CHAPTER 3

Rationale for and Design of Fiscal Policy to "Get Energy Prices Right"

The first part of this chapter discusses why environmental taxes or the equivalent emissions trading systems (ETSs) should be front and center in getting energy prices right, though design details, such as targeting the right base, exploiting the fiscal dividend, and establishing stable prices aligned to environmental damage, are critical. The second part discusses a variety of further design issues, including specifics for power generation and transportation fuels, the role of other instruments, overcoming challenges to price reform, and issues for low-income countries.

Policies that emerge in practice from political processes may deviate in all sorts of ways from the economically ideal design principles outlined here. Nonetheless, having a clear sense of sound policy design helps discipline the policy debate, provides a sense of the direction in which policy should be heading, and provides a benchmark against which other, perhaps more politically palatable, policies should be evaluated to illuminate the trade-offs. And as discussed, some of the design principles carry over if regulatory approaches are chosen instead of fiscal approaches.

Other complementary policies are needed—investments in transportation and energy distribution systems, safety regulations governing the extraction and production of energy (including shale gas and nuclear) and use of roads, and so on—but are largely beyond the scope of this book, which is about pricing for residual environmental damage.[1]

POLICY INSTRUMENT CHOICE FOR ENVIRONMENTAL PROTECTION

There are three basic reasons for using fiscal instruments to address the environmental side effects of energy:

- *They are environmentally effective*—so long as they target the right base (e.g., emissions).
- *They can achieve environmental objectives at lowest economic cost*—so long as the fiscal dividend is exploited (e.g., revenues take the place of other burdensome taxes).
- *They strike the right balance between the environment and the economy*—so long as they reflect environmental damage.

[1]The appropriate design of these broader policies can depend on fuel pricing policies. For example, taxing coal may increase the need for power grid extensions to wind and solar generation sites.

These criteria are important, not just for their own sake, but also for credibility and sustainability. The next three subsections elaborate on these principles. Environmental taxes in a broader fiscal context, and taxes versus trading systems, are discussed in the subsequent two subsections.[2]

The Effectiveness of Alternative Environmental Policies

There are two basic points here:

First, if environmental taxes or similar pricing instruments are applied to the right base (a critical "if"), they will exploit all opportunities for reducing a particular environmental harm.

Second, in contrast, regulatory policies by themselves are typically far less effective because they are focused on a much narrower range of these opportunities—though a fairer comparison might be between pricing instruments and various combinations of regulations.

Energy-related carbon dioxide (CO_2) emissions are used to illustrate these points. The discussion goes into detail, given the importance of choosing the right instrument and that relatively ineffective instruments are often used in practice. Box 3.1 illustrates similar points about the effectiveness of well-targeted fiscal instruments in other policy contexts.

Opportunities for reducing energy-related CO_2 emissions

Opportunities for mitigating energy-related CO_2 emissions can be classified as follows:

- *Increasing the use of renewable generation fuels*—that is, shifting the power generation mix from fossil fuels to carbon-free renewables like wind, solar, and hydro.
- *Other options for reducing the emissions intensity of power generation*—including shifting from high-carbon-intensive coal to intermediate-carbon-intensive natural gas and from these fuels to carbon-free nuclear. Emissions intensity might also be reduced through adoption of carbon capture and storage technologies, provided they become viable in the future.
- *Reducing electricity demand*—through the adoption of energy-saving technologies, such as more energy-efficient lighting, air conditioners, or appliances, and reducing the use of electricity-consuming products.
- *Reducing transportation fuel demand*—by raising the average fuel efficiency (kilometers per liter) of vehicle fleets (e.g., adopting technologies to improve engine efficiency or reduce vehicle weight, shifting to smaller vehicles or various classes of electric vehicles) and curbing vehicle-kilometers driven (reducing vehicle ownership and the intensity with which vehicles are used).
- *Reducing direct fuel usage, mainly for heating, in homes and industry*—again, through adoption of energy-saving technologies such as insulation upgrades, or reduced product use such as turning down the thermostat.

[2]For more discussion of some of the issues covered below see, for example, Goulder and Parry (2008), Hepburn (2006), IMF (2008), Krupnick and others (2010), OECD (2010), and Prust and Simard (2004).

