and container vessels move faster than bulk carriers. Cargo typically chooses faster service if it is valuable per tonne or otherwise time-sensitive. Speed and small lots (or 'vehicle' sizes) generally burn a lot of energy. Thus, large shipment lots and low speeds represent abatement options not only for GHG emissions, but

Figure 10: Estimates of the relative roles in global cargo freight by mode of transport, from 2011 and 2012
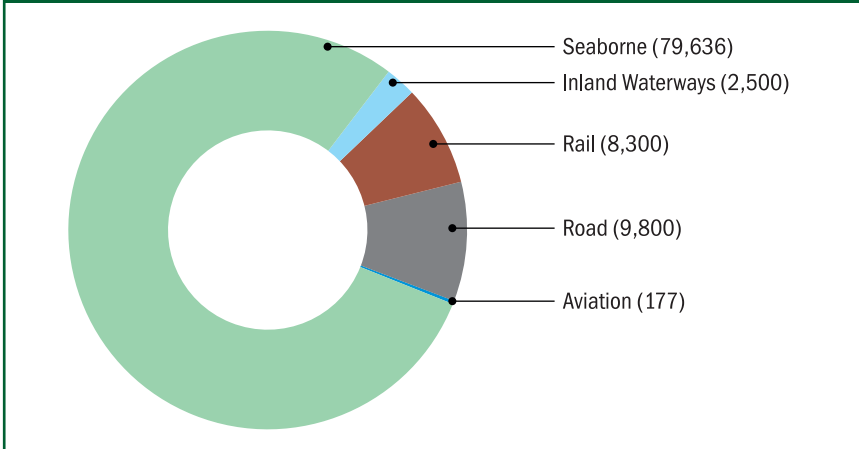
Seaborne (79,636)
Inland Waterways (2,500)
Rail (8,300)
Road (9,800)
Aviation (177)

also for other pollutant emissions. With regard to 'short-travelled' consumption (e.g., buying from your neighbourhood grain producer), efficient transport (e.g., not driving too much between suburban shops and farmers) is, by several orders of magnitude, more important than import distance for grains. To visualize the difference, imagine the small share of payload when tomatoes travel in your car as opposed to the large payload when they are imported in larger lots with specialized carriers and less staff.

Regarding the topic of fuel and CO_2 consumption in maritime shipping, it is important to note that ships have typically been built to operate at or close to their maximum speeds (Silverleaf and Dawson 1966, Lindstad *et al.* 2014). However, in the years 2011–14, high oil prices resulted in bunker fuel (the fuel in most vessels). The high price of bunker fuel challenged the status quo, slowed down ships and raised interest in the relationship between speed and emission (see Corbett *et al.* 2009, Seas at Risk 2010, Psaraftis and Kontovas 2010, 2013, Lindstad *et al.* 2012, Jonkeren *et al.* 2012, Assmann *et al.* 2015).

A key observation from maritime shipping is that in an interval between a vessel's maximum and minimum speeds, the fuel input 'q' (and CO_2 emissions) per hour 'h' is the cube of speed (distance per hour, d/h), $q/h = (d/h)^3$. This implies that when a ship reduces its speed, the fuel consumption and emissions per freight work unit are reduced. A 10 per cent speed reduction reduces fuel consumption and emissions per day by 30 per cent; it reduces consumption and emissions per tonne-mile transported by 20 per cent. This emission reduction, with speed, is

Figure 11: Grams of CO_2 per unit of transportation work performed (tonne-kilometres and m³ kilometres)
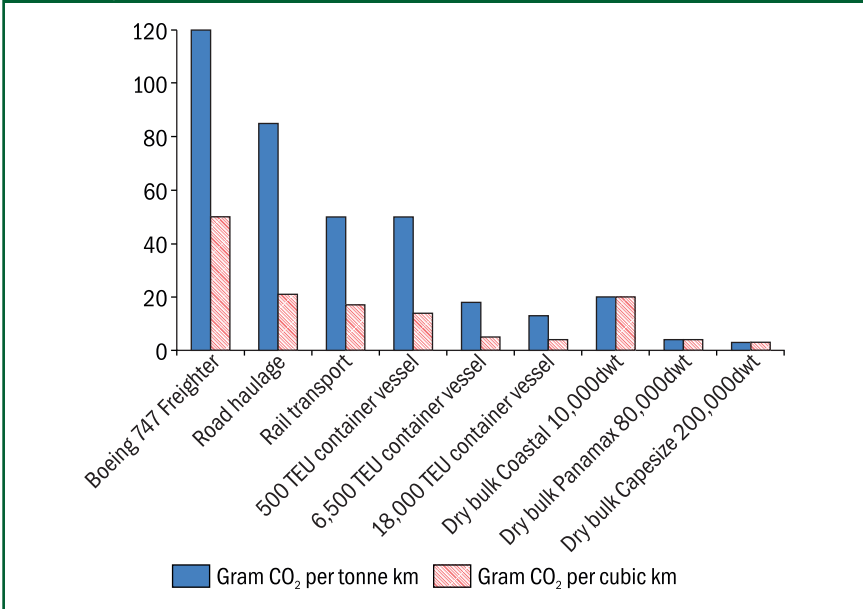
mainly a substitution by capital for labour. Lower speeds require more capital tied up in vessels and cargo between ports.[12]

A second observation on maritime shipping is that large ships tend to be more energy efficient per freight unit than smaller vessels (Cullinane and Khanna 2000, Sys *et al*. 2008, Notteboom and Vemimmen 2009, Stott and Wright 2011, Lindstad *et al*. 2012, Lindstad 2013). Other, non-energy costs also tend to rise less than proportionally to cargo capacity. Thus, there are basically port and canal considerations that allow a role for small- and medium-size vessels, as when small shipments are required by port or storage constraints, or by low throughput, either at the exporter or importer nodes.[13]

A third observation on maritime shipping is that it is possible to introduce energy efficient designs, such as slender hulls, without making logistical changes

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[12] Tjalling Koopmans (1939) and Leif Johansen (1972) studied capital-energy substitution with oil tankers (see Lindstad and Eskeland 2015).

[13] A source of convexity ensuring that shipment size is smaller for buyers or sellers with lower throughput per time period is the cost of storage between shipments. Jansson and Schneerson (1982) emphasized port and handling costs in lending a role to smaller vessels. The economics of hauling, however, favours the larger vessels.

(Lindstad *et al.* 2012,; Lindstad 2013a, Lindstad 2013b). Slender designs outperform the traditional full-bodied designs even with bunker fuel prices as low as $300 per tonne (corresponding to the present 2015 oil price of $50 per barrel, half of the 2011 to 2014 average).

The vessel types chosen for illustration here are ocean-going tankers that transport crude oil from oil producing areas to refineries in consumer markets. In total, these vessels perform 20–23 per cent of the global seaborne freight work, measured in tonne miles (UNCTAD 2014). Figure 12 shows optimal speeds for tankers of different sizes and shapes, and the fuel consumption (and CO_2 emission) consequences on a round-trip basis, using $600 per tonne as bunker price (roughly the 2011 to 2014 oil price level). As we can see, the very large crude carriers (VLCCs)—the largest vessels that are almost three times the capacity of an Aframax (an oil tanker that is smaller than 120,000 metric tonnes and with a breadth not greater than 32.31 metres)—reduce costs by about 20 per cent, and reduce fuel consumption and CO_2 emissions by about the same amount. These calculations are based on a high oil price, but the VLCCs still travel quite fast (13 knots), in part because an advantage of large vessels is low resistance per tonne transported.

Exploring the question of optimal speed, it is worth using the example of crude oil carriers to analyse how a market-based measure, such as a fuel tax or a CO_2 cost scheme, can reduce fuel consumption and associated emissions. In Figure 13, we have introduced two types of variations around a central fuel cost assumption of $600 per tonne. First, we subtract and add 50 per cent to the fuel price, resulting in $300 and $900 per tonne. Second, we compare this to a scenario where a CO_2 cost of $100 per tonne of CO_2 is introduced on top of the fuel price of $600 per tonne. This CO_2 tax is chosen to raise the fuel cost from $600 to approximately $900 per tonne. Figure 12 shows that raising the fuel price from $600 to $900 per tonne, reduces the cost-minimizing speed from 13 to 12 knots and fuel consumption from 13 to 12 kg per tonne of crude transported on a round-trip basis (covering the same distance and performing the same transportation work). The difference when fuel costs are raised by the same amount through a CO_2 fee is that the value of the cargo is not increasing. The speed reduction is, for this reason, twice as large from 13 to 11 knots, and fuel consumption falls from 13 to 11 kg per tonne transported. This special result for oil carriers comes about because for these vessels, oil is also the cargo and the effect of a cargo value increase alone is to raise optimal speed through the capital cost of the cargo. For a CO_2 tax, in contrast, the bunker costs increases, but the value of the cargo does not. The higher responsiveness of emissions to CO_2 taxes than to oil prices is indicative of the responsiveness to CO_2 taxes or bunker price increases that one can expect in cargo trades, other than oil carriers, as long as cargo prices do not covary with the bunker costs.

Figure 12: Different vessels and their cost-minimizing speeds (based on $600/tonne bunker cost)
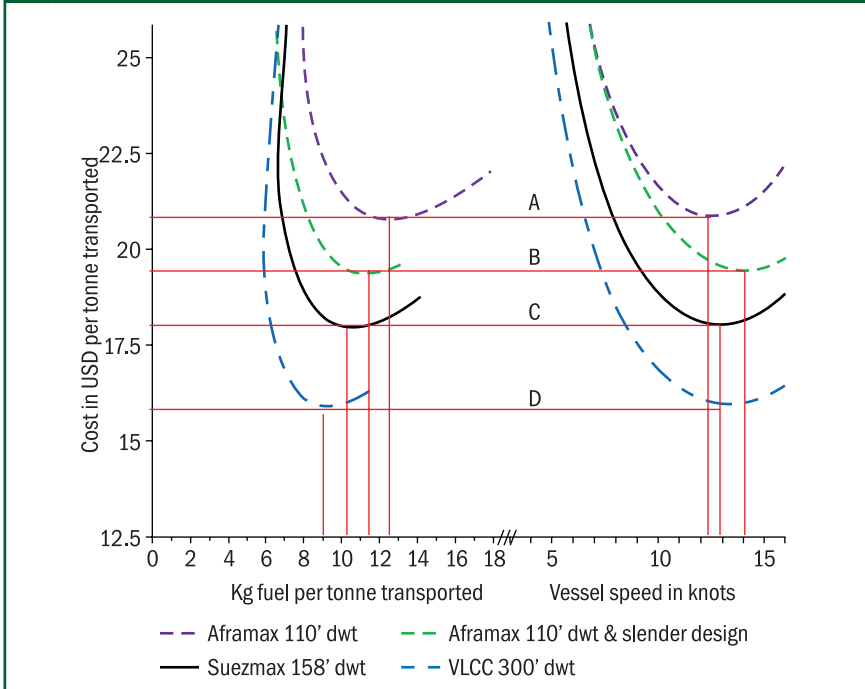
Issues for Discussion

As noted in the introduction, in general, fuel taxes will be imperfect policy instruments for environmental policy goals associated with transport. Nevertheless, in our examples of road traffic and maritime shipping, we have highlighted some themes beyond simply economizing with the level of output in transport activities.

For cargo, we found a very consistent pattern that energy efficiency, and thus CO_2 emissions and to a great extent also air quality, is enhanced by various factors, such as the size of lots and vehicles (that is, vessel size, train length, and bus capacity), capacity utilization, and speed reduction. Figure 14 demonstrates the same tendency for movement of passengers. Passengers are valuable cargo who value speed and comfort, penalizing loading and unloading. Also, for passengers, the 'speed penalty' in terms of emissions is less important and less notable as long as we do not have non-motorized movements in comparison.

Figure 13: Fuel and cost per tonne transported as a function of speed, fuel and carbon price
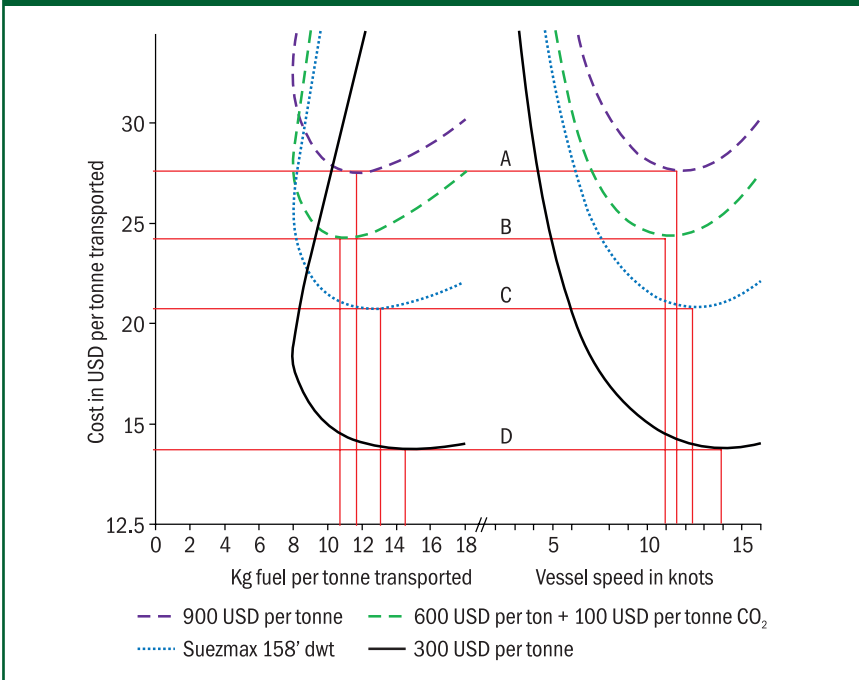
Source: Authors' own calculations

Reasons for this consistency are that scale reduces energy consumption related to resistance and also, typically, acceleration by reducing the weight of the vessel itself per unit of cargo carrying capacity. Reduced speed does the same.

Environmental and climate policies—for instance fiscal instruments, such as taxes on emissions and fuels, exert pressure on every owner, shipper, operator, and traveller to slim their emissions per tonne kilometre and passenger kilometre, including efforts to allow greater scale, capacity utilization, and slower movements. These responses will, for policies regarding emission of air pollutants and GHGs, include:

- A shift towards non-motorized modes and less travel and transport, perhaps also denser urbanization;
- An increase in alternative fuels and technologies;
- A substitution between modes (in principle) from air to surface, road to rail and rail to sea;
- Greater capacity utilization (fewer empty seats, containers and trips);
- Slower movements (with the exception of when speed relieves congestion, as with separate, high-capacity lines and lanes); and
- Larger vehicles and shipments.

Figure 14: CO$_2$ grams per passenger kilometre
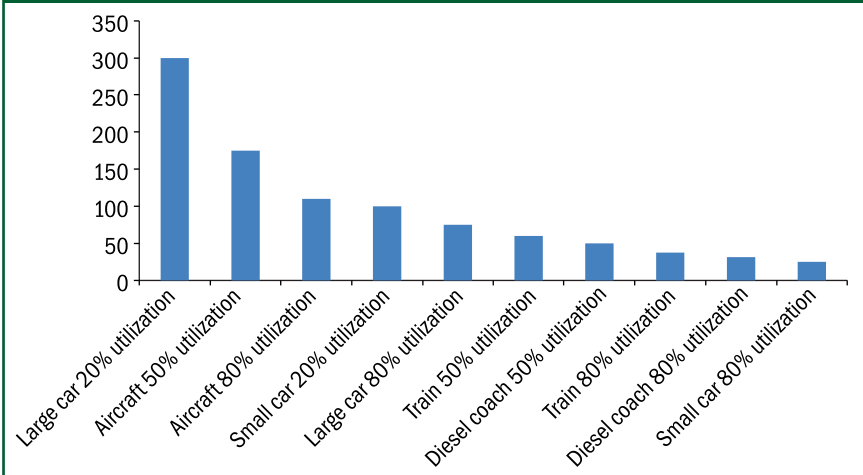
Sources: Lindstad, Asbjørnslett & Strømman (2015), Manufacturer's specifications, and authors' own calculations
Note: Energy efficiency, for different modes, reflects fairly closely a penalty to speed and scale economy in terms of capacity utilization and passengers per vehicle.

For other public-goods problems associated with transport, such as congestion, safety, noise, water pollution and recycling, responses will be different in the specifics but will largely include a similar logic. For example, larger vehicles have the potential to use the road network better and thus reduce congestion and raise safety (higher occupancy or load factor can also reduce congestion and raise vehicle safety).

The Role of Fuel Taxes Alone and in Combination with Other Policy Instruments

We have concentrated on a big picture that incorporates:
- Various forms of transport (persons, cargo and modes);
- Various environmental public goods affected by transport and the specific responses that can be expected and hoped for to help provide and protect them; and
- The role that fuel taxes can play, working alone or together, with other policy instruments to induce these responses.

In this big picture, fuel taxes are imperfect policy instruments. The weight of intervention for public goods, such as air quality, GHG mitigation, congestion, road damage, and accidents will tend to increase with population, urbanization and income growth, but relative priorities will also change. For example, with income growth and urbanization, fatal accidents can fall, not only per vehicle kilometre, but in total. Similarly, road capacity problems change from being addressed

mostly through capacity expansion to also including demand management through fuel taxation and tolls, as with the London and Stockholm congestion-charging schemes.

Thus, as priorities for environmental public goods rise and change, fuel taxes will probably rise, and should rise, but this depends on the relative priorities as well as the effectiveness of supplementary instruments, such as emission standards for local air quality and congestion tolls for urban commuting capacity. A reason fuel tax rates might not increase despite rising priority of environmental public goods (the value of saving a statistical life, for instance, will typically be rising) is in part interaction with other instruments. It may be that feebates or standards make cars and fuels less emitting, thus lowering the tax base per litre, even though the tax rate per gramme of pollutants emitted is rising. And it could be that toll-based congestion charges are introduced to discourage driving in urban areas, thus reducing the fuel taxes that are motivated by national (including global) environmental objectives, which are not varying with time and location.

Fuel taxes may still remain and grow in power, however, both because of the general desirability of raising private variable costs to internalize a range of remaining externalities, and because an important range of public goods—GHGs and air quality in particular—gain from reduced scale of transport activities as well as from reduced energy intensity per unit of transportation work. If and when such impacts as emissions of air pollutants and car safety issues are successfully brought down per tonne-kilometre, per passenger kilometre and per litre, pricing variable costs due to issues such as congestion and climate change may prevail and grow in importance. This paper has thus emphasized that certain sweeping and large responses that serve several environmental goals are consistent with fuel taxes. It is important, therefore, to be aware of the generally attractive consequences (as well as the shortcomings) of incentivizing these responses.

Different Public Goods and Abatement Options

As with air quality management, congestion management is an objective that is imperfectly addressed by fuel taxes. In addition, congestion management needs differentiation to be more elevated in urban areas, if and when these are more polluted and/or congested.[14] Public transport policies, of course, assist in both the geographical and time dimensions. Ideally, congestion fees should differentiate not merely by time of day and a cordon or area (both of which are possible in toll rings and demonstrated in London, Stockholm, and Trondheim), but also by the actual traffic and pollution situation. Future schemes and technology

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[14] Parry and Strand (2011) provided a formula and an application to Chile, including peak and off-peak conditions, and the share of driving occurring in urban areas. Stockholm and London are well-studied, successful cases of congestion fees internationally (see, for instance, Leape 2006). Since economists have long advocated road and congestion charges (Vickrey 1969), analysts of the Stockholm and London examples have emphasized not only the substantial net benefits, but also explanations of their political success.

developments, including global positioning system (GPS) monitoring and seat-sharing systems, will certainly expand the possibilities and further raise the net benefits of congestion charges. Utilization of present technologies is, nevertheless, much below what is possible. Toll rings in Norway, for example, would be suitable to charge less from less polluting vehicles, uncongested hours, and in less polluted months, but all these are neglected.

Road wear is proportional to vehicle usage (vkm, say, or tkm) but depends heavily on such vehicle characteristics as axel pressure (weight) and studded tires. Vehicle characteristics can be and are charged for in taxation—at registration, new sales and annually—and should then ideally include an odometer-based mileage fee. Germany's truck toll, motivated in part by the many foreign vehicles passing through or operating in the country, combines vehicle characteristics, such as axel load and pollution class in a distance-based charging system.

Agglomeration benefits exist when activities similar to each other benefit from being located next to each other, as with a garment district. Agglomeration benefits may not be fully internalized in themselves, thus providing a rationale for zoning and/or subsidies. Since agglomeration benefits may involve commuting requirements, they may be relevant to transport policy (see Lucas and Rossi-Hansberg 2002, Rossi-Hansberg 2004, Eskeland and Lall 2015).

Accidents, and associated accident prone behaviours, could in principle be internalized to some extent through insurance premiums and liability (e.g., pay-as-you-drive insurance premiums). Governments will want to do more than this, not only because of the public good nature of an accident-lean traffic system, but also because certain measures (police presence, fines and infrastructure, including design) are suited for government.[15]

Road transport is particularly dominant in domestic transport. Nation states are able to intervene with ease and good justification for within-nation public goods. Also when attempting GHG mitigation in the roads sector, policies will yield no or very little direct carbon leakage, since transport work is not very mobile across country borders. Nevertheless, transit traffic as well as foreign registered vehicles in domestic traffic may represent an issue, and the German example with foreign trucks paying fees for road use shows that solutions can be found for such problems.[16]

Aviation and maritime shipping activities are, in contrast, subject to carbon leakage in ways that influence policies, and for two main reasons. First, visitors and cargo might choose alternative destinations and routes if flying or sailing

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[15] Kopits and Cropper (2008) for an analysis of traffic fatality rates internationally (rising and scheduled to rise, globally, but falling per vehicle kilometre). Apart from vehicle numbers and kilometres driven, the literature emphasizes quality of cars and infrastructure, exposure of pedestrians, driver age, and education, police presence and enforcement, alcohol and (other) substance abuse. Kolstad *et al.* (1990) compares liability ex-post to regulation ex-ante.

[16] Available at <http://roadpricing.blogspot.no/2014/04/germany-expands-road-pricing-part-1.html>

into or via a country becomes costly. Second, small ports and states wanting to be visited by cleaner ships or planes have less of a chance to influence emissions if acting alone, though clean ship rebates in ports are starting to be seen. Jones *et al*. (2013) found the absence of fees in international aviation and shipping highly anomalous, waiting for international coordination.

For sectors exposed to carbon leakage, such as aviation and shipping, we believe the power of port states and port states in coordination (such as the United States, Europe) is substantial, and may be underestimated. The potential for fuel (and emission) efficiency—intermodally, and in size, speed, slenderness, and technological advance—will probably be sought with multiple instruments, and the role of emission and fuel taxes may be slowed by lagging transnational coordination.

Important environmental problems range from local, spontaneous challenges (e.g., accidents, spills or carbon monoxide problems in a dense neighbourhood) to global, intergenerational challenges (e.g., GHG emissions). One can envision a city or nation acting on air quality with policy instruments that effectively compel automobile companies to reduce emissions of dust particles, or national authorities intervening to reduce nitrogen oxides and sulphur according due to national priorities, or national authorities acting according to international agreements for public goods that are transnational in nature. Control of nitrogen oxides (NOx) and sulphur oxides (SOx) in northern Europe are examples of pollution problems that have been addressed at a regional, transnational level. A good example of a problem that has been dealt with at a global level, is ozone depleting substances through the Montreal Protocol.