BOX 3.1

Environmental Effectiveness of Alternative Instruments: Further Examples

Sulfur dioxide emissions. As discussed in Chapter 4, sulfur dioxide (SO_2) emissions from coal-fired power plants are a major cause of premature death. Options for reducing these emissions include the following:

- Installing filter technologies in smokestacks to capture or "scrub" SO_2 (turning it into sludge and solid waste for impoundment in landfills or recycling)—some scrubbing technologies can capture 90 percent or more of emissions
- Shifting to coal with a lower sulfur content
- Washing coal at processing plants, which lowers sulfur content (and other impurities)
- Shifting from coal to other generation fuels (natural gas, renewables, and others) by retiring coal plants
- Reducing the demand for electricity

Charging for SO_2 emissions released from smokestacks addresses all these possibilities—the first four options lower generators' tax liabilities, while the pass-through of emissions taxes and abatement costs to consumers addresses the last response through higher electricity prices. Alternatively (and perhaps administratively easier), all these responses could be addressed by a tax levied on coal use in proportion to its emission rate, with appropriate crediting for use of emissions control technologies.

In contrast, mandating SO_2 control technologies exercises the first response, but not the others. Limiting average SO_2 emissions per unit of electricity over generators' portfolios of plants is more effective, in that it elicits the first three responses, but provides only weak incentives for the last two because generators do not pay for the full social cost of coal plants. A coal tax unrelated to pollution addresses the last two options but misses the first three.

Road traffic congestion. Various possibilities for reducing urban road congestion are available (taking transportation infrastructure as given), including encouraging people to

- Carpool
- Use alternative transport modes (bus, rail, bike, walk)
- Reduce trip frequency by telecommuting, combining several trips, or simply reducing travel
- Set off later or earlier to avoid the peak within the rush hour
- Avoid the rush hour altogether by driving off peak

Charging motorists per kilometer driven on busy roads, and varying the charge as congestion rises and falls during the course of the rush hour, gives rise to all these responses because each would reduce motorists' tax liabilities.

A simple toll per kilometer driven that does not vary with time of day is less effective because it does not encourage the last two responses. And a transit fare subsidy is far less effective still because it exploits only the second response (and even then it does not encourage shifting to other nontransit alternatives).

Effect of carbon pricing

Pricing all fossil fuel CO_2 emissions through a carbon tax (or ETS) exploits all five of the mitigation opportunities because the emissions price is reflected in higher prices for fuels and electricity.

For illustration, suppose that 25 percent of the CO_2 reduction comes from shifting to renewable generation fuels, 25 percent from other measures to reduce CO_2 per kilowatt-hour (kWh) in power generation, 20 percent from reductions in electricity demand, 15 percent from reductions in transportation fuels, and 15 percent from reductions in direct fuel consumption in homes and industry—with reductions in electricity demand and transportation fuels split equally between energy efficiency improvements and reductions in product demand.[3] These illustrative reductions are summarized in the first row of Figure 3.1, where the lengths of the green bars are scaled to the emissions reductions forthcoming from different sources.

Effectiveness of regulatory policies relative to carbon pricing

Other rows in Figure 3.1 illustrate the relative effectiveness of various alternative policies; each is scaled such that the emissions reductions for the particular source targeted by the policy are the same as those under carbon pricing.[4] Light gray bars indicate a source of emissions reduction and dark gray bars indicate policies that actually increase emissions (by lowering energy costs). Other policies typically have limited effectiveness because they fail to exercise many of the mitigation opportunities exploited under carbon pricing.

For example, a subsidy for renewable generation fuels misses 75 percent of the emissions reductions achieved by carbon pricing. And a vehicle fuel efficiency standard misses 93 percent of those reductions. In fact, fuel efficiency regulations cause a partially offsetting increase in emissions, by lowering fuel costs per kilometer and thereby increasing driving, though this "rebound effect" appears to be relatively modest.[5]

However a package of regulations can be much more effective than individual regulations. For example, a CO_2 per kWh standard will address all opportunities to lower CO_2 emissions per kWh in power generation (50 percent of the emissions

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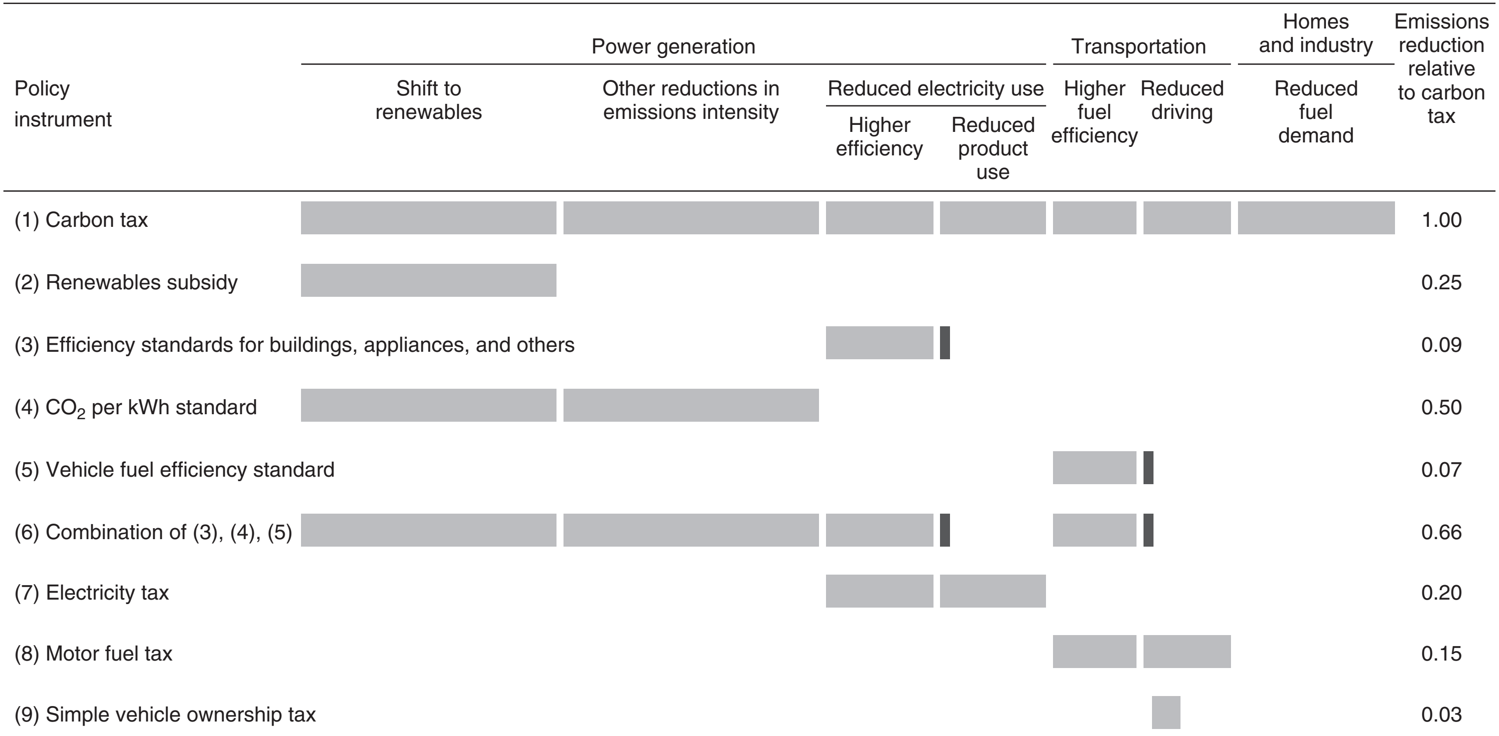
[3]These assumptions are based approximately on carbon price analyses for the United States in Krupnick and others (2010) and Parry, Oates, and Evans (2014). Most of the low-cost mitigation options are related to fuel switching in power generation, given the array of alternatives to high-carbon coal. In transportation, options for switching from fossil fuels to cleaner fuels remain limited, and vehicle fuel efficiency is already encouraged by high fuel prices and fuel efficiency regulations. One complication (not considered here) is the possibility that future pledges to penalize carbon emissions might, by lowering the future returns to fossil fuel production, accelerate incentives for fuel production in the nearer term, thereby undermining some of the emissions benefits. For alternative perspectives on this possibility, see Sinn (2012) and Cairns (2014).