Sulphur emissions are now addressed through emission controlled areas (ECA) for maritime shipping covering north western Europe on the one hand and Canada and USA on the other. One should not be surprised that such trans-state initiatives for pollution control from a difficult sector, such as shipping, are first seen in regions that are dense in population, education, wealth, and maritime traffic.

An example of coordination challenges that may then occur is when ECAs combat regional problems in ways that exacerbate global climate problems, as when pressure on NOx and SOx emissions reduces combustion efficiency and raises warming by removing reflective aerosols. Such examples serve to illustrate the need to accelerate the global treaty and policy developments.

Indeed, one may expect a general tendency that institutions and policies will develop sequentially, first to address local problems, then regional and national, and finally global and intergenerational. It will then vary by case, whether what has started at one level facilitates what needs to be done on another, or has actually exposed a conflict between goals, between solutions. But in both cases, the need for coordination at higher levels will show a tendency to become more important over time.

Hurdles

Raising fuel taxes often faces political hurdles, and important among them is the transfer of income from households and firms to government. Environmental tax reforms (as well as environmental policy reform in general) require clarity and communication on:

- The rationale underpinning the provision of public goods, such as air quality and its public health benefits, road space, safety, and greenhouse gas mitigation; and
- The use of the proceeds.

With regard to the latter point, decisions will have to be made on whether fuel taxes should be used to operate environmental services and programmes, to reduce other taxes that are costly in efficiency terms (e.g., labour income and business taxes), or to support government services (e.g., schooling, crime prevention, and infrastructure development) and vulnerable groups (e.g., social insurance programmes).

There are other obstacles to environmental improvements. Some are specific to fiscal instruments and fuel taxes in particular. One example is the difficulties that are encountered in levying CO_2 taxes or fuel taxes on international aviation and maritime shipping (Keen *et al*. 2013). Understanding the kinds of sectoral responses one would want to see continues to be valuable. For example, it is important to understand that fuel efficiency standards for various categories of ships—emphasized by the International Maritime Organization—will miss very important opportunities if implemented without polices that can stimulate ships and shipments both to slow down and to move up in lot size or towards more slender vessels. Fuel taxes or emission taxes would stimulate both.

Our analysis should not be seen mostly or only as an advocacy of taxes on emissions and fuels; rather it should be seen as a demonstration that the use of imperfect instruments in environmental protection (fuel taxes being an important case in point) requires knowledge of the polluting sector because it requires delicate combinations of policy instruments. The use of imperfect but powerful instruments such as fuel taxes also requires some decisiveness and commitment to simplicity and practicality, prioritization, and communication.

Acknowledgements

Annexures

Annexure 1: Domestic Transport's Share in Domestic Energy Use

	GDP/capita (purchasing power parity)	Transport share of energy consumption (%)	Domestic aviation (%)	Road transport (%)	Rail (%)	Domestic navigation (%)
Democratic Republic of the Congo	712	2.5	0.0	2.5	0.0	0.0
Mozambique	977	7.9	0.0	7.3	0.0	0.7
Eritrea	1,139	9.9	0.0	9.9	0.0	0.0
Ethiopia	1,171	2.9	0.0	2.9	0.0	0.0
Togo	1,273	19.2	0.0	19.2	0.0	0.0
Haiti	1,580	4.8	0.0	4.8	0.0	0.0
United Republic of Tanzania	1,596	5.9	0.0	5.9	0.0	0.0
Zimbabwe	1,626	5.0	0.0	4.6	0.4	0.0
Benin	1,643	33.4	0.0	33.4	0.0	0.0
Nepal	2,044	6.2	0.0	6.2	0.0	0.0
Senegal	2,163	29.7	0.5	27.8	0.0	1.4
Tajikistan	2,212	5.3	0.0	5.2	0.0	0.0
Kenya	2,585	11.8	0.0	11.2	0.5	0.0
Bangladesh	2,589	12.6	0.0	10.2	1.0	1.4
Cameroon	2,610	15.5	0.3	14.8	0.3	0.1
Cambodia	2,646	14.6	0.2	12.2	1.7	0.5
Côte d'Ivoire	2,706	8.6	0.0	7.2	0.6	0.8
Kyrgyzstan	2,921	36.3	0.0	36.1	0.2	0.0
Ghana	3,446	23.1	0.0	21.3	0.8	0.9
Sudan	3,524	22.6	0.0	22.3	0.2	0.0
Zambia	3,557	2.7	0.0	2.6	0.0	0.0
Yemen	3,761	36.7	0.0	36.7	0.0	0.0
Republic of Moldova	4,179	15.7	0.0	15.1	0.6	0.0
Nicaragua	4,215	26.6	0.0	26.6	0.0	0.0
Pakistan	4,261	17.7	0.9	16.4	0.3	0.0

	GDP/capita (purchasing power parity)	Transport share of energy consumption (%)	Domestic aviation (%)	Road transport (%)	Rail (%)	Domestic navigation (%)
Honduras	4,345	25.5	0.0	25.5	0.0	0.0
Uzbekistan	4,412	5.0	0.4	4.4	0.2	0.0
Vietnam	4,717	21.5	0.4	20.9	0.0	0.2
India	4,883	11.9	0.4	10.6	0.8	0.2
Nigeria	5,217	7.5	0.0	7.5	0.0	0.0
Plurinational State of Bolivia	5,462	33.3	1.6	31.7	0.0	0.0
Congo	5,569	43.7	1.3	42.4	0.0	0.0
Philippines	5,721	33.7	1.3	29.5	0.0	2.8
Georgia	6,322	26.5	0.6	24.8	1.1	0.0
Morocco	6,698	36.1	0.0	35.9	0.2	0.0
Armenia	6,812	25.8	0.0	25.5	0.3	0.0
Guatemala	6 957	21.3	0.0	21.3	0.0	0.0
Angola	7,094	21.2	2.2	18.8	0.0	0.1
Paraguay	7,186	34.9	0.0	34.9	0.0	0.0
El Salvador	7,352	39.9	0.0	39.9	0.0	0.0
Mongolia	7,495	20.8	0.0	14.7	6.2	0.0
Sri Lanka	8,112	26.7	0.1	26.0	0.6	0.0
Kosovo	8,223	24.9	0.0	24.8	0.1	0.0
Ukraine	8,295	12.0	0.0	10.8	1.1	0.1
Indonesia	8,438	24.7	1.4	22.0	0.0	1.3
Jamaica	8,485	24.2	0.0	24.2	0.0	0.0
Namibia	8,715	39.1	0.6	36.8	0.0	1.7
Bosnia, Herzegovina	9,248	33.7	0.0	33.4	0.4	0.0
Ecuador	9,882	54.1	0.0	45.9	0.0	8.1
Albania	9,897	39.6	0.0	38.4	0.2	1.0
China	10,041	12.8	0.7	10.4	0.7	1.0
Tunisia	10,235	27.2	0.0	27.2	0.1	0.0
Peru	10,429	35.0	0.0	34.8	0.0	0.3
Egypt	10,629	25.9	1.2	24.0	0.0	0.7

	GDP/capita (purchasing power parity)	Transport share of energy consumption (%)	Domestic aviation (%)	Road transport (%)	Rail (%)	Domestic navigation (%)
Dominican Republic	11,264	31.3	0.0	31.3	0.0	0.0
Jordan	11,292	38.0	0.1	37.8	0.0	0.0
Colombia	11,332	32.4	0.1	31.1	0.2	1.1
Libya	11,358	50.0	0.0	50.0	0.0	0.0
Turkmenistan	11,361	8.1	0.0	8.0	0.1	0.0
South Africa	11,910	24.7	1.5	22.7	0.5	0.0
Serbia	12,572	20.2	0.0	18.1	1.9	0.2
Algeria	12,606	37.3	0.0	37.1	0.2	0.0
Costa Rica	12,694	44.9	0.2	44.7	0.0	0.1
Thailand	12,798	23.3	0.0	23.1	0.1	0.2
Iraq	13,248	50.3	0.0	50.3	0.0	0.0
Botswana	14,051	35.3	0.1	34.7	0.5	0.0
Montenegro	14,069	25.9	0.0	25.6	0.1	0.1
Brazil	14,301	33.9	1.7	31.1	0.5	0.6
Bulgaria	15,278	26.6	0.2	26.0	0.4	0.0
Azerbaijan	15,754	26.3	1.4	23.9	0.5	0.5
Mexico	15,887	44.8	0.0	43.5	0.6	0.7
Iran (Islamic Republic)	15,970	24.4	0.0	24.4	0.0	0.0
Panama	16,254	38.3	0.0	38.3	0.0	0.0
Lebanon	16,431	45.9	0.0	45.9	0.0	0.0
Belarus	16,603	16.6	0.0	15.2	1.4	0.0
Romania	17,363	20.8	0.5	18.8	1.2	0.2
Gabon	17,488	8.7	0.0	8.7	0.0	0.0
Uruguay	17,645	29.2	0.1	29.1	0.0	0.0
Turkey	17,998	18.0	0.4	16.5	0.2	0.9
Cuba	18,796	8.1	0.0	7.0	0.4	0.8
Latvia	19,516	26.7	0.0	24.6	2.1	0.1
Chile	20,154	28.9	1.3	26.1	0.3	1.2
Croatia	20,571	28.9	0.9	26.8	0.6	0.6
Kazakhstan	20,772	9.8	0.2	9.1	0.5	0.0

Contd...

	GDP/capita (purchasing power parity)	Transport share of energy consumption (%)	Domestic aviation (%)	Road transport (%)	Rail (%)	Domestic navigation (%)
Malaysia	21,096	32.2	0.0	32.1	0.0	0.1
Poland	22,110	24.7	0.0	24.2	0.5	0.0
Lithuania	22,322	24.5	0.0	23.3	1.1	0.1
Russian Federation	22,570	13.5	1.4	10.5	1.3	0.3
Hungary	22,737	22.6	0.0	21.8	0.8	0.0
Estonia	23,580	26.1	0.0	24.7	1.2	0.2
Slovakia	25,560	19.2	0.0	18.9	0.4	0.0
Portugal	26,588	33.1	0.8	31.3	0.3	0.6
Greece	26,944	35.3	1.2	31.3	0.1	2.7
Malta	28,178	44.1	0.0	44.1	0.0	0.0
Czech Republic	28,455	22.3	0.2	21.4	0.7	0.0
Slovenia	28,715	37.6	0.0	37.1	0.5	0.0
Trinidad and Tobago	28,743	6.2	0.0	6.2	0.0	0.0
Israel	30,159	26.9	0.0	26.9	0.0	0.0
Cyprus	30,260	44.6	0.0	44.6	0.0	0.0
Republic of Korea	31,327	18.3	0.3	17.6	0.2	0.2
New Zealand	31,683	36.1	2.8	32.3	0.4	0.7
Spain	32,606	36.1	2.4	31.9	0.9	0.9
Japan	34,316	24.1	1.0	21.5	0.6	1.0
Italy	35,917	29.9	0.6	28.1	0.3	0.8
United Kingdom	36,629	31.9	0.6	29.4	0.8	1.2
France	37,312	28.5	0.5	27.0	0.6	0.3
Iceland	39,911	9.3	0.2	8.8	0.0	0.2
Bahrain	40,083	19.6	0.5	19.1	0.0	0.0
Finland	40,280	17.2	0.5	15.6	0.4	0.7
Belgium	40,997	21.5	0.0	20.6	0.4	0.4
Canada	41,333	27.5	1.6	24.1	1.0	0.8
Australia	41,706	37.7	3.3	31.9	1.4	1.1
Germany	42,381	24.3	0.3	23.0	0.8	0.1
Denmark	42,803	29.8	0.2	27.6	0.8	1.1

Contd...

	GDP/capita (purchasing power parity)	Transport share of energy consumption (%)	Domestic aviation (%)	Road transport (%)	Rail (%)	Domestic navigation (%)
Sweden	43,875	25.1	0.5	23.5	0.7	0.4
Austria	44,240	28.5	0.1	27.6	0.7	0.0
Ireland	45,176	34.5	0.1	33.9	0.4	0.2
The Netherlands	46,309	19.5	0.1	18.8	0.3	0.3
Oman	46,430	16.9	0.0	16.9	0.0	0.0
Saudi Arabia	49 230	31.2	0.6	30.6	0.0	0.0
United States	49,803	38.1	3.3	33.7	0.8	0.3
Hong Kong, China	50,086	20.8	0.0	20.8	0.0	0.0
Switzerland	54,215	30.6	0.3	28.8	1.4	0.0
United Arab Emirates	56,377	21.3	1.2	20.1	0.0	0.0
Norway	61,896	23.1	1.7	16.7	0.3	4.3
Brunei Darussalam	71,991	24.8	0.0	24.8	0.0	0.0
Singapore	74,594	12.0	0.0	11.2	0.8	0.0
Kuwait	82,475	27.0	0.0	27.0	0.0	0.0
Luxembourg	90,297	59.7	0.0	59.3	0.3	0.0
Qatar	133,734	33.1	0.0	33.1	0.0	0.0

Source: IEA (2014)

Annexure 2: Cargo freight: Speed, Size, Costs, and Emissions

Carrier		Boeing 747 Freighter (1)	Truck & Trailer (2)	Rail (2)	6500 TERU container vessel (1)	18 000 TEU container vessel (1)	Dry Bulk Panamax 80 000 dwt (1)	Dry Bulk Capesize 180 000 dwt (1)
New built price 2014	MUSD	180	0.2	40	80	190	30	50
Annual depr.& financial cost	MUSD	14.4	0.04	4.0	6.4	15.2	2.4	4.0
Annual operational cost	MUSD	18.0	0.14	3.6	3.2	7.6	1.2	2.0
Daily TC-equivalent	USD	93 000	500	21700	27 000	65 000	10 000	17 000
Fuel cost per ton	USD	950	1000	1 000	630	630	630	630
Cargo – weight capacity	ton	115	25	1 500	63 000	160 000	76 000	170 000
Cargo – volume capacity	m³	857	70	3 000	162 500	450 000		
Utilization of weight capacity	%	50%	50%	50%	50%	50%	62%	55%
Utilization of volume capacity	%	75%	75%	75%	65%	65%		
Average volume payload	m³	640	53	2 250	106 000	293 000		
Average weight payload	ton	57.5	13	750	32 000	80 000	47 000	93 000
Distance Asia – Europe	km/h	10 000	10 000	10 000	20 000	20 000	20 000	20 000
Voyage speed	km/h	850	60	60	39	39	22	22
CO_2 Emissions per ton km	Gram/ton km	550	85	50	18	13	4	3
CO_2 Emissions per cubic km	Gram/m³ km	50	21	17	5	4		
Cost per 10 000 ton km		2865	590	444	55	45	13	11
Fuel cost per 10 000 km		1652	275	161	41	30	8	6
TC cost in percentage per ton		42%	53%	64%	25%	33%	39%	43%
Fuel cost in percentage per ton		58%	47%	36%	75%	67%	61%	57%

Sources: Lindstad, Sandaas & Sverre (2014), Lindstad, Asbjørnslett & Pedersen (2012), and author's own calculation.

Abbreviations: MUSD = millions of US dollars; TEU = twenty foot equivalent unit, dwt= dead weight tonnage; TC= time charter

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ARTICLE

A Conceptual Framework for Measuring the Effectiveness of Green Fiscal Reforms

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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'

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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)
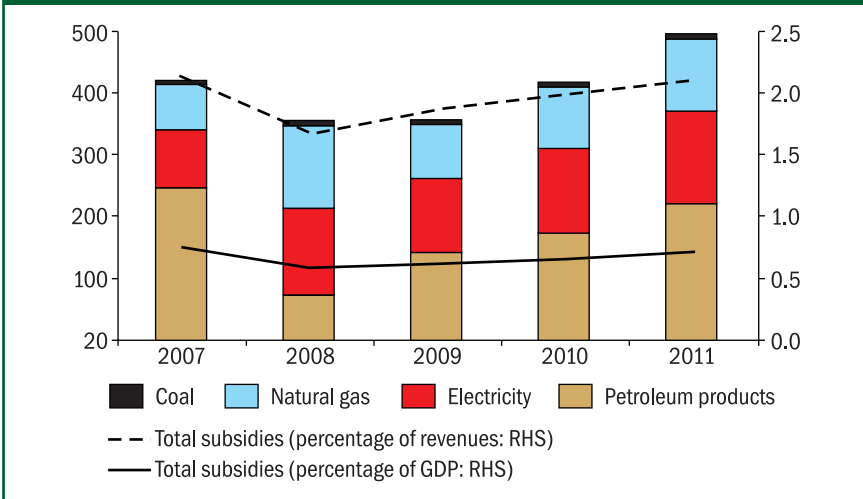
Source: Clements et al. (2013)

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

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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

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[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

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[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,

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[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

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[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.

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[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

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[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
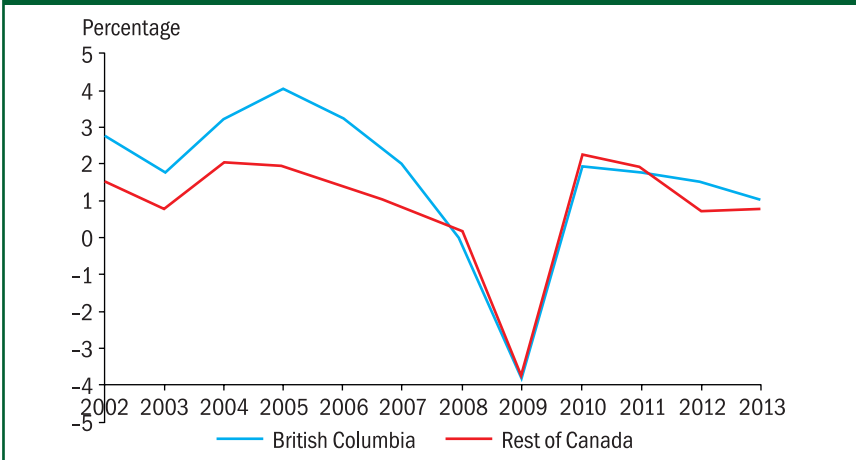
1999 through 2013. Table 3 reports the regression results. The first column reports results from a regression on the post-2007 indicator variable alone interacted with an indicator variable for British Columbia. The coefficient on the interaction term indicates a sharp negative impact of 8 percentage 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,

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[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

Terajoules per capita

Fiscal year
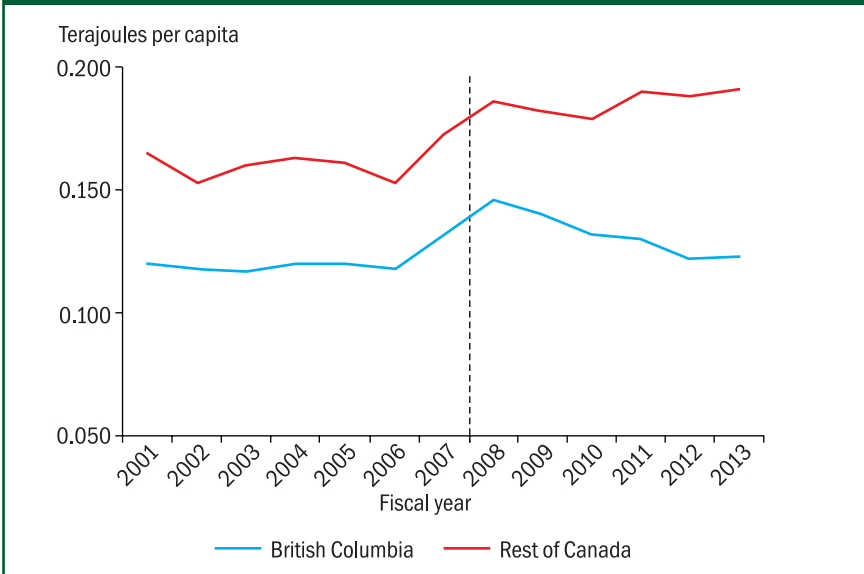
— British Columbia   — Rest of Canada

Figure 4: Public attitudes towards the British Columbia carbon tax

Percentage

—○— Support   —■— Oppose
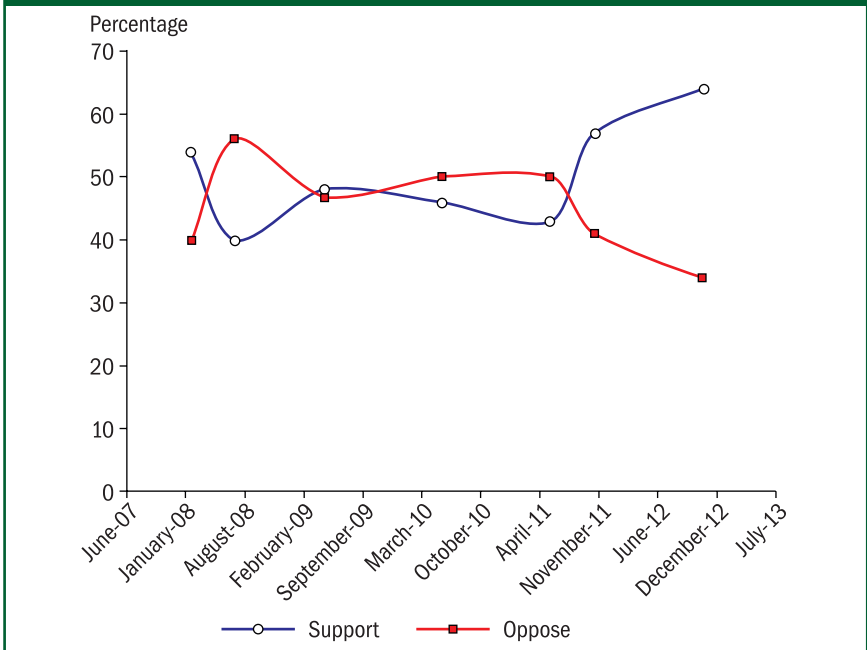
By FY 2015 (projected), those payments account for about 45 per cent of carbon tax revenue. Meanwhile, business tax benefits rose from 33 per cent of carbon tax revenue in 2009 to over 70 per cent in the FY 2015 budget.[23] Finally, based on the analysis of Clements *et al*. (2013), it does not appear 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

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[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).