[4]For example, an electricity tax is assumed to reduce electricity demand by the same amount as a carbon tax, and a renewables subsidy is assumed to cause the same emissions reduction (by shifting from fossil fuels for generation to renewables) as the carbon tax.

[5]The illustration assumes this effect offsets 10 percent of fuel savings from improved fuel efficiency, based on Small and Van Dender (2006).

Figure 3.1 Illustrative Sources of Fossil Fuel CO_2 Reductions under Different Policies



Sources: Based approximately on analyses for the United States in Krupnick and others (2010) and Parry, Evans, and Oates (2014).

Note: Light gray bars indicate emissions reductions induced by different policies; policies are scaled (when applicable) to have the same effect, for example, on fuel efficiency and electricity demand, as a carbon tax. Dark gray bars indicate sources of increased emissions because lower per unit energy costs increase demand for energy-using products (the rebound effect).

reductions under the carbon tax). If combined with comprehensive policies to improve the energy efficiency of vehicles and electricity-using equipment, such a package could exploit up to two-thirds of the emissions reductions under the carbon tax. But some mitigation opportunities are missed, such as encouraging people to drive less. Moreover, regulatory packages can be excessively costly without extensive credit trading (as discussed below), and they do not raise revenue.

Targeting the right base

Other "proxy" taxes are usually far less effective than carbon pricing (again, see Figure 3.1). For example, excise taxes on electricity consumption miss 80 percent of the mitigation opportunities achieved by carbon pricing. Also prevalent are vehicle ownership taxes (sales excises as well as registration fees and annual road charges), but these taxes, at least in their simple form unrelated to emissions, miss about 97 percent of the mitigation opportunities brought about by carbon pricing in this example.[6]

Cost Effectiveness: A First Look

Besides their effectiveness, the second main rationale for fiscal instruments is that they achieve a given environmental improvement at the lowest overall cost to the economy.

The focus of this discussion is on economic costs, as defined in Box 3.2, rather than other metrics such as GDP and employment. For now, policies are compared based on a limited definition of cost that ignores important links with the broader fiscal system (discussed in the main text below).

Environmental taxes (and ETSs) are cost-effective because they promote equalization of incremental mitigation costs across different behavioral responses. For example, with the same price on all CO_2 emissions, firms and households alike face the same incentives to alter their behavior in ways that reduce emissions up to the point at which the cost of the last ton of CO_2 reduced equals the emissions tax. ETSs are also cost-effective in this regard (so long as credit trading markets are fluid) because they also establish a uniform price on emissions across different sources.

Traditional regulatory policies, in contrast, may not perform well on cost-effectiveness grounds if they require that all firms meet the same standard and there is significant variation in pollution intensity among firms (implying it is much more costly for some to meet the standard than others). Credit trading in fluid markets is required to make these policies cost-effective, including provisions allowing the following:[7]

- Firms, such as generators with relatively emissions-intensive plants, to fall short of the standard (e.g., a limit on average emissions per kWh produced)

[6]This assumes (based on Fischer, Parry, and Harrington, 2007) that one-third of the reduction in driving in response to higher fuel prices comes from reduced vehicle ownership and two-thirds from reductions in kilometers driven per vehicle (a vehicle excise tax only induces the first response).
[7]Empirical studies (see, e.g., Newell and Stavins, 2003, and the references contained in their footnote 2) have documented cases of substantial cost savings from these types of flexibility provisions.

by purchasing credits from other firms that have relatively clean plants that exceed the standard

- Firms to trade credits across different regulatory programs, thereby establishing a uniform emissions price across all sectors covered by regulation.

BOX 3.2

Defining Economic Costs

The economic costs of environmental policies refer to the costs or benefits of the various ways households and firms respond to the policy, both directly (e.g., through responses to higher fuel prices) and indirectly (e.g., through the responses to broader taxes that might be reduced because of the increase in environmental tax revenues).

Staying with the carbon pricing example, the costs of the direct behavioral responses include, for example

- Higher production costs to power generators from using cleaner, but more expensive, fuels
- Costs to households from driving less than they would otherwise prefer (the value of trips forgone, less savings in time and fuel costs)
- Costs to firms and households from switching to more energy-efficient vehicles, appliances, machinery, and so on—that is, the upfront purchase costs less the life cycle savings in fuel costs.

More generally, higher energy and transportation costs tend to slightly contract the overall level of economic activity, which, in turn, may slightly reduce economy-wide employment and investment. As discussed in the main text below, employment and investment levels are already distorted by taxes on work effort and capital accumulation, and environmental policies cause economic costs if they worsen these distortions. However, environmental tax revenues provide an offsetting benefit if they are used to lower the taxes on work effort and capital accumulation.

Economic costs do not include pure dollar transfers between the private sector and the government—whatever dollar amount the private sector pays in tax liabilities is offset by a revenue benefit to the government. Economic costs are also quite different from job losses in industries burdened by environmental policies (at least some of which are made up by other sectors after a, perhaps lengthy, adjustment period)—employment effects do matter for costs, as just noted, but the issue is entwined with the employment effects of the broader tax system. Economic costs need not be closely related to changes in GDP either (Krupnick and others, 2010, p. 23).

The concept of economic costs has been endorsed by governments around the world for purposes of evaluating government spending, tax, and regulatory policies. In the United States, for example, a series of executive orders since the 1970s has required government agencies to conduct hundreds of cost-benefit assessments a year, based on the notion of economic costs, to determine whether major policy initiatives are warranted from society's perspective.

The broader macroeconomic impacts of environmental taxes are likely to be modest, at least if revenues are used to lower burdensome taxes on work effort and capital accumulation. The short-term macroeconomic impacts could be larger if revenues are used to reduce budget deficits, though that would be true of any fiscal consolidation measure. The fiscal crisis late in the first decade of the 2000s should not detract from efforts to price environmental damage, not least because of their contribution to badly needed revenues (Jones and Keen, 2011).

Balancing Benefits and Costs

The third attraction of tax and pricing policies—that they can strike the right balance between environmental benefits and costs to the economy—requires that prices be set equal to their "corrective" levels, that is, equal to incremental environmental damage. If prices are less than environmental damage, some socially desirable environmental improvements will be forgone; if prices exceed environmental damage, some environmental improvements will be made that are not justified by their cost.[8]

The corrective tax calculations in Chapter 6 assume that the environmental damage per unit is constant (e.g., damage per ton of emissions, or congestion costs per vehicle-kilometer traveled). This seems reasonable, for example, for CO_2 damage, because one country's emissions in one year add very little to the atmospheric accumulation of greenhouse gases. The assumption might appear more questionable for local air pollution, implying, as it does, that the corrective tax should be independent of local ambient air pollution, though some justification is provided in Box 3.3.

Constant environmental damage per unit also favors the use of instruments that price emissions (but that allow the quantity to vary with changes in energy demand, fuel prices, and so on) over instruments that fix the quantity of emissions but allow prices to vary. The latter are more appropriate when the thresholds beyond which environmental damage rises sharply are known (Weitzman, 1974), though these cases do not seem especially relevant for this volume.

Damage per unit also varies across regions within a country, for example, the human health effects of air pollution depend on local population exposure. In principle, charges could be differentiated according to the location of the emissions source, though this complicates administration—mostly because pollution from tall smokestacks can be transported great distances (Chapter 4). Moreover, studies (e.g., Muller and Mendelsohn, 2009) suggest that imposing an appropriately scaled, uniform emissions charge produces the biggest net benefit—differentiating the charge according to region produces additional, but smaller, benefits.

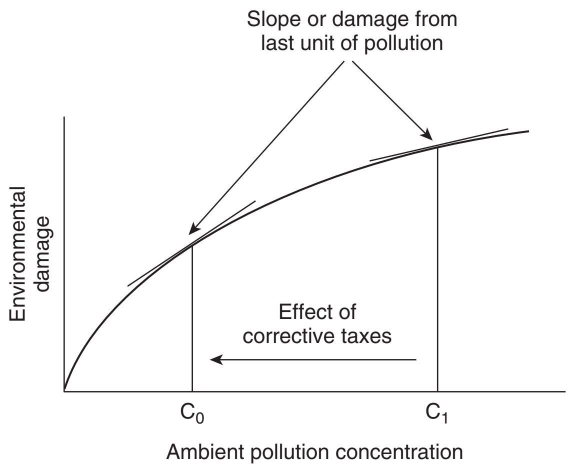
[8]Corrective taxes are sometimes called Pigouvian taxes after the economist Arthur Pigou, who first recommended them.