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[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]

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[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

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[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

US$ per litre
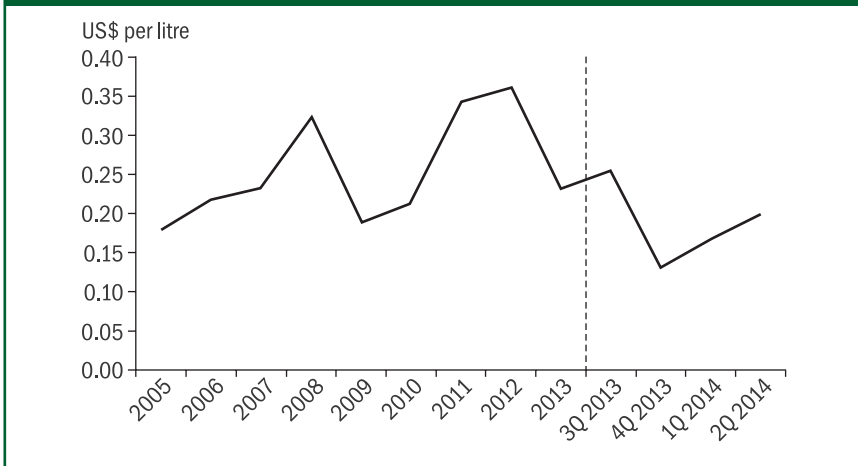
price reforms and carbon tax raise the price of energy, other tax reforms are targeted more at higher income households (higher tax rates on top brackets, for example), illustrating the shared burden of revenue raising tax increases across the income distribution. A complete assessment would consider 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

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[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 $(\rho\text{-}r)/\rho$, 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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Choice and Design of Fiscal Policy Instruments to Accelerate Innovation in Renewable Energy

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Abstract: Many of the most promising low-carbon technologies currently have higher costs than the fossil-fuel based technologies. It is only through incremental learning from research, development, and deployment that these costs can be reduced. Government intervention in the innovation process through fiscal policy instruments can be useful to accelerate this process, and catalyse early adoption. This paper reviews the best practices associated with the choice and design of such instruments and identifies the main lessons learned from their implementation in the case of renewable energy. The paper outlines an analytical framework which identifies the characteristics of drivers and barriers in innovation of RETs; sequencing of various steps involved in promoting innovation; and various policy tools in the context of each barrier that will help accelerate the process and enhance the outcomes. The paper notes that the issue of design and implementation of fiscal policy measures for RE technologies is complex and requires a nuanced, case by case approach, however, some useful broad conclusions can be drawn on the lessons learnt from these programmes for future policy design and implementation.

Keywords: Fiscal instruments, low-carbon technology continuum, renewable energy policy framework, price and quantity based instruments, market failures and barriers

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Introduction

Achieving the steep climate change mitigation targets across the world would require both deployment of known 'low-carbon' energy technologies and invention of new technologies (IEA 2011). The magnitude and pace of technological transformation required in this context is highly challenging and unprecedented (IPCC AR5, WGIII). At least two key challenges differentiate this with other cycles of technological transformations, in general as well as specifically in the energy sector, than those encountered in the past—the need for systematically internalizing the externalities (social and environmental costs) and the huge upfront investment cost of technologies and supporting infrastructure, e.g., power lines to connect renewable plants, pipelines for carbon capture and storage (CCS). These challenges are compounded by the absence of markets that could signal the real scarcities and the global scale of impacts that deems it necessary to have a faster pace of much needed innovation (Altenburg *et al.* 2014, Goulder and Parry 2008, Narayanamurti *et al.* 2011).

The emissions control policies (e.g., market-based—getting prices right—approaches, such as emissions pricing, emissions trading, environmental fiscal reforms) have been argued to be efficient (cost minimizing) solutions[3] to achieving GHG emissions reduction. These could potentially work as an incentive to technological innovation in low-carbon energy sector and also to bring changes in consumer behaviour. However, theoretical and empirical literature suggests that government intervention towards the innovation process through additional policies to promote low-carbon energy technology is necessary because environmental externalities are not the only market failure inherent in low-carbon energy technologies.

The energy sector is also affected by market failures associated with technology innovation and diffusion. The difficulty that industry faces in fully appropriating the benefits of research, development, and deployment (RD&D) and preventing competitors from capturing some of the benefits has been thoroughly explored in economics and business literature and represents one of the main justifications for government support of R&D (Jaffe *et al.* 2005).

Also, since emissions control policies provide innovation incentives only indirectly (by emissions pricing or by raising the costs of conventional production methods through direct regulation) these may be insufficient to foster the necessary investment in RD&D of new low-carbon energy technologies (Cohen and Noll 1991) as well as to stimulate the dynamic learning process in known technologies to bring down the costs to an economically competitive level (Griliches 1992, Jones and Williams 1998, Levin *et al.* 1988).

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[3] The economic efficiency argument favouring this approach is that it does not necessarily distinguish between the potential solutions—e.g., renewable energy, energy efficiency, CCS, etc.

Many of the most promising low-carbon technologies currently have higher costs than the fossil-fuel based technologies. It is only through incremental learning from RD&D that these costs can be reduced (IEA 2010). Government intervention in the innovation process can be useful to accelerate this process beyond what would be expected from market forces alone, and catalyse early adoption.

Consequently, countries across the world (both developed and developing) have implemented a wide range of complementary policy instruments, including the fiscal instruments, to promote RD&D of low-carbon energy technologies (Azuella and Barroso 2011). This, however, has been achieved with varying levels of success and with both direct and indirect costs (Gillingham and Sweeney 2012). A snapshot of these instruments by stages of innovation is presented in Figure 2 later in the article. Public policy instruments by nature put pressure on governments' budgets and thus, in turn, have implications for their ability to sustain funding support to investment flows in low-carbon energy sector (UNEP 2011).This is a serious concern and calls for efficiency in designing and implementing these instruments.

Against this background, this paper reviews the best practices associated with the choice and design of such instruments and identifies the main lessons learned from their implementation in the case of renewable energy. The remainder of the paper outlines an analytical framework which identifies: (i) the characteristics of drivers and barriers in innovation of RETs; (ii) sequencing of various steps involved in promoting innovation; and (iii) various direct and indirect instruments helping enable Renewable Energy (RE) and policies that help in accelerating the process and enhancing the outcomes. It reviews the different policy instruments deployed as support to RE technologies and provides useful insights on the lessons learnt from these programmes for future policy design and implementation. It also provides key lessons from some country cases on best practices and experience with specific instruments.

Choice and Design of Complementary Fiscal Policy Instruments (CFPI)

A number of domestic and international considerations both inform as well as influence the choice and design of CFPI in a country. The entire process from identifying the appropriate instrument to design and implementation of CFPI is a step-by-step process and at each step a great deal of ground work including engagement with stakeholders is required (Figure 1).

Setting the Stage: Drivers of Promoting Low-carbon Energy Technologies

Six drivers/energy development goals that, either alone or in combination, commonly shape energy development pathways, are identified (IRENA 2013) in Table 1. Broadly, these would guide the direction of the low-carbon energy technology policy as well as the choice of public policy instruments in promoting

Figure 1: Choice and design of policies

A number of considerations inform and influence the choice and design thus rendering identifying an appropriate instrument a substantial challenge

The entire process from planning to development of CFPI can be divided into

Setting the stage

Basic guiding principles in actual design and implementation stage

Drivers of promoting low-carbon energy technologies.

Articulating an energy RD&D policy framework to make it sustainable and attractive for all stakeholders; and identifying the source of funds comensurate with energy policy goals.

Clearly identifying the barriers faced by different technologies.

Choice of policies

- Should be tailored to the national objectives and ground realities (institutions, governance, market conditions, etc.)
- Policy should be firm so as to win the trust and confidence of the investor; at the same time be flexible to adapt to changes in policy signals in a dynamic market.
- Policy sequencing is as important as choice of appropriate policy. Thus, it is essential that necessary preconditions are met before the policy instruments are introduced.

Design of policies

- Policy design is a dynamic process
- To maximize the policy performance, policy design should be in consonance with other critical factors on the ground even at the cost of being less than theoretically sound.

RD&D of low-carbon energy technologies. The choice of one or more of these goals and their relative weights will depend upon specific characteristics (e.g., demand/supply of energy, technical capacity, market structure, and existing institutions and regulations) of different countries. An analytical framework which identifies: (i) general characteristics of each driver/goal; (ii) various steps/functions involved in promoting innovation in the context of each driver/goal; and (iii) examples of policy tools that will help accelerate the process and enhance the outcomes is presented in Table 1.While the processes and end results appear to be significantly different across various national contexts, the framework is expected to be relevant to policymakers in varied settings.

Need for an Energy RD&D Policy Framework

A particularly challenging issue is how to identify which technologies need to be promoted, underscoring the need for a comprehensive energy RD&D policy

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Box 1: Considerations for comprehensive energy RD&D policy framework

An energy RD&D policy framework based on good practices:
- Coherent energy RD&D strategy and priorities
- Adequate government RD&D funding and policy support
- Coordinated energy RD&D governance
- Strong collaborative approach, engaging industry through public private partnerships (PPPs)
- Effective RD&D monitoring and evaluation
- Strategic international collaboration

Source: IEA (2011)

Germany's integrated climate and energy policy, and RE Technologies planning
- Germany has set a target of 30 per cent RE by 2020 and 50 per cent by 2030.
- The National RE Action Plan (NREAP) projected that it would achieve 38.6 per cent RE by 2020 (projection of how the market might grow).
- To meet national targets and NREAP trajectories, Germany projects that the two fastest growing RE technologies will be wind and PV during 2010–20.
- Wind will, therefore, contribute 48 per cent of total RE in 2020 and PV will account for 19 per cent.
- Projections are made for both total installed capacity as well as annual additions. These details enable the government to design strategies for volume management.

Source: Based on Fulton and Mellquist (2011)

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framework (Box 1)[4]. Such an exercise can be used both as a guide by countries to help draw clear linkages of policy instruments with the targets as well as assist in monitoring the impact of policy instruments. It can also help improve the confidence and trust of potential investors in the reliability of targets and policy ambitions, and thus boost the pace of RD&D of low-carbon energy technologies (IEA 2011, Pandey *et al.* 2014, Kammen *et al.* 2004).

In addition, a strong commitment from governments to make RD&D a sustainable and attractive proposition for all stakeholders is important. This is achieved when clearly defined energy production goals and realistic targets—and not *ad-hoc* programmatic or fiscal interventions—guide the medium-term to long-term direction of the energy innovation portfolio (Pandey *et al.* 2014, Kammen *et al.* 2004, IEA 2011, Fulton and Mellquist 2011). For example, countries with small grid capacities may need to set targets which would reflect constrained grid capacities and, hence, may initially promote distributed generation over centralized generation. Similarly, in the case of both wind and photovoltaic (PV) technology, the promotion of power storage technologies would dramatically enhance their effectiveness. Further, characterization of technologies by the

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4 For a review of energy RD&D priorities in select countries based on announced technology programmes/strategies, see Pandey and Mehra (2015).

Table 1: Characteristics of drivers, functional steps, and examples of policy tools

Drivers	Functions						
	Creating and Sharing New Knowledge	Building Competence and Human Capital	Knowledge Diffusion/Creating Collaborative Networks	Developing Infrastructure	Providing Finance	Establishing Governance and the Regulatory Environment	Creating Markets
				Policy Tools			
Energy security (reducing dependence on vulnerable energy supplies)	Support studies to quantify value of energy security; high-resolution RE resource assessments; Grid modelling to estimate performance under varying penetration levels of RETs.	Subsidies and incentives for education and training in power sector engineering, Project development, finance, engineering, and construction.	Joining international cooperation seeking energy security; To identify gaps and prospects regarding energy use and efficiency.	Facilitating huge RET deployment via investment in grid infrastructure, roads, rail, and ports.	Project finance loan guarantees; 'Green' banks or revolving funds; Public bonding support for infrastructure.	Intellectual property protection and legal recourse for joint ventures; To improve investment climate; Specific and credible energy efficiency and renewable energy targets; Utility-scale interconnection standards.	Feed-in tariffs; Renewable Portfolio Standards; Government/ public procurement.

Drivers	Functions						
	Creating and Sharing New Knowledge	Building Competence and Human Capital	Knowledge Diffusion/Creating Collaborative Networks	Developing Infrastructure	Providing Finance	Establishing Governance and the Regulatory Environment	Creating Markets
				Policy Tools			
Energy access (reducing energy poverty and expanding access to secure, reliable, and low-cost energy)	High-resolution RET resource assessments in low energy access areas; Studies to quantify market size of low- and middle-income consumers; Opportunity and gap analysis of RET deployment in off-grid settings; Analysis of future grid modernization pathways.	Subsidies and incentives for education and training in off-grid system design and equipment maintenance, micro-grid design and engineering, power system planning, entrepreneurship, marketing, micro-finance.	Joining international cooperation for expanding energy access; Supporting community groups and entrepreneurs for RET deployment; Supporting micro-finance networks.	Enabling grid development in high-priority areas; Improving tele-communications coverage for novel smart grid applications.	Support energy technology micro-finance models; Removing barriers to Traditional and novel finance pathways.	Setting specific energy access targets; Establishing micro-grid interconnection standards, Bolstering property rights for low-income citizens; Removing barriers to new business models, e.g., solar system leasing.	Feed-in tariffs extending to micro-grid operators and low-income citizens; Public procurement of RET systems in government-subsidized housing.

Functions							
				Policy Tools			
Drivers	Creating and Sharing New Knowledge	Building Competence and Human Capital	Knowledge Diffusion/Creating Collaborative Networks	Developing Infrastructure	Providing Finance	Establishing Governance and the Regulatory Environment	Creating Markets
Cost (reducing exposure to persistently costly energy services)	High-resolution RET resource assessments; Energy road-mapping and System analyses; Grid capacity studies.	Subsidies and incentives for education and training in off-grid system design and RET equipment maintenance, micro-grid design and engineering, power system planning; Biofuels production, energy. efficiency, entrepreneurship, marketing, micro-finance.	Initiating international cooperation; Supporting community groups for energy access and towards micro-finance networks.	Grid moderniza-tion; Vehicle electrification infrastruc-ture; Biomass logistics and processing infrastruc-ture.	Project finance loan guarantees; Alliance with international bodies to support financing and insurance of RET systems; Support for energy technology micro-finance models; Removing barriers to novel finance pathways.	Establishing distributed generation and micro-grid interconnection standards; Designating RET project development areas; Setting energy efficiency standards; Removing barriers to novel business models, such as energy performance contracting or solar system leasing.	Renewable Portfolio Standards; Feed-in tariffs; Energy efficiency obligations; Public procurement of RET systems in government buildings; Incentives for alternative fuel vehicles and energy efficiency.

Drivers	Functions						
	Creating and Sharing New Knowledge	Building Competence and Human Capital	Knowledge Diffusion/Creating Collaborative Networks	Developing Infrastructure	Providing Finance	Establishing Governance and the Regulatory Environment	Creating Markets
				Policy Tools			
Competitive-ness (Trade; achieving greater competitive-ness in international energy markets)	Detailed international market and supply chain studies; Detailed analysis of domestic industrial and service capabilities.	Subsidies and incentives for education and training in international business, foreign languages.	Brokering international joint ventures; International conferences to showcase indigenous capabilities; Supporting trade missions to markets; Participation in multilateral trade bodies.	Less critical in this policy setting.	Credit guarantees to improve credit-worthiness of domestic firms in joint ventures.	Intellectual property protection and legal infrastructure to support joint ventures or international collaboration.	Less critical in this policy setting.
				Policy Tools			
Modernization (modernizing national energy systems)	High-resolution RET resource assessments; Energy road-mapping and associated System analyses; Grid capacity and expansion studies.	Subsidies and incentives for education and training in power sector engineering, RE resource assessment, project development and system engineering, finance, and international business.	Hosting conferences to showcase investment opportunities; Brokering International joint ventures; Supporting reverse trade missions to firms.	Transmission expansion tailored to RE resources; Enhancements to shipping and Logistics infrastructure.	'Green' banks or other credit facilities; Project finance loan guarantees; Credit guarantees or other instruments to improve credit-worthiness of domestic firms in joint ventures.	Grid interconnection standards; Establishment of priority transmission zones; Enhancements to IPR protections and determinants of investment climate.	Feed-in tariffs; Renewable Portfolio Standards; Government/public procurement.

	Functions						
Drivers	Creating and Sharing New Knowledge	Building Competence and Human Capital	Knowledge Diffusion/Creating Collaborative Networks	Developing Infrastructure	Providing Finance	Establishing Governance and the Regulatory Environment	Creating Markets
			Policy Tools				
GHG emissions reduction, focussing on reducing the GHGs and impacts on environment	Subsidies for basic research stimulate international technology and knowledge flows.	Subsidies and incentives for education and training in power sector engineering, project development, finance, engineering, and construction.	Joining international cooperation seeking GHG emission reduction; to identify gaps and prospects regarding energy use and efficiency.	Facilitating RET deployment via investment in grid infrastructure, roads, rail, and ports.	Project finance loan guarantees; 'Green' banks or revolving funds; Public bonding support for infrastructure.	Intellectual property protection and legal recourse for joint ventures; To improve investment climate; Specific and credible energy efficiency and RE targets; Utility-scale interconnection standards.	Feed-in tariffs; Renewable Portfolio Standards; Government/public procurement, carbon pricing, reforming subsidies to fossil fuel based energy.

Source: Authors' construction based on IRENA (2013)

stages of technology development can help contextualize the types of innovation activities that are possible and/or necessary to advance a given technology at a given time, and thus help determine which types of policy instruments, and the level and duration of support might be appropriate for a technology at a specific stage of risk and maturity[5].

Barriers in Development and Adoption of RE Technologies

A clear understanding of the barriers faced by different RE technologies is required to develop relevant and effective policies, although the significance of one barrier over the other may vary across the countries, technologies, organizational types of energy production (e.g., centralized vs. decentralized electricity generation)and stages of RD&D, etc. (Box 2).

The most documented market failure in the case of most technologies is the inability in fully capturing/appropriating (AP) the benefits of R&D (Goulder and Parry 2008). Empirical studies suggest that the (marginal) social return to innovation in general might be greater than the (marginal) private return (Griliches 1992, Levin *et al*. 1988, Jones and Williams 1998) implying a disincentive to the innovator/investor resulting in less than optimal investment in low-carbon technology R&D, thus justifying governmental intervention in the form of public sector research, subsidies for private R&D, tax credits, stricter patent rules, etc. While AP issue may arise in all three phases of the innovation, R&D spillovers may be much more important for very early stage R&D, rather than for technologies at the pilot or implementation stage (Nordhaus 2010).

Another market failure may arise from knowledge spillovers post pilot stage of innovation. It is usually argued that learning-by-doing (LBD)[6] is necessary in bringing down the costs of technologies. This is supported by empirical evidence (Ek and Söderholm 2010, IEA 2010), though, actual size of learning rates may vary widely for specific technologies (Lindman and Söderholm 2012). However, competitors may benefit by the external benefits of the efforts of early adopters. Consequently, investments in learning will be sub-optimal in stimulating the efficient levels of cost reduction, thus adversely affecting the pace of adoption. Empirical evidence on LBD is still limited (Lehman 2013) relying primarily on anecdotal observations (Junginger *et al*. 2005). Braun *et al*. (2010) using patent data shows that innovation in wind and solar technologies is strongly driven by knowledge spillovers. Gillingham and Bollinger (2012) also finds clear evidence of LBD at the country level and for the state of California. Empirical evidence on the extent of the LBD spillovers as well as AP is limited constraining the optimal policy design.

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[5] Feedbacks and linkages are often present between these different stages, and the boundaries between them are porous. For example, feedback from the market and from technology users during the commercialization and diffusion phases can lead to additional RD&D, driving continuous innovation (IEA 2011).

[6] LBD implies that the unit cost of a product/service decreases with increasing cumulative investment, production, and market growth.

Box 2: Barriers faced by RE technologies

- Inadequate pricing of environmental externalities (lack of/ imperfect emissions policy);
- Market failures in protecting the benefits of innovation, and external benefits of learning-by-doing*;
- Policy barriers (such as fossil fuel subsidies) which artificially reduce the competitiveness of RE technologies (in most countries, subsidies to support the production and consumption of fossil fuel-based energy are more than the subsidies to RE);
- Market failures due to imperfect information and distortions (high transaction cost of information, principal agent problems, policy co-ordination problems (Groba and Breitschopf, 2013); and
- Institutional barriers (gaps in institutional capacity to support adoption of new technologies and to monitor and enforce performance standards).

Besides, fossil fuel technologies have several other advantages, which work as barriers for RE energy, such as:
- Well-organized energy markets and delivery systems for conventional energy;
- Availability of supporting infrastructure;
- Consumers' familiarity with costs, risks, and performance;
- Financial sector understands the risks and market demand relatively better.

* Although market failures are not limited to the clean energy sector, the case for public policy support for clean energy technologies in the context of climate change mitigation is magnified due to the need for quick and decisive actions owing to the threat of climate change, and lingering uncertainties about how climate change policies will play out in terms of their impacts on relative price of RE and thus enthusiasm for innovation in RE (Fischer and Newell 2007; Montgomery and Smith 2007).

Innovation in RE technologies often has very high capital requirements, and involves long time horizon. Economies of scale can be considered a barrier or market failure if there are capital constraints or a simultaneous coordination problem. Capital constraints issue is likely to be more significant in emerging economies, which lack active investors, venture capitalists, and private equity institutions. Simultaneous coordination problems are more likely to occur in developing new infrastructure for electric or hydrogen vehicles (Gillingham and Sweeny 2010), provision of smart grids, etc.

Another potential market failure may arise from consumer myopia causing undervaluation of benefits of energy efficiency/low-carbon energy. In addition poor information and differences in cultural and social perspectives present strong resistance to adoption.

Guiding Principles Underlying the Choice and Design of Instruments

Broadly there are three important issues in choice and design of instruments: (i) identifying the appropriate instruments which would successfully address the identified barrier(s); (ii) assessing how well the instrument will perform on the identified performance criteria (e.g., target for RE, per unit cost reduction); and (iii) at what cost.

Choice of Policies

Although a number of considerations, with significant overlap among them, would determine the choice of policies, there are some general points which may be used as broad guidelines.

- The choice of appropriate policy instruments will also depend on how optimal the policies dealing with GHG emissions are. For instance, in the presence of a sub-optimal emissions policy (e.g., a carbon tax with no link to emissions reduction targets and/or covering only a few sectors of the economy) the role of CFPI can be seen as a way of correcting negative environmental externalities resulting from the use of fossil fuels and of addressing market failures in the RE technology market; whereas in the presence of an optimal emissions policy along with a clear roadmap to fossil fuel subsidy reform, the role of CFPI will be a way of achieving dynamic efficiency by stimulating technical change. (Fischer *et al.* 2012).

- Even with strong emissions policy, certain technologies that require large capital investment to scale up in order to realize cost reduction are likely to face barriers, if there are capital constraints or a simultaneous coordination problem. Therefore, a policy mix incorporating targeted regulatory, fiscal, and financial policies will need to be designed (IRENA 2013).

- Certain technologies, such as CCS may require, among others, direct support by way of grants and facilitation of international collaboration.

- Availability of empirical evidence on how knowledge spillovers contribute to hampering the development/penetration/adoption of different RE technologies is important. Status of many critical factors such as skilled manpower, R&D capability, strong supporting institutions and capacity for developing systems for price discovery (e.g., auctions, reverse bidding) significantly influence both the choice of CFPI and their impacts.

- Maturity of RE market, regulatory provisions, such as policy and financial commitment to mainstream RE and realistic targets for RE are some other important determinants of CFPIs. Whether or not policies at the sub-national levels are in agreement and consistent with national policies and goals may also impact the performance of a policy/instrument.