BOX 3.3

Shape of the Air Pollution Damage Function

As discussed in Chapter 4, some evidence suggests that the relationship between environmental damage and ambient air pollution concentrations begins to flatten out at higher levels of pollution concentration (because people's ability to take in more pollution becomes saturated). Therefore, the slope of the environmental damage function is flatter at the high pollution concentration C_1 in Figure 3.3.1, compared with the slope at the lower concentration level C_0. Thus, additional pollution emissions do less harm at concentration C_1 than at C_0.

Figure 3.3.1 Shape of the Air Pollution Damage Function



This function might suggest that, given other factors, the corrective tax on fuel or emissions should be lower, paradoxically, in high-pollution countries. This possibility is ignored in this study, however. If corrective taxes of the scale typically estimated in this volume were to be introduced, emissions would fall dramatically, most likely lowering pollution concentrations below levels at which the damage curve might flatten out.

Environmental Taxes in a Broader Fiscal Context

This subsection discusses the distortions to economic activity created by the broader fiscal system and how environmental taxes impact these distortions. The appropriate treatment of energy products under value-added taxes (VAT) or similar sales tax systems is discussed in Box 3.4, but, assuming normal procedures are applied, is not relevant for corrective tax design.

BOX 3.4

Coverage of Energy Products under the Value-Added Tax (VAT)

Leaving aside environmental considerations, basic tax principles suggest that all consumption goods should be included under any VAT (or other general sales tax) system, to raise revenues without distorting choices among consumer goods. Intermediate inputs should be excluded from VAT to avoid distorting firms' choices about the mix of labor, capital, energy, and material inputs. These principles apply automatically under normal VAT systems, so long as intermediate goods are sold to entities paying VAT—any taxes paid under the VAT for power generation fuels and electricity used by industry are, appropriately, reimbursed.

In contrast, any tax rate applying to consumer goods in general should also be applied to household purchases of electricity, vehicles, and fuels. Ideally, any VAT should apply to fuel prices including corrective taxes, to avoid distorting choices among consumption goods, taking account of their full social costs of production. Corrective fuel tax estimates reported in Chapter 6 are before any application of VAT.

Taxes on labor income (e.g., personal income and payroll taxes) can cause large differences between wages that workers take home and compensation paid by firms. As a result, these taxes tend to depress work effort by discouraging labor force participation, overtime, effort on the job, investments in human capital, and so on. The VAT (and other consumption taxes) has similar effects because it reduces the amount of goods that can be purchased from a given amount of work effort.

Similarly, taxes on corporate income and individual income from savings tend to burden the economy by reducing capital accumulation below the level that would otherwise occur.

Environmental taxes (or similar instruments) interact with these sorts of distortions in two opposing ways (Goulder, 2002; Parry and Oates, 2000).[9]

First, because environmental taxes are passed forward into the prices for fuels, electricity, transportation, and so on, they tend to contract, albeit very slightly, the overall level of economic activity, which, in turn, reduces employment and investment. In effect, energy taxes act like implicit taxes on labor and capital, and they compound the adverse effects of those taxes. Studies find that the costs of environmental taxes (or ETSs) are considerably higher—possibly several times higher (Goulder, 2002; Parry and Oates, 1999)—when their adverse effects in tax-distorted factor markets are taken into account.

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[9]This discussion abstracts from the possibility of other, nontax, distortions in labor markets, such as wage rigidity (e.g., from union power) and chronically deficient demand.

Second, however, if environmental tax revenues fund broader tax reductions, relatively large economic benefits are produced by increasing incentives for work effort and capital accumulation, reducing incentives for informal activity, and reducing distortions from tax preferences (e.g., for housing). This offsets most, or more than offsets the adverse effects on factor markets from higher energy prices, implying moderate costs overall for the economy and perhaps negative costs if revenues are used to reduce a particularly distortive tax. Although environmental tax revenues are earmarked more often than other taxes, there are notable examples of environmental tax revenues substituting for other taxes (Box 3.5). Of course, there are alternative revenue uses that might yield comparable economic benefits, including reducing budget deficits, which, in turn, lowers future tax burdens, and funding socially desirable spending.

Despite the fiscal dividend, this is not necessarily a reason to set higher tax levels—roughly speaking, environmental taxes should be set on environmental grounds, with further revenue requirements met through broader fiscal instruments (personal income taxes, VAT, and so forth).

BOX 3.5

Environmental Tax Shifting in Practice

Several countries have introduced, or increased, environment-related taxes while simultaneously cutting other taxes:

- In the early 1990s, Sweden introduced taxes on oil and natural gas to charge for carbon and (for oil) sulfur dioxide and on coal-related sulfur dioxide and industrial nitrogen oxide emissions. These reforms were part of a broader tax-shifting operation that also strengthened the value-added taxes while reducing taxes on labor and traditional energy taxes (on motor fuels and other oil products).
- Between 1999 and 2003, Germany increased taxes on transportation fuels and introduced new taxes on natural gas, heating fuels, heavy fuel oil, and primarily residential electricity consumption. About 85 percent of the revenue was used to fund reductions in employer and employee payroll taxes, about 14 percent was used for budget consolidation, and 1 percent for renewable energy programs.
- In Australia's carbon pricing scheme, which covers about 60 percent of carbon dioxide emissions, about three-quarters of the allowances are auctioned, with half of this revenue used to fund a tripling of personal income tax thresholds. This scheme was implemented in 2012, but now looks likely to be scrapped.
- From 2008 to 2012, British Columbia progressively introduced a carbon tax covering 70 percent of fossil fuel emissions, with more than 90 percent of the revenues used to fund reductions in personal and corporate taxes.

Sources: Department of Climate Change and Energy Efficiency (2011); Government of British Columbia (2012, pp. 66).

However, insofar as possible, exploiting the fiscal dividend is critical, given the large amount of revenue at stake (Chapter 6). If revenues from environmental taxes are not used productively, the overall costs of environmental taxes can be substantially higher.[10]

This last point has some notable policy implications:

- *Be wary of earmarking* environmental tax revenues, such as for clean energy programs or climate adaptation. Ideally, any earmarked spending should generate comparable economic benefits from alternative revenue uses (e.g., lowering other tax burdens).[11]
- *Compensate appropriately*: Compensation payments (e.g., for groups especially vulnerable to higher energy prices) may have high equity and political value, but can significantly reduce the overall cost-effectiveness of environmental taxes by reducing revenues for other, perhaps more economically efficient, purposes such as cutting other burdensome taxes. Policymakers need to evaluate the trade-offs carefully.
- *If possible, use compensation schemes that improve economic efficiency:* Tensions between compensation and cost-effectiveness might be ameliorated if the compensation scheme produces economic benefits. For example, providing relief to low-income households through tax reductions (e.g., lowering the basic rate of tax, rebating payroll taxes, providing earned income tax credits) improves incentives for work effort, whereas transfer payments made regardless of work effort do not.

Taxes versus ETS: A Quick Look

In principle, the choice between emissions taxes and ETS is less important than implementing one of them and getting the design details right. The most important of these details are the following:

- Comprehensively covering the sources of environmental harm
- Prudently using the fiscal dividend
- Scaling program stringency to environmental damage
- Establishing stable and predictable prices.

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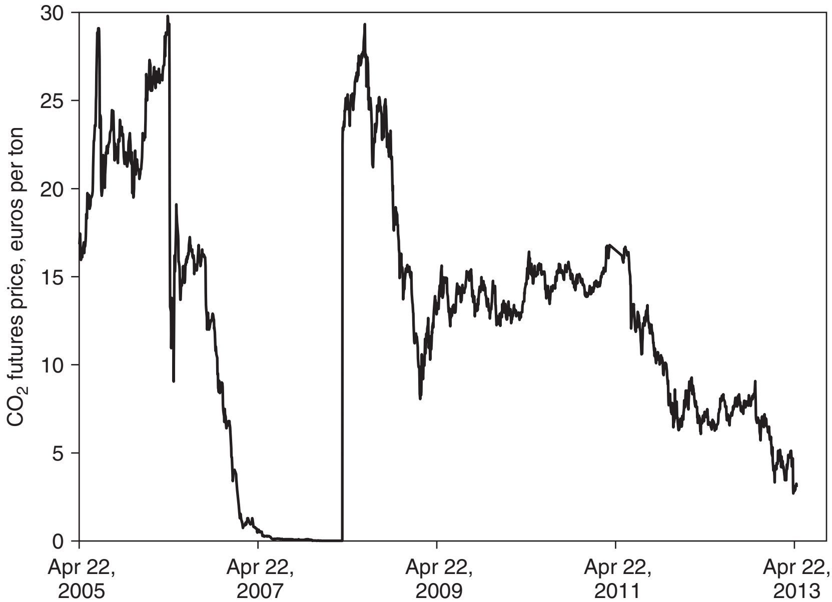
[10]In fact, environmental taxes can lose their cost-effectiveness advantage over regulatory alternatives (Goulder and others, 1999; Parry and Williams, 2012). Environmental taxes can cause larger increases in energy prices (because they involve the pass-through of tax revenues in higher prices) than regulatory policies (which do not raise revenues): the larger the increase in energy prices, the larger the adverse effects on tax-distorted factor markets—and hence the need to offset these higher costs with productive use of revenues.