Design of Policies

The most important aspects of designing CFPIs are the determination of the support level and the duration of the support. This is more complex than it may seem. For instance, policy instruments that would effectively promote basic R&D are different from those needed to stimulate dynamic learning process and bring down the cost of technology. This emphasizes the need for differentiating technologies by stages of technology development and identifying specific

barriers faced (Figure 2). Further, as the RE technologies evolve, markets mature and the costs of RE lowers, the financial support to RE will need to be gradually phased out. This would require that the design of the support scheme has the built flexibility in level and timeframe to accommodate changes in the development of costs and technologies without any adverse impact on the momentum of potential innovation, pace of RE generation targets, and other drivers.

Public Policy Mechanisms Available to Policymakers

UNEP (2011) defines public finance mechanisms (PFMs) as financial commitments made by the public sector that alter the risk-reward balance of private sector investments by reducing or removing barriers to investment. It further states that while policy instruments that set the overall economic framework conditions for investment in low-carbon technology, such as FITs, carbon taxes and renewable portfolio standards (RPS) are not regarded as PFMs, their presence has a significant effect on the success of a given PFM. They should, therefore, be taken into account when evaluating the context in which successful PFMs operate.

A suggestive framework for Public Policy mechanisms through five different stages of the technology continuum is provided in Figure 2. This framework differentiates a whole basket of policy instruments between regulatory, fiscal, and financial instruments and by different stages of innovation and at the same time

Figure 2: The low-carbon technology continuum

Stage of development	R&D innovation	Demonstration	Targeted deployment	Untargeted diffusion	Market independence
Objective	Encourage innovation and entrepreneurship	Prove concept at scale	Support diversity of scalable technologies	Support resource efficiency and competitiveness	Stable and securing ongoing growth
Policy/Tax mechanisms	• National targets • National research agendas • Fiscal incentives	• Regulatory and legal framework for specific developments projects • Investment tax incentives	• Feed-in tariffs • Portfolio standards • Grid development • Targets for specific industries/resources	• Technology neutral renewable energy targets • Carbon taxes • Carbon trading • BAT requirements	With or without • Carbon taxes • Carbon trading
Example of public finance mechanism	R&D Grants Incubators Public/Private VC Funds	Project Grants Public/Private PE Funds	Guarantees and Insurance Products Soft Loans Mezzanine Finance Credit Lines Technical Assistance		

Mature Markets
Independent Markets

provides a suggestive link between the primary objectives through various stages of innovation.

CFPI Differentiated into Market-Pull and Technology-Push Policies

This differentiation is helpful in identifying the right instrument and its appropriate design (Groba and Breitschopf 2013, Pandey and Mehra 2015). While the demand-pull policies aim to increase the RE demand by addressing environmental externalities or reducing market barriers, technology-push policies primarily aim at increasing the incentives to generate new knowledge and further work on the available knowledge to improve upon its performance and cost. As a general rule, policies such as R&D support, financial incentives, and procurement incentives are more suitable for stimulating commercialization and initial market creation for new technologies, which can create a technology push. Once a technology is established in the market, further growth can be stimulated by policies, such as FIT, RPS, and other financial incentives.

An important issue, however, is to strike a balance between technology-push and market-pull measures from the beginning. To do so, policymakers need to understand how these measures interact under and respond to different market conditions. This, however, is an area for future research; although some discussion on this is available in Dong (2012) that points toward more empirical research on the structural reasons for a country to adopt a given policy. This should be done in a technology, country and a case-specific way.

Design of CFPIs: Some Guidelines and Knowledge Gaps

The comparative efficiency of different policies: Four criteria are suggested in analysing the impact of CFPIs (Menanteau *et al*. 2003). Table 2 presents relative merits of some policy instruments on these criteria. As a general point, it may be noted that in applying price based (P) and quantity based (Q) (Cropper and Oats 1992) concepts to stimulate low-carbon energy generation, a simplified argument would be that a Q based approach would be preferable when the slope of the MC is relatively flat. Conversely, a P instrument such as FIT may lead to significant increase in supply and consequently in subsidies. It can then be argued that the Q based approach is more effective in controlling the cost of government incentive policies whereas in P based systems (e.g., FIT), production cannot be anticipated with any precision because of the uncertainty regarding cost curves. Therefore, if the emphasis is on fast pacing the RE generation and also keeping a check on the cost of subsidies the policymaker should choose a combination of Q (e.g., RPS) and P instrument, such as competitive bidding (CB)[7] which provides incentive to reduce costs vis-a-vis FIT. However, this may or may not work for all types of technologies. Dong (2012) finds that FIT has better long-term effects in promoting wind energy, although in the short-run, RPS could also provide some incentives

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[7]   Since competing producers must reflect lower costs in prices in order to win subsidies.

to developers. An explanation would be that the surplus that goes to the producers in Q based approach is limited whereas technical change tends to increase the producers' surplus in the case of P based approach (e.g., FIT), thus encouraging them to innovate more.

According to Menanteau *et al*. (2003), if social preference is attached to climate change prevention and reflected in a high quantitative target for RE, FIT is a good compromise in order to promote technical progress. The quota/certificate system also presents a number of advantages in terms of static efficiency, but its ability to stimulate innovation is still to be confirmed by experience. The study also finds that in terms of installed capacity, P approaches yield better outcomes than Q approaches. This is ascribed to the strong incentive effect of fixed prices that induce greater stability and predictability for the investors. However, in terms of control over costs, the system of fixed feed-in tariffs renders it difficult to anticipate the level of RE production on account of uncertainties of cost curves. Thus, in this respect, quantity-based approaches induce lower costs as bidding for successive quotas provides an indirect way of controlling overall costs.

Dynamic efficiency (establishing sustainable technical progress) has two components: one relates to the technological learning process pertaining to wider diffusion of technologies, and the other depends on the manufacturers' R&D investments and thus on surpluses that might be generated. Thus, if the objective is to encourage local R&D to achieve the goal of developing a competitive RE industry, some protection to the domestic industry will be required before it can be opened to external competition. A FIT system will be helpful in such a situation (this is evidenced by the fact that Germany, Denmark, and Spain are the world leaders in wind turbine production).

The potential advantage of green certificate trading system is that the goal of new energy generating capacity can be achieved in a cost-effective way by distributing the overall objective among several technologies. But given the limited experience with green certificates and the number of challenges (e.g., those associated with the risk of small number of participants, risk of price volatility, other transaction costs, creation of floor prices, ability to enforce penalties due to complex market structure and political infeasibility on defaulters), its real efficiency is still to be proven (Fristrup 2000). A framework to redistribute funds collected through penalties will contribute in improving the acceptance of investors.

Important empirical questions around inherent flexibility and time- frame of support: As the RE technologies evolve, markets mature and the costs of RE lowers, the financial support to renewables will have to be gradually phased out, with the exception of the support for R&D expenditure to immature new technologies on the anvil with good long-term potential. In this context, the overall framework conditions which constitute the best-practices with regard to

Table 2: Criteria for choice and design of instruments

Instrument	Design	Incentives to Reduce Costs and Prices	Capacity to Stimulate RE Generation	Stimulation of Technical Change	Cost to Community	Remarks
Feed–in–Tariff						
(Price based systems)	Government sets a price and markets determine the quantity of RE at that price. Effectively it involves a subsidy to the producers of RE. Whereas a regulation (RPS) makes it obligatory for the electric utilities to mix RE in its portfolio.	No incentive to producers; government has no direct control on Q; Governments have introduced a provision to gradually reduce FIT to take account of progress in RE technologies. FIT does not encourage innovation because of guaranteed prices.	• Reduces risk for RE developers. Thus encourages capacity generation. • Low risk and transactions cost and potential to reduce costs provides strong incentive to add more capacities. • Has better L-R effects promoting wind energy.	• Increase in installed capacities lead to cost reduction and consequently improved margins. This enables producers to invest in R&D. • Strong incentive to invest in R&D to consolidate their industrial base. • Strong incentive to producers and manufacturers who would benefit from reduced costs and thus higher surpluses.	• Costly in terms of subsidies but simple to administer. • Q can exceed the targets. • Support for RE is unrelated to electricity prices. • Support levels can be customized, and combined with regular built-in tariff reviews as costs reduce over time, especially for technologies with short development times and high learning rates, such as solar PV.	• Well suited to technologies that are somewhat away from being competitive. • Useful if the objective is to develop local manufacturing and other capacity for installation and servicing; Potential benefits employment and export earnings.

Instrument	Design	Incentives to Reduce Costs and Prices	Capacity to Stimulate RE Generation	Stimulation of Technical Change	Cost to Community	Remarks
Reverse auctions FIT	This system is a competitive process to award its FIT entitlements assessed on multiple performance criterion including the price. Government sets a Q and markets determine the FIT price subject to performance assessment.	No incentive to producers to reveal cost reduction.	• Revenue certainty leads to investment in capacity. • Bidder pre-qualifications assessment is important to ensure capacity generation is delivered.	• Incentive to reduce EPC capital cost.	• Subsidy can be controlled. • Significant transaction costs.	• Cost-effective in the case of established technologies.
Competitive bidding	Government sets a quantity and organizes competitive bidding from RE producers to allocate this amount at prices determined by them. Electric utilities are obliged to purchase RE from selected RE producers.	• Strong incentive to producers to cut production costs	Limited margins with respect to risk will result in limited capacities.	• Relatively low margins may limit R&D below optimal. • Surplus generated from reduced costs is shared among producers, manufacturers, and consumers/tax payers. • Incentive to reduce EPC capital cost.	Through indirect controls, level of subsidies can be controlled. Significant transaction costs. Support for RE is unrelated to electricity prices.	Prudent in the case of established technologies. Bidding permits competitive price discovery and works well for mature technologies that are close to being competitive.

Instrument	Design	Incentives to Reduce Costs and Prices	Capacity to Stimulate RE Generation	Stimulation of Technical Change	Cost to Community	Remarks
Green certificates (Quantity based approach)	Green certificates are attributed to RE generators who sell power at wholesale market prices; and sell certificates to operators with a quota to meet.	Strong incentive to control both equipment and operating costs.	More adapted to liberalized energy markets.	Strong incentive.	• Potentially, the most efficient way for distributing the overall RE target among several technologies and scaling RE development. Costs are distributed equitably among consumers. • Makes it possible to use least cost source for a single technology (such as wind before PV). But may prevent investment in promising but less developed technology.	• Deployment volumes and prices can be regulated via caps, buy-out fees, and price floors and banding. • In general, TGCs are most suitable for mature technologies.

Instrument	Design	Incentives to Reduce Costs and Prices	Capacity to Stimulate RE Generation	Stimulation of Technical Change	Cost to Community	Remarks
RPS	RPS is structured as a Q regulation, letting the market determine the price for RE. Targets are set to ensure a certain mix of RE in total generation capacity. In most cases REC are created to track the performance. RECs allow for trading in the market.	Strong incentive, as RPS can potentially incentivize competition among different RE technologies.	Could provide incentive to producers in S-R Provides incentive to utilities to either produce RE or buy REC. Properly designed RPS and well-functioning REC markets are required. This implies a long-term policy and target on RE and strong regulator.	Likely to create a competitive environment for all RE technologies and thus provide incentive to R&D.	Flexibility of RPS allows generators to comply at least cost.	For wind E cost curve is relatively flat so Q instrument would be superior to P. In the case of wind E, RPS is favoured over FIT.
Investment Subsidy	Reimburses the capital investment on equipment or total capital cost of the project.	No incentive to producers	Strong incentive (Key to growth in Wind E in Denmark).	May be	yes	Useful in supporting certain technologies that may have potential but not fully developed, thus expensive.

Source: Authors' construction

cost components and its calculation, automatic tariff degression, and timeframe for support are relevant (European Commission 2013).

For competitive allocation schemes, cost calculations (most importantly translating the levelized cost of electricity into an actual support level)can serve as a reference for the policymakers or as benchmark for technology-staggered auction processes. Incentive schemes should include automatic tariff digressive characteristics, as also built-in revision mechanisms. For most RE technologies, the timeframes for support broadly vary between 10–20 years, with most offering support for 11–15 years. An alternative to formulating time bounds in terms of years is to limit support in terms of "number of full-load hours supported" [For a review of best practices in this context, see European Commission (2013) and Pandey and Mehra (2015)].

Issues in how the subsidy should be distributed: This is a tricky question and would require a case by case examination, analysis, and solutions; although interesting insights from some of the evolving literature on evaluating the impact of CFPIs and using feedback loops in phasing out of CFPI can be useful. The key message in available research is to take into account feedback loops, such as LBD, and information diffusion as these are important in determining how to distribute the subsidies to accelerate the diffusion and optimize the total subsidy. The reasoning is that some technologies may need policy intervention in the early stages of market transformation to remove market barriers, which will increase the sale of new technologies and through learning and scale economies, will accelerate the reduction in per unit costs leading to rapid market growth (Doner 2007). This was supported by an empirical study for Germany (Lobel and Perakis 2011).

The study shows that the current solar policies in Germany are not efficient. More subsidies should have been introduced in the beginning—a stronger subsidy policy, perhaps—and a stronger phase-out in the later stages of the programme. The reasoning is that in the early stages of the adoption process, it is optimal for the government to provide strong subsidies, which take advantage of network externalities to reach the target adoption level at a lower cost. As the adoption level increases, these network externalities become saturated and the price paid for raising the adoption target becomes increasingly more expensive.[8]

Design and Implementation of CFPI: Best Practices and Lessons Learnt

Policy context in which RET Development and Deployment Incentives have Emerged

Policy design and implementation can also be linked to the market structures in the economy. The tabulation below is elucidatory (Table 3).

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8 The qualifier is that due to limited access to data this is not a full empirical study of the German solar market. We have very limited access to data.

Table 3: Select review of policy context within which RET development and deployment incentives are placed

Policy impacts	Policy context	Country-wise analysis
Policy supports	Presence of a clear political resolve	*China:* Successful design and implementation of policies and complementary support measures for encouraging RETs in China can be ascribed to a clear political will, combined with an aggressive pricing mechanism and a strong manufacturing base to back this process. *Germany:* RE development was also incorporated as an integral part of the industrial development policy, complemented by Germany's commitment to shift from nuclear and fossil fuels to RE. *Japan:* In Japan as well, it was the National Energy Law (1997) that specified the target for RE in aggregate primary energy supply. This was supported by RE promotion rules on how the costs of grid reinforcement were to be financed, and how the transmission networks were to be improved and maintained (Jager and Rathmann 2008).
	Compliance with international treaties	*Canada:* It is after the adoption of the Kyoto Protocol in December 1997 that a fresh thrust on policy and measures supporting RE investment and deployment were introduced.
	Domestic policy &compliance with international treaties	*India:* The driving factors in India have been a mix of national policy resolve and requirements placed by the international treaties. (Government of India 2013 and WWF and WRI 2013).
Policy barriers	Complex administrative and planning procedures and grid connectivity constraints	*France:*The change of regulatory procedures in 2005 has somewhat improved the situation. In 2006, with newly installed capacity of 810 MW, France managed to more than double its market for wind power (Jager and Rathmann 2008). Italy: Similar constraints can be observed in case of Italy. Moreover, the administrative procedures for grid connection have been long and complicated, entailing high transaction costs (Jager and Rathmann 2008).

Policy performance linkages	Size of the economy and the market structures therein	*Select emerging economies:* Azuela and Barroso (2011) find a clear distinction between large and medium-size countries (defined in terms of gross national income and size of power sector) in the variety of instruments used. In general, Brazil, India, and Turkey have implemented a more diverse set of mechanisms to promote RE than Indonesia, Nicaragua, and Sri Lanka. Also, BRICS countries, Brazil and India, have been relying on more evolved types of instruments (well-developed FIT design, REC market, and auctions). Furthermore, policies to support RE have been more effectual in the higher-income countries (Brazil, India, and Turkey). In comparison, low RE market growth has been exhibited in both Indonesia and Nicaragua for reasons related to policy or contract design in combination with select external or background factors (such as regional financial crises, governance constraints, or regulatory uncertainty).

Source: Authors' compilation

Against this backdrop, we discuss the country experiences with use of incentives and support measures for RE development and deployment and allude to the lessons learnt therefrom.

Effectiveness and efficiency of support schemes for development and deployment of RETs: Key lessons learnt

A discussion is now presented based on a review of literature (IEA 2011; Jager and Rathmann 2008) and select country cases on how CFPIs have performed. Three key sets of support schemes have been taken up for analysis:

- Price based market instruments such as feed-in tariffs (FITs) and feed-in premiums (FIPs)
- Quantity-based market instruments called renewable portfolio standards (RPSs) or quota obligations
- Tendering/competitive bidding.

The impact of support measures on stimulus to renewable energy sources for electricity (RES-E) based on the policy impact indicator (PII)[9] and the cost-efficiency of the support scheme by relying on the total cost indicator (TCI)[10] is

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9 PII measures the progress toward a defined goal and provides a measure of the impact of policies on stimulating RE deployment. It calculates the percentage of gap between the 2005 generation and the World Energy Outlook (WEO) 2030 target that was achieved in a given year. The indicator helps in comparing policy effectiveness across countries in stimulating the deployment for different technologies. The sample included 35 countries of which 17 were using FITs, 6 were relying on certificate schemes, and five were without any policies; period 2001–2009.

10 The TCI is defined as the amount of additional annual premiums paid for an additional unit of generation per year. For normalization across countries, the annual premiums are expressed as a percentage of the total wholesale value of all the electricity generated.

considered. Both the indicators have been harmonized by the IEA to allow cross-country comparisons (IEA 2011). The other impacts studied pertain to incentives toward technology cost reduction and technology market maturation based on Jager and Rathmann (2008), which indirectly point towards incentive to innovate. And finally, key lessons from select country cases.

Stimulus to RES-E

In terms of PII for onshore wind, for the entire span of period 2001–09, the average PII in countries with reliance on FITs was 3.23 per cent, 1.5 times of the level for countries using certificate schemes (at 2.1 per cent). Based on 2009 data alone, TGCs fared better than FITs (4.75 per cent versus 4.36 per cent). The reasons for this development could be traced to a number of factors. First, the RE systems may have encountered strong learning effects, more so in recent years. Another reason may be the low baseline effectiveness level of certificate systems to start out with, and deployment on select sites rendered easier after some level of learning is attained.

In the case of Solar PV, the average PII for countries using FITs is much higher (at 0.83 for the overall time period 2001–09 and 2.13 in 2008–09) as compared to those relying on certificate schemes (which are found to be at 0.43 for 2001–09 and 0.42 for 2008–09).According to IEA, in terms of country-wise impacts, five distinct categories can be identified. The first group comprises countries that display little or no noticeable rise in PV deployment and have very low domestic policy support levels (namely, Brazil, China, South Africa, Mexico, Russia, Norway, Iceland, New Zealand, Turkey, Ireland, Hungary and Denmark). The second group exhibits very low levels of deployment, even though the policies provide for substantial financial support (as in India and, to a lesser extent, Greece with 2010 effectiveness of 3.3 per cent), on account of non-economic barriers. The third group displays a steady and smooth increase in policy effectiveness over time (as in case of US, Japan, Switzerland, and Canada) or an established effective policy environment (Germany). In contrast, the fourth group includes countries that have seen a sudden jump in policy effectiveness (namely, Australia, Belgium, Italy, Austria, Slovakia, France, and the Czech Republic). The last group (Spain, Portugal, and Korea) witnessed a peak in effectiveness but, thereafter, very low levels of deployment.

Cost effectiveness

In the case of onshore wind, on a broader spectrum, countries show very large dispersion of total premium payments as measured by the TCI, and a generally positive correlation between TCI and deployment of wind power. The lowest values have been exhibited by New Zealand, where no incremental premiums were required to be paid for the 1.5 per cent of electricity that was covered by new wind generation in 2009. This is followed by India and Australia. Ireland too paid relatively smaller premiums and displays low TCI in comparison to the extent

of stimulus to wind power. The premiums were comparably large in Sweden, taking into account the smaller contribution of new wind generation. Portugal paid the highest total premiums for wind power capacity that was deployed in 2009, which is why it also reaped a large amount of additional generation from wind power. Similar results can be observed for Spain and Denmark. It can also be seen that FIT and FITP exhibit a better trade-off than TGCs between wind's additional deployment and total premium costs. In general, solar PV support deems it necessary to have payment of comparably high premiums. To evaluate the aggregate burden that support policies put on the national energy economy, the TCI was worked for the incremental generation produced in 2010. Due to its relatively small size, combined with high tariffs, the Czech Republic displays the largest burden with respect to its overall power system: the share being almost double that of Germany.

Contribution of scheme toward cost reduction and level of market maturation

In terms of static efficiency, the incentive to reduce costs is mainly experienced in the case of competitive bidding and TGCs (as the producers tend to be price takers). In comparison, the FITs/ FITPs do not provide the same level of incentive for cost reduction. However, once the dynamic effects are internalized in relation to the stimulus to RES capacities (these largely operating through the effects of learning curves on cumulative production) FIT is likely to perform relatively better in terms of the overall installation than competitive bidding or TGC systems. The system that performs better dynamically is the one that stimulates RE market and is corroborated by the data below (Table 4).

As can be seen from the 2006 data for select OECD countries where the RE support policies have been in place for some time (Jager and Rathmann 2008), price instruments FITs and FITPs have generally performed better in reducing the cost of technology (significantly or moderately significantly) than quota obligation (with TGCs), competitive bidding, production and other fiscal incentives. Moreover, wind (both onshore and offshore) technologies exhibit the highest possibility of cost reduction, followed by combined biomass power and heat, with the lowest cost reduction experienced in case of solar PV. Further, evidence is weak as to whether FITs or FITPs are associated with mature markets for technologies in comparison with quota obligations or tendering schemes.

Impact on innovation

EEA (2014) demonstrates that there exists a strong positive correlation between R&D expenditure by the government and patents applications. The case of four countries (of the EU-27), namely Czech Republic, Netherlands, Switzerland and Spain, is illustrative. However, there is lack of conclusive evidence on the link

Table 4: Contribution of the support scheme to cost reduction of RES and level of market maturity

| Country | Instrument characterization | Contribution of the scheme towards reducing the costs of RES | | | | Market maturity level |
		Wind- onshore	Wind-offshore	Combined heat and power biomass combustion	Solar photovoltaic	
Canada and Canadian Provinces	Production incentive	Insignificant	Insignificant	Insignificant	Insignificant	Moderately mature
Ontario	Feed-in-tariff	Significant			Moderately significant	Moderately mature
	Tax incentives					
	Competitive bidding: Tender (contract price)					
Quebec	Competitive bidding: Tender (contract price)	Significant				Moderately mature
France	Feed-in tariffs	Significant	Significant	Significant	Significant	Emerging
	Competitive bidding:/ tendering					
	Tax measures					
Germany	Feed-in tariff	Significant	Significant	Significant	Significant	Fully mature
Italy	RPS (Quota obligation)	Significant	Significant	Significant	Significant	Emerging
	Feed-in tariff	Significant	Significant	Significant	Significant	Emerging
Japan	RPS (Quota obligation)	Insignificant	Insignificant	Insignificant	Insignificant	Moderately mature
The Netherlands	Feed-in premium	Significant	Significant	Moderately significant	Insignificant	Moderately mature

Norway	Investment subsidy	Moderately significant	Insignificant	Moderately significant		Emerging
Spain	Feed-in tariff/ feed-in premium Tax deduction Low interest loan	Significant	Insignificant	Moderately significant	Significant	Fully mature
UK	RPS (Quota obligation)	Significant	Moderately significant	Moderately significant	Insignificant	Moderately mature
	Tax deduction	Significant	Moderately significant	Moderately significant	Insignificant	Moderately mature
	Investment subsidy	Significant	Moderately significant	Moderately significant	Insignificant	Moderately mature
US & US States	Production tax credit	Insignificant		Insignificant	Insignificant	Fully mature
California	RPS (Quota obligation)/ production incentive	Significant		Significant	Significant	Fully mature
Minnesota	RPS (Quota obligation)	Moderately significant		Moderately significant	Moderately significant	Moderately mature

between energy support measures and innovation (EEA 2014). The data from EEA for the EU-27 group of countries for the period 2005–11 demonstrates a weak relationship between per capita RE production (wind, solar and geothermal) and per capita patent applications granted. Denmark is the only exception: it exhibits a much larger share of patents followed by Luxembourg, Norway, and Switzerland compared to their RE generation from these technologies. In comparison, Italy, Portugal, and Spain have much fewer patent applications as compared to RE generation. This leads to the conclusion that a mere strong focus on deployment (demand-pull) does not necessarily lead to accelerated innovation in the RE sector.

Key Lessons from Select Country Cases

The Case of FITs and Emergence of PV Bubbles in Germany and Spain

The poor design of FIT was one of the main reasons for its failure in Spain that included:
- An over-generous rate structure of FIT, especially in 2007
- No subsidy degression initiation with the falling costs of the solar PV projects.
- Extremely long period of transition to policy schemes when tariff reduction was expected.

The Experience with Auctions in Brazil, India, and China

- Well-organized auctions provide an interesting alternative for countries in which the energy market lacks a mature RE segment, especially the emerging economies, such as India and Brazil, where the risk of a few firms exerting too much market power has been a barrier to RPS schemes (Azuela *et al*. 2014).
- To allow policy consistency and compatibility, auction mechanisms should be fully integrated with other regulatory, planning, and economic strategies of the country.
- Auction mechanisms have proved to be very effective in lowering energy prices in Brazil, China, and India, when compared with the levelized cost benchmarks calculated on the basis of 'reasonable' assumptions.
- Commonly, delays in construction and under performance have been identified as key systemic problems with auctions, which can be dealt with by stiffening penalties for failing to meet the original objectives.

United States' Production Tax Credit (PTC) Programme

The lesson learnt from the US experience in respect of PTC is that frequent expiration of the policy have created uncertainty in the industry, which has posed a challenge to development of RE and this could be corrected by appropriately timing the extension of PTCs which can cater to the issue and provide for continued expansion and economies of scale to persist.

Table 5: Experience with FITs in Germany and Spain: A Comparison

What Germany did	What Spain did
Used price to control volume (**no hard caps**)	**Overcompensated** solar PV
Increase in solar PV delivery with a **fall in FIT costs**	**Exponential** growth in solar PV deployment with a corresponding **growth in costs of FIT**
FIT degression options—Degression was automatic and transparent	**No subsidy degression** options—transition period between revisions of FITs were too long
Initially a fixed degression followed by a flexible degression schedule	Rise in prices of Solar PV subsidies
Active policymakers and **political consensus** in tune with investor's needs	**Slow reaction** by the government in turn hurting investor confidence
Adopted **triggers, adjustments,** and most important **review** concepts and how it impacts TLC	Should design a policy that **avoids cost crisis**, develop tracking methods so that government can **detect and react** to problems promptly and try to **limit damage** in case of crisis
Increased employment and trade in international market of solar PV	Domestic **job losses** and contraction in international market
Merit Order Effect (MOE) took place	No MOE took place
Germany is world's dominant solar energy market	The solar energy market failed in Spain

Source: Authors' construction based on Fulton and Mellquist (2011)

Denmark: The Case of a Leader in Innovation in RETs

The key lesson to be learnt from Denmark is that its current position as a front-runner in innovation in RE can be ascribed to the bold political decisions to transform the energy system, the early mover advantage in wind energy, and a favourable climate for innovative start-ups. The relatively low costs of patent applications and the opportunity to apply for patents in English language may have also played a favourable role in this regard (EEA 2014).

Conclusion

The issue of design and implementation of support measures for RE technologies is complex and require a nuanced, case by case approach. However, some broad conclusions can be drawn from a review of design and implementation of such measures discussed in the foregoing sections.

Foremost, the design of the support instrument needs to be placed in a specific policy context (e.g., energy and climate policies), with clear identification of drivers for and barriers to its design and deployment. The role of the regulatory, institutional,

and political environment needs to be emphasized, especially as the level and structure of the instrument have to be benchmarked against the prices of conventional energy, besides other advantages that conventional energy sources enjoy (e.g., supporting infrastructure, consumer acceptability, established technology among others). The cost of RE, as much as the grid based prices (and more recently the presence of carbon taxes), has a bearing on the viability of RETs. There is widespread recognition of availability of and connectivity to grid infrastructure as a constraint to diffusion of solar and wind power across a range of country studies.

Political will and incorporation of RE targets in the national policy framework are important to introduce and effectively implement policies on RET dissemination. Policy support measures have been affecting the cost-effectiveness of technologies by giving stimulus to RES. A significant impact on innovation could not be found for a large set of countries. The exception is Denmark, where a large number of patents were filed. Germany, Spain, and USA (especially California and Minnesota) have had fully mature markets, which could be ascribed to the support schemes in RES-E sector that have helped in significant cost reductions.

In general, it has been found that price-based instruments have worked better as compared to quantity-based instruments, and amongst various RES, wind technology has had the maximum potential for cost reduction and dissemination. It is also commonly suggested that incentives/support measures need to rely, as much as possible, on market based instruments, e.g., quota obligations coupled with tendering and/or green certificates, such that the true costs get revealed. A caveat in this regard is that reliance on market forces will circumscribe the ability of the producers to reap the sufficient rent that can otherwise help spur innovation. Thus, incentives for dynamic efficiency for less mature technologies (in particular) should not be ignored.

None of the instruments offer an optimal solution in all the evaluation criteria. As a consequence, governments will have to select an instrument and sustain it in the long run in accordance with the relative importance of its objectives. In a complementary way, conditions of a successful instrument vis-à-vis the regulatory risk include government's long-term commitment, foreseeability of the instrument and ex ante flexibility to capture decreasing RE cost and correct redistributive effects. The level of support must not be abstracted from the incurring risks and transaction costs.

The costs of RETs tend to fall as there is learning-by-doing and market maturation. Thus, the instrument design needs to have in-built flexibility in the price or quantity domain so as to adapt to the changing market situation. In this regard, a smooth phasing out/ exit policy for the RE technology is also prescribed as the levelized cost of the technology is lowered to approach that of conventional energy in the limit.

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Overcoming Obstacles to Green Fiscal Reform

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Abstract: *Green fiscal reforms (GFR) include a number of tax and pricing instruments that can raise revenues while furthering environmental goals such as mitigating climate change, protecting water resources, and reducing traffic congestion. Interest in GFR has been rising and the current context provides a favourable environment to launch such initiatives. However, efforts to date remain limited and are often constrained by obstacles including concerns about economic and social impacts. While such concerns are important, they should not be used as an excuse to avoid GFR as they can be addressed through careful design of the reform process. This article examines how obstacles to GFR can be overcome through targeted mitigation measures for vulnerable groups, use of revenues, and complementary tools, drawing on lessons from experiences in both developed and developing countries. This article highlights the need to adopt a comprehensive, consultative, pragmatic approach to GFR and build broad political and public support to ensure success.*

Keywords: *Environmental taxation, Biodiversity, Climate change, Compensation measures, Competitiveness concerns, Distribution impacts, Economic impacts, Energy, Fiscal reform, Governance, Mitigation measures, Natural resources, Fiscal revenues, Subsidies*

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Introduction

Environmental or green fiscal reform (GFR) refers to a "range of taxation and pricing measures that can raise fiscal revenues while furthering environmental goals" (OECD 2005a, World Bank 2005). Such measures have attracted increasing attention in recent years driven by various considerations, including the push for fiscal consolidation, recognition of the financial burden of certain measures (e.g., fossil fuel subsidies in many developing countries) and growing appreciation of some of the limitations of traditional "command and control" approaches. GFR-related intervention such as congestion charges have been adopted at various policy levels: sub-national (e.g., in British Columbia in Canada and California in the United States) and national (e.g., a number of countries in Europe, Asia, and Africa) levels.

The multiple benefits of GFR and its potential role in supporting a range of objectives are well-documented (see, e.g., OECD 2005a, 2010, World Bank 2005, De Mooij *et al*. 2012). For example, according to Coady *et al*. (2015), eliminating energy subsidies (which arise from undercharging for supply and broader environmental costs of fossil fuel energy) would raise government revenue by US\$2.9 trillion, reduce global CO_2 emissions by more than 20 per cent, and reduce premature air pollution related deaths by 55 per cent. The current context with low oil prices is particularly favourable for undertaking GFR, and the case for such reforms is increasingly made.

Despite efforts to date, the use of GFR remains limited. Only 12 per cent of annual global greenhouse gas (GHG) emissions are formally priced and typically at levels below US\$10 per tonne (World Bank and Ecofys 2014). Environmentally harmful subsidies remain significant in several sectors such as fisheries, agriculture, and energy. Various obstacles hold back further progress including the strength of special interests; a lack of political will; limited transparency and awareness; as well as administrative, institutional, and technological constraints (OECD 2005b, Withana *et al*. 2012). Lack of political will is a key obstacle that often reflects concerns about perceived economic and social impacts on vulnerable groups. While such concerns are important and merit attention, they should not be used as an excuse to avoid GFR as they can be addressed through careful design of the process.

This article is based on a paper commissioned by the Fiscal Instruments Research Committee of the Green Growth Knowledge Platform, which examines how to overcome obstacles to GFR through the targeted use of well-designed mitigation measures for vulnerable groups; careful use of revenues; complementary strategies, tools, and approaches drawing on lessons from experiences in both developed and developing countries. This article seeks to provide general insights on overcoming obstacles to GFR, keeping in mind the need for tailored approaches depending on national circumstances and priorities.

Impacts of GFR and Potential Mitigation Options

A key obstacle to GFR often relates to feared economic and social impacts of the reform. Thus, it is critical to understand and clarify these impacts, setting out the costs, benefits, and potential trade-offs (OECD 2007). Impacts are related to a number of factors (i.e. design, use of revenues, other policies, external factors, public support) and can vary over time. For example, while higher water charges may have negative impacts on certain households, revenues could be used to expand the network thus increasing access and generating health benefits among the wider population in the long term.

There are different tools to identify GFR impacts including quantitative (e.g., social accounting matrices, household consumption and input–output (I-O) data, dynamic or sector-specific models, and qualitative (e.g., literature reviews, stakeholder consultations) approaches—see Box 1.

Box 1: Fuel subsidy reform in Ghana

The 2005, fossil fuel subsidy reform strategy in Ghana was informed by a poverty and social impact assessment, which identified consumption profiles and estimated price changes and impacts on consumption costs based on input–output data. It found that rich households disproportionately benefitted from the subsidies whereas their removal would lead to an increase in consumption costs of the poor. These findings were informed through a widespread public relations campaign that communicated the need for reform and how revenues would be used.

   Mitigation measures included elimination of fees for state-run schools, an increase in public transport buses, a ceiling on public transport fares, increased funding for health care, an increase in the daily minimum wage, investment in rural electrification, continued cross-subsidization of kerosene and LPG. A pricing mechanism that linked domestic oil prices to international prices was adopted; however, it has periodically been abandoned, for example, in 2008 due to escalating oil prices and in the run-up to national elections in 2009.

Sources: Coady and Newhouse (2006), GIZ (2013), Beaton *et al*. (2013), Laan *et al*. (2010), IMF (2013), OECD (2005a)

Potential Impacts of GFR on Vulnerable Firms or Sectors

Available literature on concerns about negative impacts of environmental regulation (including GFR) on the economy does not reveal statistically significant or robust evidence to support the claim (see, for example, Albrizio *et al*. 2014). Nonetheless, perceived economic impacts of GFR remain a key obstacle and are often used to block progress or to undermine efforts. Thus, an important step when considering GFR is to clarify the scale, nature, and economic impacts of reform that depend on various factors including design, revenue use, and external and firm-specific factors. In addition, impacts can be assessed at different levels, that is, national, sector, and firm (OECD 2005b) as it is possible to have benefits for a particular sector, but losses for individual firms as well as gains at a national

level but losses at a sector level. Thus, GFR should be seen in the wider context of national transformation and structural change—see Box 2.

Box 2: Benefits of the carbon tax in British Columbia, Canada

The carbon tax in British Columbia (BC) was introduced in July 2008 at a rate of CAD 10 per tonne of CO_2 equivalent with a schedule of four annual increases to reach CAD 30 per tonne of CO_2 in July 2012. The tax rate has been frozen since 2012 and some exemptions granted. The tax is revenue neutral with revenues used to decrease taxes on corporate and personal income, and to provide tax credits and benefits for vulnerable groups.

    Assessments indicate that BC's petroleum fuel consumption per person dropped by 15.1 per cent from 2008 to 2011 and declined by 16.4 per cent more than the rest of Canada, while the province's per capita GHG emissions declined by 9.9 per cent between 2008 and 2010, which outpaced reductions in the rest of the country by more than 5 per cent. BC has also attracted green investment and green technologies at twice the Canadian average and saw a 48 per cent increase in clean technology industry sales from 2008 to 2010. Furthermore, as a result of corresponding tax cuts, BC has among the lowest income tax rates in Canada and general corporate income tax rates among G7 nations.

Sources: British Columbia Ministry of Finance (2013), British Columbia Ministry of the Environment (2012), Sustainable Prosperity (2012), World Bank and Ecofys (2014)

Potential Impacts of GFR on Vulnerable Households

The perceived effect of GFR on vulnerable social groups is often used to block action. For example, proponents of reduced VAT rates on basic necessities such as energy, food, and water argue that they are needed to protect the poor, even though evidence suggests such subsidies tend to benefit the rich more (see Box 3). Thus, it is important to clarify the scale and distribution of impacts across social groups, taking into account both direct and indirect price effects. Impacts can vary across applications and over time as well as within countries, for example, between rural and urban areas (World Bank 2014). They also depend on how revenues are used, the nature of the wider reform process, and the socio-economic context. In addition, non-price effects (e.g., substitution), possible rebound effects, and changes over time (e.g., benefits from improved access to water) (Heindl *et al.* 2014) should be taken into account.

Even if the overall GFR is progressive, a sharp increase in prices of certain essential products and services (e.g., energy, water) will have an impact on poor household budgets. Moreover GFR can have wider impacts on poor households depending on substitution effects, for example, in developing countries where access to electricity grids is limited, higher fuel prices could lead to increased use of biomass for heating and cooking with related health and environmental impacts (World Bank 2014). Thus, in some cases there may be a need to introduce targeted mitigation measures for vulnerable groups to ensure that the GFR process does not lead to increased poverty (Sterner 2012) or other adverse impacts.

Box 3: Distributional impacts of fossil fuel subsidies and their reform

Fossil fuel subsidies are increasingly recognized as an inefficient means of protecting low income groups. It has been estimated that the richest 20 per cent of households in low and middle income countries capture six times more benefits from fuel product subsidies than the poorest 20 per cent, with impacts varying across fuel types (Clements *et al*. 2013). Communicating such effects can help build support for reform.

However, even if the status quo disproportionately benefits the rich, some reforms could be regressive, particularly in the short term, depending on the type of fuel taxed and characteristics of the economy. Arze del Granado et al. (2010) found that an increase in fuel prices of US$0.25 per litre across 20 developing countries would result in an average 5.9 per cent decline in real household incomes. Direct effects vary across products (e.g., progressive impacts for gasoline and electricity, regressive impacts for kerosene). Indirect impacts accounted for a substantial share of total impacts (with regional variation), indicating that a high proportion of fuel use is for intermediate consumption.

Mitigation Measures and Approaches

Once impacts of the GFR have been identified, there is a need to select those that may require mitigation (see Box 4). The extent to which mitigation measures are introduced "is a strategic decision that involves trade-offs between fiscal savings, capacity to target, and the need to achieve broad acceptance of the reform" (Clements *et al*. 2013).

There are different types of mitigation options and in most cases a package of measure may be required with different target groups and timelines that depend among others on the resilience of affected groups, their ability to absorb or respond to changes from the GFR, external pressures, and access to alternative options (Withana *et al*. 2012). Mitigation measures should be discussed in advance with stakeholders, well-targeted and time limited, maintaining positive incentive effects, and supporting overall objectives of the GFR process; see Figure 1 for a synthesis of key steps.

Compensation Measures for Vulnerable Groups

Vulnerable Firms or Sectors

Different measures can be used to mitigate negative GFR impacts on vulnerable firms or sectors (see Table 1). Such measures should be well designed and targeted, aligning short-term concerns with long-term needs for change.

Partial reductions or exemptions

Some form of exemptions or special provisions for vulnerable firms or sectors is often relied on as a politically expedient measure when introducing GFRs. Such practices contravene conventional economic theory and tend to impair the effectiveness of GFR as the cheapest emission reduction potential is not exploited (Speck and Jilkova 2009). In some cases, exemptions are linked to one or more

Box 4: Considerations to help assess whether an impact of GFR requires mitigation

Social considerations
- Does the impact affect a group considered vulnerable based on its income or status, such as low-income households, pensioners, rural poor, impoverished women among others?

Economic considerations
- Does the impact affect a sector that plays an important role in the national/regional/local economy, such as employing a large number of people or accounting for a substantial share of GDP? If yes, does the sector have the capacity to absorb or pass on the impact?
- Does the GFR lead to isolated losses for a particular group such as job losses in a particular industry (e.g., coal mining) or within a certain group (e.g., fishermen)?

Environmental considerations
- Can the GFR lead to substitution effects that are detrimental to the environment and/or health such as increased wood burning?

Political acceptability issues
- Does the GFR have an impact on a politically influential group/sector such as farmers, energy-intensive industry?

Figure 1: Identification, design and implementation of mitigation measures for GFR
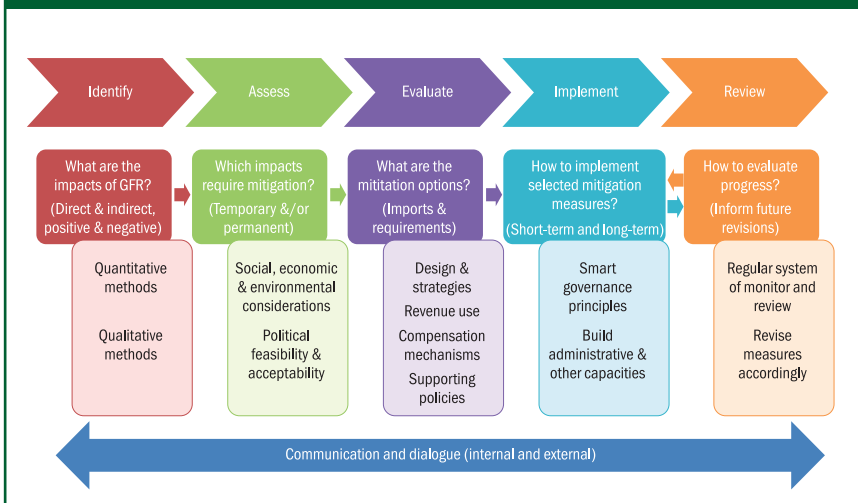
Source: Own representation.

conditionality such as voluntary agreements (see Box 5), which if well designed can improve information asymmetry between companies and authorities, inform future revisions, and potentially encourage change (ten Brink 2002). Specific requirements such as an environmental management systems and regular energy audits can also give the issue due executive attention and encourage progress (Withana *et al.* 2013).

Table 1: Overview of potential measures to mitigate impacts of GFR on vulnerable firms or sectors

Type of measure	Strengths	Weaknesses
Design and implementation approaches		
Timetable	• Phased introduction allows time to adjust • Provides certainty • Reduces opposition	• Could lead to backsliding of reform commitments • Risk of hoarding and shortages • Creates expectations of inflation
Stakeholder engagement	• Builds ownership and legitimizes process • Increases awareness of pros/cons • Reduces opposition	• Risks delaying GFR process • Opportunity for lobbying against reform
Compensation mechanisms		
Reductions/exemptions	• Reduces opposition • When linked to effective conditionality, could encourage change and improve information asymmetry • Useful for political and public acceptability	• Does not provide efficient price signal or incentive, thus foregoing cost-effective opportunities • Imply advantages for certain firms and sectors but disadvantages to others • Once established, may be difficult to revise or phase out
Transitional assistance to affected workers	• Reduces opposition • Link to complementary policies	• Could become entrenched in expectations if not time limited
Incentives for innovation	• Facilitates transition • Drives innovation • Reduces opposition	• Could become entrenched in expectations if not time limited
Minimum agreements/cooperation between countries	• Avoids concerns of leakage and competitiveness impacts • Increases support • Encourages more ambitious GFR • Reduces opposition	• Difficult to get agreement on fiscal cooperation between countries, particularly larger groupings
Border adjustments	• Reduces concerns of competitiveness impacts • Increases support • Encourages other countries to initiate pricing regimes • Reduces opposition	• WTO compliance • Could be administratively complicated • Political barriers

Source: Author's synthesis

Transitional assistance for displaced workers

If GFR has significant impacts on a specific activity, industry, or firm, targeted compensation measures can be considered. For example, transitional assistance for displaced workers was provided in France, Poland, and the UK when reforming coal mining subsidies (Bruvoll and Vennemo 2014). While such measures can help buy support for reform, they can also be controversial and costly. In the

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Box 5: The energy tax in the Netherlands

The energy tax applies to energy products for heating and electricity generation by households, small businesses, and intermediate firms. A refund is granted to large industrial electricity consumers if they enter long-term energy efficiency agreements with the government and pay on average more than the EU minimum rate. Reduced natural gas tax rates are also applied on the horticulture sector participating in energy efficiency agreements. Rebates and subsidies are provided for energy distribution firms for deploying combined heat and power, energy-saving technologies, and renewable electricity. Exemptions from energy taxation have led to low or zero energy taxes for sectors with the cheapest abatement options.

Revenues are recycled through lower income tax rates and higher tax free allowances for households, reduced employers' social security contributions, tax free allowances for small and medium sized enterprises, reduced corporate tax rates, and a lump sum refund on households' electricity bills. Until 2003, 15 per cent of revenues were earmarked to reward purchases of energy-efficient appliances. Evaluations suggest that the tax has supported a reduction in residential energy demand and an improvement in energy intensity among industry, while regressive elements of the tax are nearly neutralized through recycling measures.

Sources: Duscha *et al*. (2005), EEA (2011), European Commission (2013), OECD (2013a), OECD/EEA (2014), Peter *et al*. (2007), Speck and Jilkova (2009), Vollebergh (2008, 2013), Withana *et al*.(2013, 2014).

UK, for example, although the reform of coal subsidies enabled a more or less competitive domestic coal industry, it came with extensive mine closures and significant social costs as compensation provided was considered insufficient to avoid an increase in unemployment (IEEP *et al*. 2007). Measures need to be carefully designed and reviewed to ensure they are appropriate and adequate, with clear review clauses and end dates to avoid becoming entrenched in expectations of beneficiaries (OECD 2005b).

Incentives for innovation and more efficient technologies, processes, and practices

Certain countries use mechanisms to recycle revenues raised by the GFR into the affected sector to help keep down pressure, encourage transformation, and drive innovation (see Box 6). Such mechanisms can support structural change in the sector if carefully developed to ensure effective incentives. Incentives should be performance linked (i.e., favouring more efficient, innovative players), targeted at the most vulnerable sectors, and reduced gradually over time (see Box 6).

Box 6: The NOx tax and refund system in Sweden

In 1992, Sweden introduced a tax on emissions of nitrogen oxide (NOx) from energy generation at stationary combustion plants at a rate of Swedish Kroner 40/kg (US$ 6000/tonne) of NOx. Revenues are recycled back to participating plants in relation to the amount of energy generated. This has provided a strong incentive to reduce NOx emissions and has stimulated innovation and investment in the sector—the number of plants subject to the tax with NOx abatement technologies increased from 7 per cent in 1992 to 72 per cent in 1995. The recycling mechanism has made the tax more politically acceptable and reduced concerns of negative competitiveness impacts. However, the design of the system does not reduce the overall amount of energy produced; thus, while the average emission intensity of participating plants was nearly halved in 1992–2005, total energy output increased by more than 70 per cent and total NOx emissions did not fall by much.

Sources: OECD (2010a, 2010b, 2013b), Sterner and Turnheim (2009), De Mooij *et al*. (2012), Sterner and Höglund-Isaksson (2006), OECD (2013b)

Minimum agreements or cooperation among coalitions of countries

Cooperation between countries could overcome obstacles and lead to more harmonized or synchronized approaches to GFR—see Box 7. Such cooperation is likely to be useful in certain circumstances, in particular, depending on the ease with which a given tax could be avoided, for example through trade (e.g., waste exports) or movement of consumers (e.g., airline tax and fuel tax) (Withana and ten Brink 2015). Such cooperation is likely to be more feasible when smaller groups of countries are involved and may be more likely when countries agree to set minimum requirements or thresholds rather than specify individual rates to allow a certain degree of flexibility. For example, cooperation on waste-related taxes and fees could involve agreement to apply rates above a specified minimum so as to discourage exports/imports and thus drive waste management improvements (Watkins *et al*. 2012).

Box 7: Agreeing minimum energy taxes among 28 EU Member States

The 2003 Energy tax Directive (2003/96/EC) provides a common framework for the taxation of energy products and electricity across 28 EU member States. In 2011, the European Commission proposed to revise energy taxes to include a minimum CO_2 tax rate of EUR 20 per tonne of CO_2 for all uses of energy products and a minimum energy tax rate (European Commission, 2014). Significant opposition to the proposal led to its withdrawal in early 2015 and reflects *inter alia* the difficulty in reaching agreement among a large and diverse group of countries (the initial Directive was agreed among 15 member states, the proposed revision required agreement among 28 member states).

One option to take this forward could be for a subset of member states (currently at least nine) to cooperate under the 'enhanced cooperation procedure', which is possible under certain conditions (Bassi et al., 2010). While there has been limited use of this procedure to date (e.g., patents, financial transaction tax), it remains an option that could be relied on more frequently in the future.

Border adjustments

Trade-related measures such as border carbon adjustments (BCAs) would encourage other countries to initiate GFR as they are penalized for not having a similar system in place (De Mooij *et al*. 2012). Border adjustments are often raised in discussions; however, they are difficult to implement in practice and remain controversial. They are highly politically sensitive given trade implications. Nonetheless, there are some studies that suggest that well-designed BCAs could overcome concerns (e.g., see Vivid Economics 2012). There is a need for further analysis of such measures, in particular how they could be designed and implemented to be WTO compliant and whether they provide a feasible and practical option to mitigate some concerns related to ambitious GFR.

Compensation Measures for Vulnerable Households

Different measures can be used to mitigate negative GFR impacts on vulnerable households (see Table 2). These measures need to be tailored to the national context. For example, providing compensation through changes in social security payments may be easier in developed countries where a dedicated administration and infrastructure exists; while it may be more challenging in developing countries until such capacities are developed (Clements *et al*. 2013).

Tax free allowances or targeted reductions

Some countries provide tax free allowances or lifeline tariffs for basic use of an essential service by vulnerable groups. In Uganda, for example, a lifeline tariff of Ugandan shilling 100 per kWh is provided for electricity consumption up to 15 kWh a month by poor households (IMF 2013). Such tariff schedules can help reduce the adverse effect of price increases on vulnerable households; however, they require supporting infrastructure such as metering devices and connection to the grid (World Bank 2014). Moreover, experiences in some countries suggest they are less effective in protecting low-income households. For example, in El Salvador a large proportion of low-income households do not benefit from lifeline electricity tariffs as they are not connected to the grid or their consumption levels are above the threshold given that the family size is large (Arze del Granado *et al*. 2010). In addition, such tariffs do not incentivize reduced consumption, thus other measures could be considered such as applying the full tax rate to all users and providing a targeted refund to vulnerable groups or providing support through other channels. For example, in Denmark, water pricing is based on metering while affordability of water and waste water services is ensured by income support through social policy systems (OECD 2008), thus retaining an incentive element in water pricing for all water users (EEA 2013).

Cash transfers

Many countries use targeted or untargeted cash or near-cash (e.g., vouchers) transfers as an effective way of compensating households for effects of GFR (World Bank, 2014). However they can also be considered inefficient for the overall economy compared to other revenue use options such as cuts in payroll, personal income, or corporate taxes. Moreover, there are issues of corruption, fraud, and targeting errors that have arisen in the application of some programmes, thus they need to be carefully designed and regularly monitored to ensure they reach intended beneficiaries. Such programmes may also require complementary investments (e.g., registers of eligible groups, a system to administer the transfer) that are costly and take time to set up. Technological advancements can simplify implementation, improve targeting, reduce corruption, and prevent leakage—see Box 8.

Table 2: Overview of potential measures to mitigate impacts of GFR on vulnerable households

Type of measure	Strengths	Weaknesses
Design and implementation approaches		
Timetable	Gradual introduction allows time to adjust to revised prices Reduces opposition	Could lead to backsliding and reversals of commitments Risk of hoarding and shortages Creates expectations of inflation Foregone revenues (and environmental benefits) in short term
Sequencing	Reduces impacts on vulnerable groups	Reduces revenues from GFR Creates distortions or negative incentives Time for opposition to build up
Stakeholder engagement	Builds ownership and legitimizes process Increases awareness Reduces opposition	Risks delaying GFR process Opportunity for lobbying against reform
Compensation mechanisms		
Allowances/reductions	Protects low-income groups Reduces opposition and builds support Ease of administration Can provide incentives for conservation if well designed	Limited reach as only covers households connected to electricity grid/water system Undermines incentives for conservation if not well designed Risk of leakage if measures are not means tested or well-targeted
Cash transfers	Beneficiaries have flexibility in spending Links to conditionality to ensure transfers spent on 'desirable' uses Reduces opposition and builds support	Requires administrative capacity and infrastructure Increases risk of corruption Targeting errors Requires regular monitoring Could become entrenched in expectations
In-kind transfers	Useful when government lacks administrative capacity to implement cash transfers Eases pressure on vulnerable groups Wins political and public favour as limits freedom of recipients to spend on 'undesirable' uses Can include incentives to encourage behaviour change	Limited flexibility Distorts household choices Could become entrenched in expectations Difficult to target, risk of diversion, smuggling, corruption

Source: Author's synthesis

In some cases, transfers are linked to specific conditionality, for example, requiring the beneficiary to invest in education or health, thus simultaneously alleviating the impacts of GFR and addressing some of the root causes of poverty (Clements *et al*. 2013). Similar conditional cash transfers have been successfully used in a number of countries, including Brazil, Columbia, and Mexico. Such measures do not require complex administration or governance systems and can be distributed through existing structures such as schools or post offices (Laan *et al*. 2010).

Box 8: Driving fuel subsidy reform in India

Fossil fuel subsidy reform (and food subsidy reform) is part of a package of good governance and reform being driven by Prime Minister Shri Narendra Modi in India. Reforms announced by the government in October 2014 included immediate decontrol of diesel prices, an increase in the regulated price of natural gas, fixing the total subsidy per LPG cylinder, and direct transfer schemes. Reform has been facilitated by wider technological advancements including a programme to increase household bank accounts that will help implement cash transfers, while the Aadhaar (unique identification scheme) will help reduce corruption and leakage of benefits.

Sources: Clarke and Sharma (2014), The Economist (2014)

In-kind transfers

Where cash transfers are not feasible (e.g., due to limited administrative capacity), in-kind transfers such as investments in social programmes can reduce pressure on vulnerable household budgets and thus alleviate some negative impacts of GFR— see Box 9. In-kind transfers can also include incentives to help ease pressure on household budgets (e.g., energy efficiency improvements, tax breaks on public transport). Although such in-kind transfers are less economically efficient (as they distort household choices), they are sometimes favoured by policy makers as they ensure spending on 'acceptable' uses and are often relatively easy to implement (World Bank 2014). They should be carefully designed and regularly reviewed to ensure they reach intended beneficiaries.

Box 9: Fossil fuel subsidy reform in Indonesia

In 2005, the government began a process to eliminate fuel subsidies, supported by a public information campaign and a programme of cash and in-kind transfers that used the existing social protection programmes and included temporary unconditional cash transfer payments, investments in education, rural development and health, incentives to shift from kerosene to LPG. Following the reintroduction of subsidies in 2009 in the lead up to national elections, the reform was put back on track in 2013 and was accompanied by a package of compensatory measures including temporary unconditional cash transfers, assistance for poor students, subsidized rice, basic infrastructure, and conditional cash transfers. In November 2014, the government under President Joko Widodo raised gasoline and diesel prices and in January 2015 announced the elimination of gasoline subsidies and a reduction in the diesel subsidy. Falling global oil prices helped mitigate impacts of the reforms. Revenue savings supported social programmes, including cash transfers to the poor and infrastructure investments.

Sources: IMF (2013), GIZ (2013), Beaton *et al*. (2013), The Economist (2015a, 2015b), World Bank (2014)

Using GFR Revenues

There are different options for how revenues from GFR are used (see Table 3). How revenues are used and the proportion used to mitigate adverse impacts depends

Table 3: Overview of potential options for revenue use from GFR

Revenue use option	Strengths	Weaknesses
Tax shift	• Part of wider tax shifting programme • Can help with economy wide efficiency by allowing reduction in distorting taxes (e.g. on labour) • 'Lock-in' GFR as changes require increase in other taxes (De Mooij *et al.*, 2012) • Allows overall tax burden to remain the same	• Only affects people who pay taxes (except VAT reductions) • Needs to be combined with additional measures to address regressivity concerns • Immediate benefits may be less clear than other options, which can lead to less public acceptability
Raise revenues for general budget	• Flexibility in government spending • Maintains rigour in budgetary allocation systems • Supports fiscal consolidation needs	• May not be favoured by public as benefits not visible and expenditure cannot be tracked • Against public perceptions that revenues from 'green' reforms used for environmental purposes
Recycle into economy or affected sector	• Can transform sector and maintain competitiveness • Increases acceptance in affected sector, reduces transition costs • Revenue neutrality can increase political acceptability as overall tax burden on sector remains the same	• Limits signalling effect and incentives for change if not well designed • Should be time limited
Earmarking (full or partial)	• Facilitates/catalyses innovation • Ease transition costs among affected group(s) • Ensures resources for relevant activities (e.g., enforcement) • Can be useful to build support among public who believe GFR revenues should be used for environmental purposes	• Usually no relation between amount of revenue from GFR and the efficient amount of spending on a particular earmark • Can create distortions, lead to a prioritization of certain spending • Once in place, may be difficult to reverse or revise • Creates obstacles/rigidities in tax system • Conflict between revenue raising and environmental objectives • Legal obstacles to earmarking • Not favoured by finance/economic departments

on various factors including objectives of the GFR, stakeholder perceptions, tax structure, government credibility, and administrative capacities.

There are different types of revenue recycling mechanisms including reductions in income tax rates and social security contributions, lump sum transfers, and

tax credits. Such mechanisms need to be carefully designed to ensure effective incentives—see Box 10. Recycling mechanisms may also need to be revised over time, for example, to maintain revenue neutrality or to ensure system does not become regressive.

While earmarking revenues (partially or fully) for specific purposes is controversial, it can be useful in certain circumstances, for example, to finance environmental monitoring and enforcement efforts, particularly in countries where such activities are underfunded (OECD 2005a, World Bank 2005)—see Box 11.

Revenues could be used to support positive incentive schemes such as payments for ecosystem services (e.g., hydrological environmental services programme in Mexico financed through an earmarked share of water use fees—see CBD 2011). Such partial earmarking can build acceptance given that the public sometimes believes revenues from GFR should be used for environmental purposes. Where (partial) earmarking is adopted, it needs to be carefully designed with a clear target, level, and timescale, taking into account the absorption potential of the target group. Such provisions should also be regularly reviewed with adequate safeguards to ensure correct management and use of funds (OECD 2005a).

Smart Principles for the Design and Implementation of Compensation Measures

Compensation measures need to be carefully designed and monitored to ensure they achieve intended objectives, maintain a positive signalling effect, contribute to overall objectives of GFR, avoid becoming entrenched in expectations of beneficiaries, and costs do not spiral out of control (UNEP 2004). Some smart principles to guide design are set out in Box 12 (building on findings by Withana *et al*. 2013).

Strategies, Approaches, and Tools to Drive GFR

In addition to mitigation measures, there are a number of strategies, approaches, and tools to help overcome obstacles to GFR. These form part of a comprehensive GFR strategy encompassing all stages of the policy cycle (see Figure 2).

Processes and Tools to Support GFR

Before deciding on whether to undertake a GFR, there is a need to identify priority areas for action. For example, in relation to subsidies, countries could screen the status quo to establish which subsidies are harmful and require action and are thus priorities for reform. Such an assessment could make use of different tools such as the OECD's quick scan (OECD 1998), checklist (OECD 2005b), and integrated assessment framework (OECD 2007), and other such as the subsidy reform flowchart (see Figure 3). These efforts could build on existing work that is particularly advanced on fossil fuel subsidies (e.g., Parry *et al*. 2014).

Box 10: Lessons from the carbon tax experiment in Australia

A carbon tax introduced in July 2012, which was to be replaced by a tradable permit system from July 2015, was repealed in July 2014. Although no longer in existence, the tax had a number of interesting mechanisms to mitigate impacts including increases in pension allowances, family payments, and income tax cuts and incentives to businesses to invest in cleaner energy programmes and production processes. Support provided to 'emission-intensive trade-exposed' industrial activities was varied according to the degree of exposure of industries and was to be reduced by 1.3 per cent/year, thus providing targeted assistance while ensuring due dynamics in the sector through a gradual reduction over time.

Despite this package of compensating measures, the tax was the target of major attack with critics arguing it would lead to substantial job losses and economic costs (despite previous modelling results from the Treasury, which suggested otherwise). Political interests and a strong mining lobby led to the repeal of the tax in July 2014 and its replacement by a 'Direct Action Plan', which offers grants to companies voluntarily reducing emissions.

Sources: Australian Government (2011, 2012), BBC (2014), Withana *et al.* (2013)


Box 11: Wastewater pollution charges in Columbia

Under a national discharge fee programme, regions set pollution reduction goals, apply national base charges, and track discharges. Revenues are used by environmental authorities for environmental investments in industries and capacity building in environmental agencies. Despite some problems (including limited implementation in some regions), pollution discharges have dropped significantly in some watersheds since the programme was introduced. In addition to incentivizing emission reductions, the scheme has helped enhance transparency and accountability in certain cases, while the prospect of increased revenues has incentivized some local regulators to improve permitting, monitoring, and enforcement of wider water pollution-related legislation.

Sources: Blackman (2007), GIZ (2013), ECLAC and UNDP (2001), World Bank (2005)

Box 12: Smart principles for the design and implementation of compensation measures

- Measures should target the most exposed or vulnerable groups, for example, energy-intensive industries that operate in a highly competitive market and are in a sector with significant international trade. Criteria for granting exemptions should be developed with tax authorities to ensure that they are practical and enforceable.
- Measures should have a clear timeline that includes a schedule for a progressive phase out.
- Measures should be developed in an open, participatory approach with key stakeholders.
- Measures should be simple to administer and build on existing systems to the extent possible.
- Exemptions should be gradually reduced or phased out over time.
- Partial reductions should be used rather than full exemptions to maintain positive incentives.
- Exemptions (and other compensation measures) should be linked to effective conditionality.
- Exemptions should have some sort of reporting agreement that requires beneficiaries to demonstrate the merits of the exemption (proof of effectiveness).
- A monitoring and review system should be established to assess effectiveness of measures (and use of revenues) and undertake revisions where necessary.

Figure 2: Stylized representation of GFR policy cycle
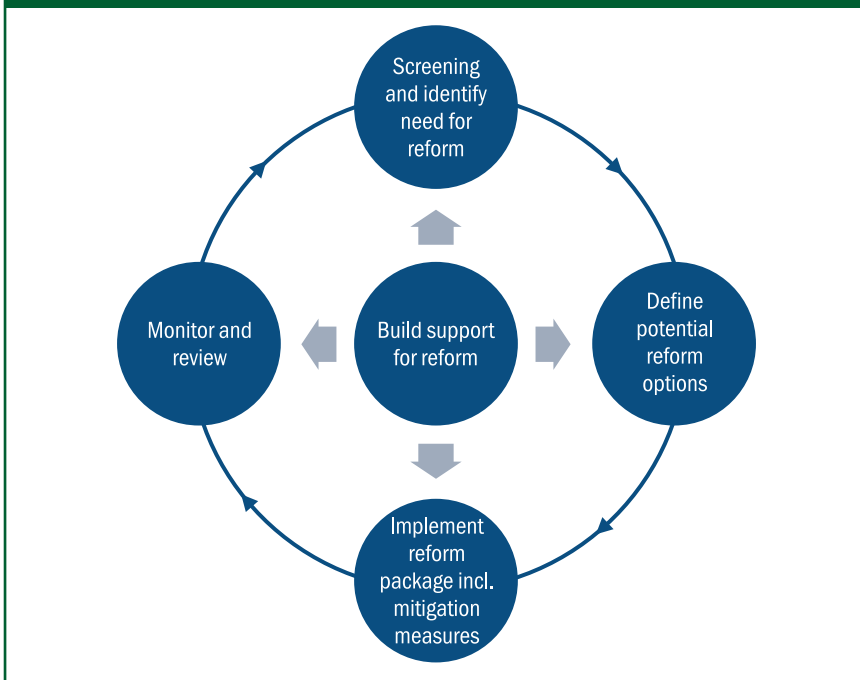
Source: Author's representation.

Countries could establish commissions or committees on (green) fiscal reform to identify reform options (e.g., in Portugal and Norway). Technical support could be provided by external actors such as international organisations (e.g. GIZ-IMF-UNEP Green Fiscal Policy Network, Energy Subsidy Reform and Delivery Technical Assistance Facility of the World Bank), national agencies, and civil society organizations.

Design and Implementation Options

In a number of cases, a phased approach to GFR (e.g., starting with low rates and progressively scaling up over time) may be easier to implement as it allows actors time to adjust and reduces resistance. The risk of such an approach is backsliding, particularly over longer timelines—for example in Indonesia in 2009 (see Box 9) and in Australia in 2014 (see Box 10). Although there are some cases where a swift reform has been successful (see Box 13), there are however significant risks associated with such a sudden price hike. For example, in Nigeria, an overnight increase in gasoline prices of 117 per cent in January 2012 led to mass public riots and the government had to subsequently scale back the price increase (IMF 2013). Similarly in Bolivia, the elimination of subsidies in 2010 led to an unexpected and

Figure 3: Subsidy reform flowchart piloted in the UK to identify incentives harmful to biodiversity
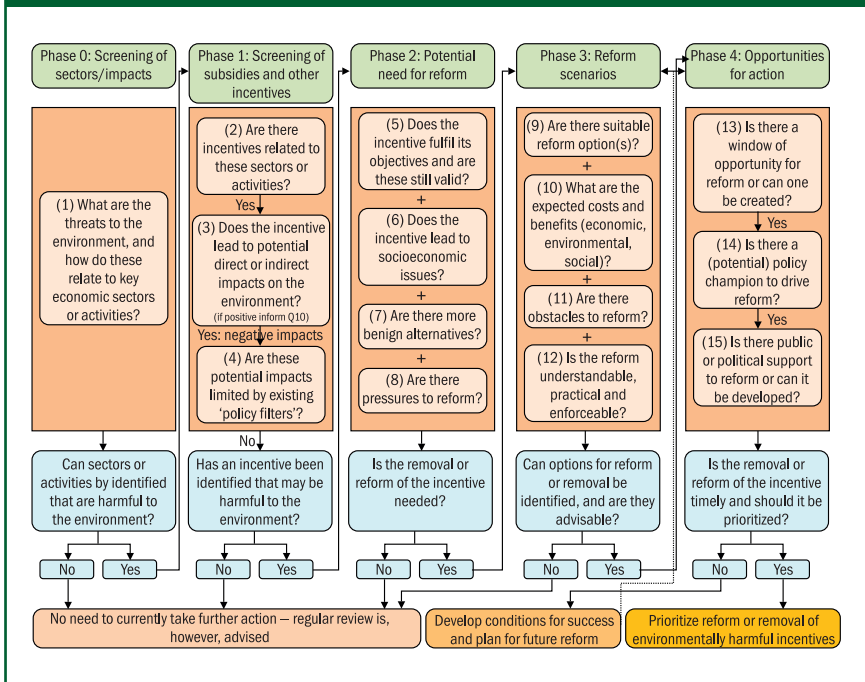
Source: Oosterhuis and ten Brink (2014)

sudden increase in prices by over 80 per cent that led to widespread protests and eventual reinstatement of the subsidies (WEF 2013, UNEP/CBD/WGRI 2014). These experiences illustrate that even a sudden GFR requires appropriate planning and communication and should be accompanied by a wider package of measures.

The timing of GFR is another important consideration. For example, one could introduce GFR at a time when effects are minimized such as in summer period when heating costs are lowest or when fuel prices are falling (e.g., recent fossil fuel subsidy reforms in India and Indonesia). One could also coordinate the GFR with other measures, for example, increases in electricity tariffs in Uganda coincided with an expansion in grid capacity that helped increase acceptability (Clements *et al.* 2013).

Sequencing of GFR is important and can be a temporary measure to alleviate impacts. For example, fossil fuel subsidy reform could start by focusing on subsidies that benefit the rich most (e.g., gasoline) while adopting a slower pace of reform for subsidies that affect the poor (e.g., kerosene). This should only be considered a short-term solution as large price differentials between different

types of fuels could lead to distortions such as smuggling (Beaton *et al*. 2013). One could also implement a pilot scheme to indicate expected effects and fine-tune reform before widespread implementation. Such an approach was, for example, adopted when introducing a congestion charge in Stockholm, Sweden (De Borger and Proost 2012).

GFR as Part of a Wider Reform Package and Policy Context

Making GFR part of a wider reform package that includes compensation mechanisms and complementary policies (e.g., investments in substitution possibilities) can help overcome obstacles, ease transition costs, and contribute to long-term sustainability (Lehmann *et al*. 2011)—see Box 13.

It is useful to link GFR to wider policy commitments and processes at different levels. For example, in France, work to identify and analyse biodiversity harmful incentives were launched in the context of the Grenelle de l'environnement process, which helped maintain focus on the issue (Withana *et al*., 2012). GFR commitments can also be framed in relation to commitments at the regional (e.g., G-20, APEC, EU), or international levels (e.g., CBD) to build a further case for reform.

Addressing issues of corruption, good governance, credibility, and trust could be an important entry point for GFR in some countries—see Box 14. This is by no means a trivial task and encompasses multiple challenges relating to governance, transparency, accountability, administrative capacities, and stakeholder engagement. Some of the tools and strategies for GFR can contribute to these efforts (e.g., encouraging stakeholder dialogue, building enforcement capacities, supporting budgetary transparency, etc.).

Communication and Engagement

Building support is critical to ensure success of the GFR process. For example, an IMF review of experiences with subsidy reform in 40 countries between 2002 and 2006 found that the likelihood of success almost tripled with public support and an engaging public communications campaign (IMF 2011). A strong communication

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Box 13: Reforming fisheries subsidies in New Zealand

New Zealand undertook a major reform of its fisheries policy in the late 1980s, which saw subsidies eliminated abruptly. This was combined with more fundamental changes to the fisheries management regime that dampened the effect of the subsidy removal. The reform package included introduction of a property rights-based quota management system and individual transferable quota combined with a minimum buy-out of existing rights from fishermen. These measures helped create a sustainable fishing sector, avoid potential negative social and environmental impacts of the sudden removal of the subsidies, and increase public acceptability. The subsidy removal and new management regime contributed to more effective management of fish stocks and in some cases a recovery of certain stocks from overexploitation.

Sources: CBD (2011), Lehmann *et al*. (2011), OECD (2007, 2011), ten Brink *et al*. (2014a)

Box 14: Forestry reform in Cameroon

In the late 1990s, the government initiated a number of transparency and governance reforms in the forestry sector to improve its international credibility and increase revenues (corruption was estimated to lead to lost revenues from the sector of over US$ 100 million each year). The reform was driven by the Ministry of Finance. Publication of data on lost revenues helped build support for reform while a number of key stakeholders were engaged in the reform process. The reforms increased revenues from about US$ 5 million to US$ 50 million per annum in revenues to the state, and from close to zero to US$ 9 million per annum in revenues to local governing bodies from 1994 to 2002. The reforms also led to substantial environmental improvements, encouraged stakeholder collaboration, and improved forest governance and transparency.

Source: OECD (2005a), Topa *et al*. (2009), World Bank (2005)

and engagement strategy is needed throughout the process—see Box 15. This strategy should use a variety of media and target external (stakeholders, public, and parliamentarians) and internal (different government departments) actors. It is important to frame messages in a positive narrative, clarifying concrete impacts on people's everyday lives (e.g., improved service provision, expanded coverage of network, impacts on health), clarify how those adversely affected will be supported, and refer to cases of successful reforms in other sectors and/or countries.

Monitoring and Review

Impacts of GFR can change over time, thus it is important to regularly review the process to reassess impacts over time, ensure mitigation measures are effective, and maintain momentum. This can be done at different levels, for example:

• At the national level, revenues raised and their use should be independently monitored to assess implementation of government spending commitments and reduce risks of corruption. The effectiveness of mitigation measures should also be assessed.

Box 15: Plastic bag levy in Ireland

The Irish plastic bag levy was introduced in 2002 at a rate of EUR 0.15 per bag and increased to EUR 0.22 from July 2007. Following its introduction, plastic bag use fell from an estimated 328 bags per capita in 2002 to 14 bags per capita in 2012. In preparing for the introduction of the levy, the government undertook extensive consultation on the design of the scheme with the public, the Irish Business and Employers' Confederation, and leading retailers. A national publicity campaign reiterated the message that revenues would be used for environmental purposes. The levy was introduced at the end of the winter when littered plastic bags are especially visible. The then Irish Environment Minister ensured close collaboration between various arms of government and was influential in ensuring a robust legislative and regulatory base for the levy.

Sources: Convery *et al*. (2007), GIZ (2013), Lyons (2013), O'Connell (2013), Withana *et al*. (2014)

- At the regional level, voluntary peer-review processes initiated under the G20 and APEC in relation to fossil fuel subsidies can be used to monitor progress.
- At the international level, reporting could build on efforts to monitor progress on international commitments such as regular reporting on Aichi Biodiversity Target 3 (UNEP/CBD/COP 2014).

Windows of Opportunity

The current economic context, high levels of public debt, and needs for fiscal consolidation have been used by some countries such as Ireland, Italy, and Portugal to drive forward recent GFR-related initiatives (Withana *et al*. 2014). Thus, a crisis, such as an economic or financial one, can simultaneously be a useful trigger to mobilize action and an opportunity to generate change. Other windows of opportunity at the national level include a post-election period (e.g., see Box 8 on India), deteriorating public energy or water infrastructure, dwindling national energy reserves, corruption concerns (e.g., see Box 14 on Cameroon), and a decline in oil prices (e.g., see Box 9 on Indonesia). Such efforts should be based on a comprehensive strategy to ensure they are not reversed when times change.

Commitments at the regional or international level can also be useful windows of opportunity. For example, GFR processes could be framed in the context of implementing Sustainable Development Goals (SDGs) and related targets (e.g., on fisheries and fossil fuel subsidies) or to meet CBD and UNFCCC commitments to mobilize financing for biodiversity and climate change, respectively.

It is also possible to create new windows of opportunity and avenues for progress. For example in the EU, the European Semester process provides a mechanism to monitor Member States' progress on issues including GFR and recommend improvements. A future avenue could appear in a possible revision of Regulation on European Environmental Economic Accounts No. 691/2011 to include a module on environmentally related subsidies (ten Brink *et al*. 2014b).

Moving Forward with GFR

GFR has attracted renewed interest in recent years. However, efforts remain limited and are often constrained by various obstacles. While these concerns are important they should not be used as an excuse to avoid GFR as they can be addressed through well-designed mitigation measures for vulnerable groups, use of revenues, and complementary strategies. GFR requires a comprehensive, integrated, and consultative approach. There is also a need to be pragmatic, allowing for deviations from certain theoretical ideals (e.g., no earmarking, avoiding exemptions), as a politically expedient way of making progress. Such departures should be tolerated provided they are well designed with adequate safeguards including monitoring and review mechanisms.

The political challenges of reform remain significant and sometimes despite good intentions and due processes, GFR efforts fail or decisions are reversed. Thus, it is critical to build widespread support and political capital for reform that transcends party–political lines and short-term electoral timelines to ensure GFR stays on track despite changing circumstances. As with other types of political reform, durable GFR also depends on government credibility and links to wider issues of good governance. This is by no means a trivial task; however, the tools and strategies for GFR can contribute to these processes.

Additional research including ex-post assessments of GFR in different areas (including but going beyond climate and energy) and impacts (including on competitiveness, jobs, and health) can build support and provide lessons on design. Research on options for further progress such as cooperation between countries or border adjustments could drive more ambitious efforts. There is also a need to better understand the role of GFR in the policy mix to support the shift to an inclusive green economy and implement the SDGs.

There are currently several attractive windows of opportunity to further promote the GFR agenda, including falling oil prices. Some countries are already seizing these opportunities and creating new avenues to promote GFR. Others should be encouraged to follow their lead. Such efforts should be based on a comprehensive reform strategy and seek broad support to ensure their success.

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Acknowledgements

Fiscal Considerations in the Design of Green Tax Reforms

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Abstract *: Fiscal policy is a crucial instrument that can facilitate the transition to 'green economies'. Choices regarding the source of government revenues and the recipients of government spending fundamentally influence both consumption and investment decisions by businesses and households. The rationale is that taxes change prices of products and services and therefore influence the production and consumption choices of market actors. Finance ministries have become increasingly interested in environmental taxes as an attractive option to improve their fiscal position. To this end, a conceptual framework for understanding the revenue potential of green fiscal instruments is developed. It is developed from a Finance Ministry's point of view to fully consider its interests which is mainly—apart from environmental benefits—raising fiscal revenues, achieving fiscal efficiency gains, creating jobs and economic growth, encouraging innovation. Tax exemptions and reductions, e.g., due to required compensation for equity and competitiveness reasons, impacts from inflation and behavioural responses and Interdependencies with raising other revenues, allocation of revenues, alleviating the tension between environmental and fiscal effectiveness are thus carefully analysed and considered in this article.*

Keywords: *Environmental fiscal reform, Eco-tax, Revenue raising, Environmental and fiscal policy*

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Introduction

Fiscal policy is a crucial instrument that can facilitate the transition to 'green economies'. Choices regarding the source of government revenues and the recipients of government spending fundamentally influence both consumption and investment decisions by businesses and households. The rationale is that taxes change prices of products and services and therefore influence the production and consumption choices of market actors. With debt levels increasing rapidly in most developed countries since the financial crisis of 2008, finance ministries have become increasingly interested in environmental taxes as an attractive option to improve their fiscal position. Developing countries, on the other hand, still lack adequate funding options to reduce poverty and improve education/health/transport via socially desirable investments, mainly due to the difficulty of raising significant revenue from personal income and capital taxes. Reducing energy subsidies and establishing broad environmental taxes (e.g., energy taxes) that are relatively easy to administer are attractive ways to generate revenues. In this article, a conceptual framework for understanding the revenue potential of green fiscal instruments is developed.

Background of Environmental Fiscal Reforms from a Fiscal Perspective

In the 1970s and early 1980s, environmental policy was mainly driven by command-and-control regulations, such as emissions standards, environmental quality controls, and detailed rules for business processes and technologies. Fuel taxes, though long established in many countries, were largely designed from a fiscal rather than environmental perspective; only tax differentiation along environmental criteria, such as the lead content (and more recently the sulphur content) was used as an environmental incentive. Later, a new orientation towards market-based instruments gradually started to shape environmental policy, primarily because of the need to find more cost-effective and flexible tools for environmental progress (EEA 1996). There was (and partly still is) insufficient implementation and enforcement of command-and-control regulation, often because actors tried to evade costs by finding ways to circumvent environmental rules. The self-interest of actors was in conflict with the goals of environmental regulation because costs induced by additional regulation would reduce competitiveness. New environmental policies were then developed to use profit maximization as a core motivator and to create financial incentives for businesses to behave in environment-friendly ways. The concepts of Environmental Fiscal Reforms (EFR) have thus been on the political agenda for more than two decades, and they have been introduced in many countries with positive impacts on the environment and human health, the economy and employment, and (most importantly for the purpose of this study) on government revenues and their fiscal positions.

An EFR is an inclusive concept, which refers to the pricing of environmentally harmful behaviour. It includes explicit price-instruments, such as environmental taxes and fees and charges. The Organisation for Economic Co-operation and Development (OECD), the International Energy Agency (IEA), and the European Commission define environmentally related taxes as any compulsory, unrequited payment to general government levied on tax bases deemed to be of particular environmental relevance (OECD 2006). As used herein, that term and the term "environmental tax" are often used as synonyms. EFR also covers the removal of EHS, since this also discourages environmentally harmful behaviour.

Within EFR, the narrower concept of an Environmental Tax Reform (ETR) is, according to the European Environment Agency (EEA), a "reform of the national tax system where there is a shift of the burden of taxation from conventional taxes, for example on labour, to environmentally damaging activities, such as resource extraction or pollution. The burden of taxes should fall more on 'bads' than 'goods' so that appropriate signals are given to consumers and producers" (EEA 2005). Given that ETR is a subset of EFR, it will generally speak of EFR, unless a clear distinction is called for.

EFR instruments are meant to accomplish a range of goals: (1) environmental benefits; (2) raising fiscal revenues and increasing fiscal efficiency; and (3) encouraging economic growth, innovation, and job creation.

Environmental Benefits

The most common rationale for EFR is its positive environmental impact. Increasing the price of environmentally harmful behaviour (e.g., using an environmental tax) discourages it through market mechanisms (i.e., a price signal). This type of government intervention can correct a market failure if the environmental damage of a given action constitutes an externality. Negative externalities arise whenever the actions of one party make another party worse off, and where the first party does not bear the cost of doing so (Gruber 2011). Externalities cause market failures, which in turn lead to economic inefficiencies. Market actors receive a distorted price signal because the externalized costs are not included in the price paid by the actor. Artificially increasing the price of environmentally harmful behaviour in such a way that its external costs are fully internalized within the price incentivizes actors to account for the social and environmental costs of their behaviour. The EFR intervention gives market actors a 'correct'—or at least a more accurate—price signal, which better reflects the full and thus true cost of certain behaviour.

Unlike with command-and-control interventions, market actors generally have free choice over how to respond—and hence very much in line with the philosophy of a market economy—and can individually adapt their behaviour, leading to a situation in which the environmental damage is avoided at minimal costs (that is, the environmental damage is avoided where the costs of doing so are the lowest, whilst still achieving the same environmental objective). This is often referred to as the "first dividend of EFR" (Goulder 1995).

The internalization of external costs is mostly attractive from a theoretical perspective. In practice, it is often difficult to estimate the external cost of certain actions, such as producing and using a plastic bag. However, it is important to mention that a lot of work and progress on this challenge has been made, allowing us to accurately assess the external costs in many areas (Schwermer 2012a, 2012b, Schwermer *et al*. 2014, Parry 2014).

Raising Fiscal Revenues

The second obvious benefit of EFR is that it creates revenues for government spending. Be it through taxes, fees and charges, or through the removal of environmentally harmful subsidies (EHS) or the auctioning of pollution allowances, EFR enables governments to collect funds that it does not need to raise elsewhere. These revenues can then be spent in various ways: for balancing the budget, for reducing overall public debts, for reducing other more distorting taxes and social security contributions or to increase spending, or for general consumptive or environmental purposes such as financing technological innovations, or to offset potentially negative impacts on some groups or sectors.

Fiscal Efficiency Gains

EFR can be useful to improve the efficiency and equity of fiscal systems. This fact can allow markets to operate more efficiently. Regular taxes, such as payroll taxes, distort markets in a way that makes certain goods (e.g., labour) artificially unattractive, creating deadweight losses (i.e., inefficiencies) in the economy. This applies, particularly, when there is unemployment. EFR can, therefore, be used to increase employment by using its revenues to lower the tax burdens and distortions on labour, mainly because EFR raises revenues efficiently and its funds can be used to lower other distortive taxes, creating a second social welfare gain. This is often referred to as the "second dividend of EFR" (OECD 2000).

Creating Jobs and Economic growth

EFR is also useful to achieve political goals in the areas of labour market and industrial policy. When environmentally harmful behaviour becomes more expensive, market actors search for and tend to find ways to achieve their goals by changing their production and consumption patterns. From a macroeconomic perspective the following happens: If EFR revenues from energy taxes on fossil fuels are used to reduce taxes on labour, labour becomes more attractive relative to other production factors that rely on the use of energy. Therefore, energy tends to be substituted by labour. The knowledge and engineering capacities of people are used to find innovative ways to use energy more efficiently and substitute fossil energies with renewable energy sources. In other words, it causes unemployment for kilowatt hours, not people. Several studies find that when structural unemployment exists in an economy, environmental tax reform

can boost employment and profits (Bovenberg and Van der Ploeg 1998, Kolm and Holmlund 1997, Schöb and Koskela 1996).

Encouraging Innovation

A high tax on the use of fossil fuels and its emissions makes investments in alternative forms of energy production more attractive, leading to innovation in these fields. According to the Porter Hypothesis, environmental regulation—including incentives—can help businesses to overcome market failures in innovation, thereby allowing them to get a competitive edge over their competitors in countries without taxes that incentivize innovations (Porter and Van der Linde 1995). Obviously innovation leads to job creation in new and possibly politically favoured industries. If revenues are recycled to fund environmental innovation, one may need lower tax rates to achieve environmental goals because switching to alternative technology becomes cheaper (Andersen *et al.* 2007).

Conceptual Framework for EFR Revenues

We now develop a conceptual framework for EFR revenues, which allows for a clear and distinguished understanding of the relevant factors and the trade-offs involved. This framework is particularly built for fiscal policymakers who are considering environmental taxes.

Potential EFR Revenues

There are many EFR instruments with very large potential revenues. Broad energy taxes on transport fuels are the most common example. Transport fuel taxes offer a very large base and are difficult to avoid (low elasticities), since at least in the past, there were few acceptable substitutes given the need for mobility. In 2012, Germany's total revenue from environmental taxes amounted to 58 billion EUR, of which 35.5 billion EUR (61 per cent) were raised by taxes on petrol and diesel fuel alone (Ludewig *et al.* 2014). If a broad base and low elasticity is given, EFR can be used to generate large, stable, and fiscally attractive revenue streams. Another example is the fuel duty in the UK which raises around 4 per cent of total government revenues through various taxes on hydrocarbon oil, better known as the fuel tax.

A tax on a narrow base can be useful to target a specific and unwanted, environmentally harmful entity, with the goal of discouraging its use. Given a narrow tax base for an elastic good, revenues can be expected to fall rapidly in response to a tax increase, making such a measure fiscally less attractive. Ireland's tax on plastic bags provides a prime example .

Net EFR Revenues: EFR Revenues after the Reduction of Subsidies in the Form Tax Expenditures, such as Exemptions and Reductions

The potential of EFR revenues is often undermined by various and often

perverse subsidies to certain producers and consumers (UNEP 2010). From an environmental perspective, tax exemptions and reductions for certain actors are counterproductive as long as they do not relate to environment-friendly activities or technologies. However, there are fiscal, economic, and equity reasons to compensate or support certain actors in the face of increased prices resulting from EFR measures. The most common exemptions and reductions, however, are not to assist low-income consumers but rather to support businesses, who claim that their (international) competitiveness would be undermined if they were forced to pay the full amount of an environmental tax. Given international competition, it is sensible from an environmental point of view not to tax businesses to a level which forces them to relocate to countries with lower environmental tax burdens. It may make sense, from a fiscal perspective, to grant lower tax rates to some groups than others, because it is rather difficult for domestic households to substantially decrease their heating consumption.

But there are good arguments to refute claims for exemptions. First of all, the environment does not care who or what damages it. Then, Pigouvian tax rates (Pigou 1920) are foremost market-correcting, which overrides the fiscal logic. It may be useful to first target those who react most quickly to price increases as this indicates the ease with which they can stop doing environmental harm. Generally companies should go out of business if they cannot compete with energy properly priced. The argument of carbon leakage (industries moving to low-tax countries) is, if at all, valid only for a small group of industries that have both high energy costs and strong international competition such as: lime, cement, iron steel/aluminum, refined petroleum, fertilizers and nitrogen, starches, pulp and paper, and basic chemicals (Dröge *et al*. 2009).

However, there are remedies through compensatory measures, which have clear advantages over tax breaks. Exemptions and reductions are further unattractive for administrative and political reasons. Each exemption and special treatment of a tax increases its complexity and therefore its administrative costs and opens the door for rent-seeking behaviour. While they may be necessary for political reasons, they should be minimized as much as possible. Not only do they decrease revenues, they distort consumer decisions, thus delaying structural change, and they incentivize environmentally harmful behaviour.

Interdependencies with Raising Other Revenues

Our analysis now turns to effects of an EFR more inclusively and asks how other revenues are affected by such an instrument. Consider a situation in which a government decides to introduce a broad-based air travel tax on CO_2, which increases the cost of kerosene. While this tax would surely raise revenue by itself, one should consider the broader effects of this tax. All things being equal, one would expect air travel to decline. This would decrease tax revenues from payroll taxes and corporate taxes from the airline industry. The effect on tax revenues on corporate profits is clearest, as profits will decrease due to higher fuel taxes, which

in turn lowers the tax base for profit taxes. Furthermore, if other excise taxes exist, such as the German ticket tax (Thießen and Haucke 2013), their revenue would drop in line with the behavioural response away from air traffic.

However, the effect on general revenues could be balanced out. Some potential passengers of air travel may substitute a domestic vacation for their international trip. Accordingly, tax revenues from domestic tourism would rise. At the same time, economic activity may shift to other forms of transport, which then grow and balance the losses from payroll and corporate taxes from the airport industry. It is, therefore, impossible to say from the outset if external revenue effects are positive or negative.

Another often-mentioned interaction effect of EFR instruments is on general consumption or value-added taxes (VAT). Some argue that as the price of a said fuel is increased, the government not only increases its revenues through the environmental tax but also through value added taxes, which are measured as a percentage of the price. For example, assume that the price of fuel rises from 1.50 EUR/litre to 2 EUR/litre due to a new fuel tax worth 0.50 EUR/litre. If a government levied VAT at 20 per cent on all goods including fuel, the argument goes; it would make an extra 0.10 EUR/litre as a result of the price increase. This argument, however, is misguided in terms of revenues. Assuming that VAT is collected from all commerce, one must take into account that the extra income spent on fuel in this case will not be spent on another product from which VAT would have been collected. So, while more VAT is collected at one point, it is lost at another.

Development of Revenues over Time

There are two reasons why real EFR revenues are expected to diminish over time. An EFR generally increases prices of pollutants, giving market participants an incentive to substitute away from them. However, in the short-run, it is generally more difficult to change behaviour (e.g., it takes time for consumers to buy more energy-efficient cars and housing appliances). They can only choose to use them less, while in the long-run they can adapt and substitute more easily. From a fiscal perspective, this means that elasticities with respect to taxes increase over time and revenues shrink as actors move away from the tax base.

Additionally, since most taxes are quantity taxes, their real value is diminished by inflation unless they are continually adjusted upward. In what follows, we first describe this effect and then move on to broader behavioural effects over time.

Devaluation of Quantity Taxes through Inflation

In the case of quantity taxes, the tax rate is externally set by government for a specific physical unit (e.g., EUR/MWh). This means that real government revenues decline over time, unless rates are continuously adjusted for inflation or are increased by further decisions. Within the conceptual framework, this means

Figure 1: German electricity consumption and electricity tax revenue development 2004–2010
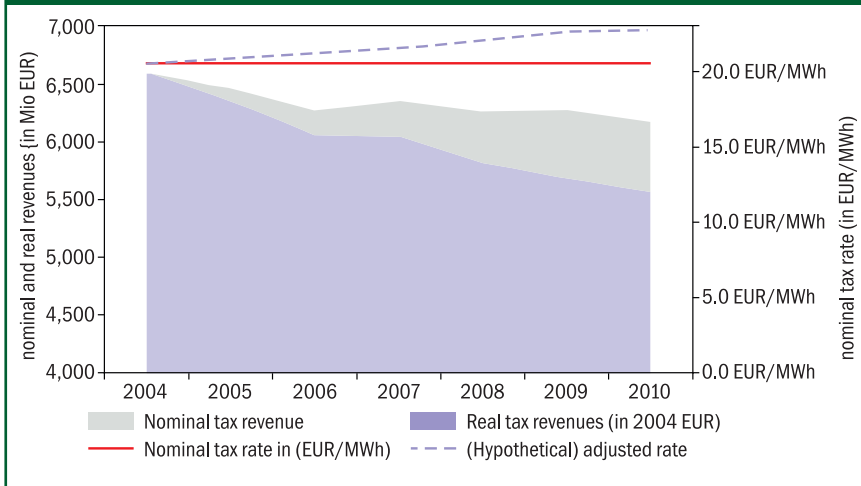
Source: Author's own graph and calculations

that the potential EFR revenue is decreased by inflation each year. At an annual inflation rate of 3 per cent, this means that an unadjusted quantity tax loses over 25 per cent of its real revenue value every 10 years. Hence, automatic inflation adjustment of quantity taxes is very crucial for two reasons. First, fiscal revenues are not eroded over time. However, more importantly, the behaviour-correcting effect of the tax does not lose its bite. Therefore, it is advisable to design a tax in a way that gives certainty to all involved actors—specifying to what extent and at what time tax rates are adjusted upwards. Depending on the situation, this could be done annually or over longer periods, such as every five years, in order to interfere with tax rates less frequently. An annual adjustment is more adequate to avoid some perverse behaviour, such as buying a lot of fuel before a large discrete jump in the tax rate.

Revenue Loss Due to Increased Behavioural Response over Time

If an environmental tax is set at the Pigouvian rate, one would expect the environmentally harmful behaviour to decline to an optimal level. As we have seen, tax revenues are created and depend on the tax rate, as well as the behavioural effect due to the price increase (elasticity). The higher the elasticity, the greater the response, and the lower the tax revenues raised. This would suggest that after a tax is introduced, behaviour would adapt and then stay constant, along with (nominal) tax revenues. However, as described above, behavioural responses increase over time as innovation makes substituting away from the tax base cheaper and easier.

Estimations suggest that the price elasticity for energy varies between -0.13 and -0.26 in the short-run and between -0.37 and -0.46 in the long-run (European Commission 2007). Considering that the behavioural response doubles over time, it is only reasonable to assume that the tax base and accordingly the revenues will slowly vanish.

If governments find themselves at a point where substantial revenues are being lost due to behavioural responses, it may either adjust rates upwards, if the tax base is fairly inelastic and if the EFR instrument is advantageous from a fiscal perspective, or it may choose to find broader tax bases to raise revenue for its funding requirements.

Administrative Perspective on the Revenues of Environmental Taxes

In order to evaluate the net revenue potential of an EFR instrument (i.e., the revenue left after all costs have been paid) it is necessary to look at the administrative cost of an EFR instrument. Generally, EFR revenues have low administrative costs. Taxes on petroleum products are usually levied on a very limited number of petroleum refineries and depots, and are hence relatively simple to administer and enforce. For instance, the administrative costs of the ecological tax reform in Germany are estimated to comprise just 0.13 per cent of the revenues raised (OECD 2006). Several examples also indicate that the administrative costs of a scheme involving a large number of tax payers can be kept at relatively modest levels. Administrative considerations should enter the discussion at the stage of policy design, as good administrative choices can minimize bureaucratic costs.

One should think of administrative efficiency as the bureaucratic cost per unit of tax revenue. The fundamental administrative challenge from a revenue perspective is to maximize revenue while minimizing administrative costs. Efficiency increases as costs per unit of revenue decreases. The first simple insight from this consideration is that administrative efficiency increases with the size of revenues. Therefore, it is important to look for proportionality between administrative expenses and the amount of collected revenues. Second, administrative efficiency decreases with the amount of complexity an EFR instrument generates for the processes of assessing, paying, collecting, monitoring, and enforcing payment of revenues and essentially depends on the administrative capacity within each country.

Assessing, Paying, Collecting, Monitoring, and Enforcing EFR Payments

In order to project and later control tax revenues, governments need to assess the expected amount of revenues. The ease of measuring EFR tax bases can be one key argument for their introduction, especially in developing countries, because governments usually have access to solid data on the amount of imported fuels or the amount of electricity produced. In comparison, in countries with large informal sectors, it may be much more difficult to assess the tax base for an income tax or a broad VAT tax than it is to assess the amount of petroleum used in a given year.

However, measuring the tax base becomes more complex as more exemptions and reductions are granted to certain groups. Exemptions add complexity to all administrative processes. In the case of assessing taxes, it complicates matters, and as with exemptions, it is not enough to estimate the size of the tax base because one also needs to estimate how much of the tax base is used by various groups who are privileged in different ways.

Perhaps the most important factor influencing administrative efficiency is the choice regarding both the payment and collection of EFR revenues. One important question here is at what point or level of aggregation a tax should be paid. Environmental and fiscal goals may once again be in conflict. From an environmental point of view, one should try to target and price the environmentally harmful behaviour as directly as possible, as this leads to efficient abatement. For example, if one raised a tax on the CO_2 content of coal, one may be able to collect the tax from coal importers (upstream), or one could tax each coal-fired power plant for their emissions (downstream). The first option is preferable from an administrative perspective since there are fewer coal importers than power plants, which decreases transaction costs per unit of revenue. However, in terms of the first option, if there is no incentive to reduce emissions after the coal has been purchased, a coal-fired power plant would have no incentive to invest in abatement technology.

If the tax was collected on the final emissions of coal plants, however, the plant has an incentive to invest in abatement equipment. This trade-off has to be evaluated on a case-by-case basis. For instance, Flachsland *et al*. (2011) find that the suitable point of regulation for a possible inclusion of the transport sector into the EU Emissions Trading Scheme is within the upstream to midstream range of the fuel stream, while Joas and Flachsland (2014) find that the added costs of downstream implementation are negligible in the power sector. Compared to overall system costs, the transaction costs are small and the differences between upstream and downstream are negligible. For this reason, policymakers may decide rather pragmatically to harness motor fuel and vehicle excise taxes rather than complex road pricing arrangements to control congestion costs (UNEP 2010).

Another aspect regarding the question of payment and collection of revenues is the presence of pre-existing administrative structures, which should be used to limit additional administrative costs. As shown for Germany's ecological tax reform, initiated in 1999, using broadly existing structures of the customs administration, it was very cheap and straightforward to implement the EFR using these pre-existing structures. In fact, the energy tax is one of the most efficient taxes in Germany as only around 0.13 per cent of revenue is used for public administrative expenses.

Since it is possible to use pre-existing administrative tax structures, it may often be cheaper from an administrative perspective to use taxes instead of cap-and-trade systems, which often require a newly built infrastructure and tend to be associated with relatively high administrative costs. For example, Denmark has introduced a carbon dioxide tax on certain energy products, but the tax does not

require a separate administrative system; it is collected jointly with the VAT and therefore needs no additional administrative structures.

Institutional Options for EFR Administration

In the context of EFR administration, it is important to decide which institutional actors should be responsible for the different aspects of reform. Usually the key actors are the Ministry of Finance, the Ministry of Environment, Forests and Climate Change and the various economic ministries that are responsible for industries relevant to the EFR instrument.

Generally, the Ministry of Finance will be the key administrative agency for EFR measures. It is usually responsible for EFR implementation within the existing fiscal framework. It is, therefore, very crucial to align the goals of EFR instruments with the interests of the finance ministry which is mainly revenue raising. It is reasonable to assume that bureaucrats within the finance ministry will tend to approach EFR from a fiscal perspective, which we have explained throughout this article.

The Environment Ministry often has a bigger stake in the environmental impact of EFR instruments. As we have argued before, if in conflict, environmental goals should have priority over fiscal goals. One should, therefore, give the agent with the biggest stake in achieving an optimal market outcome (i.e., the internalization of external effects leading to a reduced environmental impact) the power to work out the structural design of an EFR. This includes the selection of the tax base, the choice of the tax rate, and the development of optimal compensation strategies. In practice, of course, these decisions will be made in consultation with other stakeholders and should take their perspectives into account—where possible and feasible—without compromising the environmental objectives of the measure. Additionally, the Environment Ministry should be in charge of evaluating the reform according to both fiscal and environmental performance measures. This is important because in practice tax rates may have to be adapted to achieve environmental goals.

Economic ministries responsible for energy or electricity, water, agriculture, trade and industry will generally try to maintain their own power base in the bureaucracy, and may be closely allied with the key interest groups of their constituency (for instance energy producing companies), which may make some forms of EFR difficult (World Bank 2005). The influence of these ministries should play a role mostly, when it comes to questions of compensation, because some actors may need support. However, their influence in the design process should be kept to a minimum, since it is often economic ministries in alliance with industry lobby groups who undermine the effectiveness of EFR instruments by demanding an array of exemptions and special privileges. Given the strength of finance ministries, it may be useful to use the revenue interest of EFR to bring them onside in discussions with economic ministries who tend to favour exemptions and reductions for their constituents.

Allocating EFR Revenues

Having calculated the total potential revenues and subtracted revenues lost due to exemptions and reductions, external revenue effects, time and inflation, and administrative expenses, and we arrive at the revenue, which is actually available for spending. However, we make one last distinction, namely, between generated revenues and those available for free government spending. The difference between these two is the amount of revenue, which needs to be spent to protect the vulnerable and to facilitate transition.

Compensatory Spending

Compensatory spending here is defined as the amount of spending that is necessary to obtain sufficient political support for EFR. It should be clear that this is a purely conceptual idea, which is impossible to quantify with any degree of accuracy.

The first step to analysing possible compensatory spending is to find out who bears the economic burden of an EFR. The economic burden of EFR instruments tends to be concentrated among actors that are least-well equipped to change behaviour. This has nothing to do with EFR instruments, but is true for taxes more generally.

While one may see little need to compensate land owners, the situation changes when we look at a situation in which demand is very inelastic. This is the case in domestic electricity consumption, where short-term demand is inelastic because substituting or saving electricity is quite difficult in the short-run. In such a situation, the price increase is mostly passed on to consumers, who pay a higher price, while producer prices barely change. Since poor consumers are often least able to substitute away from a tax (e.g., by using new and energy-efficient products), they may be hit the worst.

For example, compensatory spending is often necessary due to equity considerations. EFR instruments on energy are sometimes regressive, meaning that they have a greater relative impact on low-income households than high-income households. This is simply the case because lower-income households tend to spend a larger share of their income on energy, particularly on heating fuels. For motor fuels, the opposite usually applies: Subsidies favour the rich, but not the poor because the latter hardly own vehicles. Electricity taxes can be progressive too, if the rich have better access to the grid and therefore spend more on electricity as a share of income. Especially in developing countries regressive EFR instruments justify compensating or protecting low-income households for their additional EFR burdens (Eskeland and Kong 1998). The removal of fossil fuel subsidies in Indonesia and its accompanying compensatory spending offers a good illustration of this fact. Furthermore, a concept for an ETR in Indonesia has been developed including how to use the revenues and shift tax burdens between local and federal levels (Schlegelmilch 2011). Another good example is Sweden's NOx charge.

General Spending Decisions

At this point in the analysis, we are left with EFR revenues, which can be used to fund any government spending. There is an ongoing debate regarding how EFR revenues should best be allocated (OECD 2005, World Bank 2005). However, considering the fact that EFR revenue is equivalent to all other revenues, answering the question of how EFR revenues ought to be spent is equivalent to answering the question of how government revenues should be spent generally. It should be clear that there is no straightforward answer. Yet, eventually political majorities and acceptance have to be achieved for its implementation, hence this criteria is certainly very important, if not the decisive one.

Earmarking Revenues for Green Investments

One way to spend EFR revenues is to earmark them for environmental spending. This may be popular, as people understand that price increases that result from environmentally harmful behaviour (e.g., driving) are leading to investments in environmentally related public goods. If the goal of an EFR is to reach certain environmental targets, green spending can help to speed up the process. If funds are used in this way, tax rates can be comparatively lower if a certain environmental target is to be achieved.[3] However, there are two general problems with this approach.

First, connecting EFR revenues to outright subsidies for certain groups may encourage rent-seeking behaviour among the recipients of EFR payments (UNEP 2010). This may be strategically beneficial since EFR revenues are used to fund a lobby group, which is favourable to EFR and can increase the likelihood of its continuation. On the other hand, recipients might grow dependent on payments and lobby for high tax rates, which may no longer be warranted from an environmental perspective.

The second problem relates to earmarking more generally, which is constitutionally forbidden in some countries. Earmarking generally complicates the budget process because it invites all sorts of groups to earmark certain revenue streams for their 'pet spending projects'. Earmarking may also prove problematic when revenues raised do not match the need of a particular spending project, as was the case with the UK Climate Change Levy revenues, which were earmarked to fund reduced national insurance contributions but did not raise sufficient revenues. An earmarked revenue stream is, therefore, very unattractive from a fiscal point of view because both politicians and the finance ministries generally demand the freedom of allocated revenues according to current requirements (World Bank 2005).

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[3] Modelling results within the COM ETR project (http://www2.dmu.dk/Pub/COMETR_Summary_Report.pdf) showed that emissions reductions could be achieved with substantially lower tax rates if 10 per cent of revenues were invested in energy efficiency measures, which shows the important interaction of taxing and spending decisions.

Environmental Tax Shift

Recycling revenues to lower other distorting taxes in the economy is a common usage of EFR revenues. The revenues from Germany's environmental tax reform were mostly used to lower pension payments, which were driving up labour costs and causing unemployment. Recycling revenues to lower distortive taxes is often described as the second dividend of EFR, since this step creates wealth by removing existing distortions, such as tax-induced unemployment (Jaeger 2012). But one still needs to identify the most distortive taxes. This is likely to vary between countries. In the case of South Africa, personal income and business taxes were lowered and the largest part was financed by an increase in the general fuel levy, as well as the electricity levy (Speck 2010).

Alleviating the Tension between Environmental and Fiscal Effectiveness

The attractiveness of a tax increases with elasticities from an environmental perspective, as by definition, the behavioural response is large. The opposite is true from a fiscal perspective, since unstable revenues and large behavioural effects are unattractive from a fiscal perspective. It should thus be clear as to why the fiscal argument does not hold in the case of EFR. From a fiscal perspective, the preference for low marginal tax rates and broad/immobile tax bases rest on the consideration that a certain amount of revenue should be raised without distorting the economy from its optimal point of allocation. This optimal point of allocation, however, is not the starting point in the case of environmental taxes. The point of an EFR is precisely to correct the existing inefficient allocation in an economy and help it find its optimal point of allocation through a tax-induced price increase. This means that worries over distorting the economy (fiscal view) are misplaced when looking at EFR instruments because it is their purpose to affect and correct behaviour. Once this is understood, one can see that EFR revenues from Pigouvian taxes are a 'free-lunch' from a fiscal point of view.

Another important step to reduce fiscal concerns over EFR instruments is to harmonize environmental taxes internationally. An increased elasticity of the tax base due to companies potentially moving to low-tax havens—though there is not a great deal of evidence for it except in very few sectors as mentioned above—is unattractive both from a fiscal and from an environmental perspective. One partial response to international tax competition is to seek agreement on minimum tax levels. This applies for the European Union where—as the only region in the world—minimum tax rates for all energy products are prescribed since 2004. The EU has thus sought to manage downward pressures on rates by adopting minimum rates, which is potentially less constraining than 'tax harmonization' in that it provides some protection to countries wishing to set relatively high rates while allowing them flexibility to increase their rates. A major rationale behind this is the problem of fuel tax tourism. Different levels of taxation provide an incentive,

particularly to those close to the border, to fill up their vehicles abroad where rates are lower.

On the other hand, the EU managed to compel some laggards to increase their tax rates to these minima. The entire fiscal policy in the EU is, however, based on unanimity voting. In other words, every single member State of the EU-28 has a veto right, which makes ambitious fiscal policies on EU-level extremely difficult. This is proven by the withdrawal of a proposal from the European Commission from April 2011 at the end of 2014 after failed negotiations. However, setting minimum rates rather than harmonizing taxation is still based on sound economic logic (differing levels of tax and market distortions may justify some variance in emissions prices across countries).

Conclusion

In this article we aimed at understanding the revenue potential of EFR instruments. We found that large and untapped EFR revenue potential exists in all countries. However, determining EFR potential should be done on a country-by-country and case-by-case basis. The conceptual framework provided in this paper can help guide this process.

By first examining a certain tax base and its elasticity with respect to price increases, we can determine the potential revenue for a given tax base and rate. Having chosen the optimal Pigouvian rate, we subtract the value of the envisioned rate reductions and tax exemptions. Ideally, one can pass an EFR without them, however, if in place they have to be taken into account. Next, we estimate the EFR instrument's effect on general revenues. This effect might actually be positive or negative depending on the instrument and surrounding tax system. Looking at revenue potential over time, we further take into account inflation effects (which can be eliminated through automatic rate adjustments) and time effects as the tax base decreases, which is essentially the goal of an EFR. Then, we look at the administrative costs of an EFR instrument as well as the necessary compensatory spending. And last, we consider how the remaining revenue can be allocated.

Probably the most sensible way to approach spending decisions is to evaluate them from a political and strategic perspective. One strategy worth considering is to identify the highest national political priority at any given moment, which are often not related to the environment (e.g., high pension contribution rates), and consider using the EFR revenues toward this goal. It is important to use funds to activate powerful stakeholders and seize opportunities to build coalitions with, for example, well-supported and popular political leaders who have the steadfastness to lead the process through the ups and downs. Approaching spending choices from a political point of view is reasonable, given that spending decisions are fundamentally political in character. Thus, one should use EFR

revenues for whatever they are most needed in a given time and place and stay flexible in order to successfully implement reforms.

The study offers policymakers a tool, which can help to make sense of the revenue potential of an EFR instrument. While being transparent about all trade-offs, it should also help to understand the extremely attractive feature of an EFR, namely, raising government revenue while fixing and not distorting an optimal allocation of resources.

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Green Growth: Ideology, Political Economy and the Alternatives

SHAILLY KEDIA[1]

Edited by Gareth Dale, Manu V Mathai, and Jose Puppim de Oliveira

This is an interesting edited volume which is a compilation of twelve essays, arranged into three sections, by 21 authors. The volume has been edited by Gareth Dale, Manu V Mathai, and Jose Puppim de Oliveira. The volume is the result of a concern, as the editors articulate, that much of the green growth terrain has been occupied by interests of contemporary capitalism that continue 'business as usual' with only minimal reform. Such a view sees Green Growth as being based on a neoclassical approach that has underpinned policy frameworks.

The three sections in which the book is organized are:

1. Contradictions of green growth
2. Case studies
3. Emerging alternatives

In terms of individual contributions, I would be in broad agreement with much of what has been written, but I feel that much of the content is based on bias which is based on the assumption of Green Growth only being underpinned by the market-oriented neoliberal agenda which has techno-economic strategies. It is clear that the concern of the editors is not just with a critical view of Green Growth, but with alternatives to Green Growth. The third part of the book is concerned with alternatives and discusses examples of radical ecological democracy, self-managed food systems, and community utilities. The book is clear in its messaging that objective of the book is to not be prescriptive but rather contribute to a meaningful conversation. To that end, the book leaves open several interesting strands.

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It needs to be discussed if policies are already looking at green growth as an alternative to neoliberal frameworks? A policy articulation on Green Growth which calls for a relook at Growth strategies is India's Thirteenth Finance Commission's where Green Growth concept was articulated as, 'rethinking growth strategies with regard to their impact[s] on environmental sustainability and the environmental resources availability to poor and vulnerable groups'. It is clear from the directions set by the Thirteenth Finance Commission, Green Growth in India was concerned with empowerment of local institutions, through fiscal means, as well as rewarding environmental performance, such as increasing forest cover and waste management.

A critical look is needed to understand practical and policy implications of the 'alternatives' of Green Growth strategies. How can Green Growth and other concepts, such as 'degrowth', 'sustainable growth', 'green economy, 'blue economy', 'rainbow economy', 'sharing economy', 'repairing economy, can together contribute to meaningful actions by citizens and policy actors? In this age of information and social media democracy, while debating and criticizing is important, engaging with stakeholders and finding practical solutions is equally important. As Prof. Kanchan Chopra argued, for practical purposes and policy making, green growth requires fundamental institutional change and should go hand-in-hand with 'selective degrowth'[2].

Finally such critical discussions would need to look at an alternative that would address issues of Laplace's demons[3] and Maxwell's demons[4] as discussed by Prof. Nicholas Georgescu-Roegen—the former looking at limitations in data and theory of existing frameworks that inform decision-making and the latter looking at bold political choices to address global issues.

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[2] Symposium on 'Growth, green growth or degrowth? New critical directions for India's sustainability'. Retrieved from <http://www.degrowth.org/wp-content/uploads/2014/10/Report-symposium.pdf>.

[3] Georgescu-Roegen, N. (1975). Energy and Economic Myths (Lecture delivered on November 8, 1972, at the School of Forestry and Environmental Studies, Yale University, in the Series 'Limits to Growth: The Equilibrium State and Human Society'. *Southern Economic Journal* XLI pp. 347–81.

[4] Georgescu-Roegen, N. (1977). 'The Steady State and Ecological Salvation: A Thermodynamic Analysis'. *Bioscience* Vol. XXVII, pp. 266–270.

The *International Journal on Green Growth and Development* aims to facilitate knowledge and learning processes, which will help in enhancing the capacity on emerging 'green' policy concepts. Contributions for subsequent issue will be based on invitation only by editors/ guest editors since the Journal is now thematic.

Type of contribution	Description	Length (approx.)	Illustration
Articles (will be blind peer reviewed)	Covers analysis through original research, reviews, and commentaries on topics of policy relevance. This section will be subject to peer review.	4,000–8,000 words	As required
Green Showcase	Features research, good practices, and initiatives	600–800 words	Preferably 1
Green from the Grassroots	Features insights from initiatives that involve interaction with communities and people	600–800 words	Preferably 2 photos

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THE INTERNATIONAL JOURNAL ON GREEN GROWTH AND DEVELOPMENT

Rethinking Growth Strategies

The International Journal on Green Growth and Development is an effort to stir a debate around emerging 'green growth' concepts. The publication aims at building knowledge through stakeholder engagement on policy-relevant issues to understand the many facets of green growth and development. It is a step towards a forward-looking knowledge process for new opportunities linked with growth and sustainable development. The journal showcases new research through peer reviewed articles, opinions, and innovative practices.

This thematic issue of The International Journal on Green Growth and Development is the result of collaboration between Green Growth Knowledge Platform (GGKP) and The Energy and Resources Institute. The papers reflected in this issue are based on working papers produced for the Third GGKP Annual Conference on "Fiscal Policies and the Green Economy Transition: Generating Knowledge – Creating Impact", held in Venice, Italy, 29-30 January 2015.

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