[11]Another problem with earmarking is that there is no relationship between the economically appropriate amount of spending on clean energy or related programs and the amount of revenues raised by a corrective environmental tax. The tendency with earmarked revenues has been to set tax levels to meet spending requirements, resulting in tax rates frequently well below levels needed to correct for environmental damage (Opschoor and Vos, 1989).

Figure 3.2 Price Experience in the European Union Emissions Trading System



Source: Bloomberg (2013) EU-ETS futures series "MO1 Comdty."
Note: CO_2 = carbon dioxide.

The importance of the first three design features was discussed above.

The fourth helps to contain program costs. Pure ETS systems carry the danger that either the cap will be too low at a given time (e.g., because energy demand turns out to be lower than expected), in which case emissions prices are depressed and low-cost mitigation opportunities forgone, or the cap will be too tight, such as in periods of high energy demand, in which case emissions prices and mitigation costs are excessive. A predictable and rising emissions price also fosters expectations that policy will be sustained, which is important for clean technology development and deployment (especially technologies with high upfront costs and long-range returns). Predictable prices also reduce uncertainty about revenues. Price volatility has been a problem in some trading systems, for example, in the European Union where futures prices reached €30/ton of CO_2 in 2006 and 2008, but fell to less than €5/ton in 2007 and again in 2013 (Figure 3.2).

Striving for price stability implies a political trade-off, however, given that emissions vary from year to year—to date, climate policy goals have usually been expressed as annual emissions levels rather than price targets.[12]

[12]"Carbon budgets" are a possible compromise between emissions targets and price targets. Carbon budgets would specify allowable emissions cumulated over a long period (say 10 years), but allow year-to-year variability in emissions. They could be implemented through a carbon tax whose rate might be adjusted later in the budget period if cumulative emissions would not otherwise be on track to stay within budget.

Appropriately designed environmental taxes naturally meet the four design features. So do ETSs if allowances are auctioned and price stability provisions such as price floors and ceilings are included.[13]

In practice, a carbon tax seems to be the instrument more likely to fully exploit the fiscal dividend because it would presumably be administered by a finance ministry, for example, as an extension of existing motor fuel excises to other petroleum products, coal, and natural gas. An environmental agency administering an ETS might be reluctant or legally unable to remit all revenues from allowance auctions to the finance ministry.

Tax and pure ETS systems can also interact differently with other climate-related policies. For example, policies to promote renewables and energy efficiency will not affect emissions if emissions are held fixed by a cap—instead, they lower emissions prices (if there is no price floor) and the potential fiscal dividend from an ETS.[14] In the presence of carbon taxes, however, other policies reduce emissions (rather than the emissions price, which is fixed by the tax) and therefore tend to have a much weaker impact on reducing revenues.

It has been suggested that an ETS is the more natural instrument for channeling climate finance to developing countries because it can be combined with offset programs. Offsets could be included under a tax, however—tax credits could be awarded to domestic fuel suppliers for funding climate mitigation projects in developing countries. Again, offset provisions, assuming they promote genuine emissions reductions as opposed to reductions that would have occurred anyway, improve environmental effectiveness under a tax without substantially reducing revenues. But under an ETS with no price floor, offset provisions lower the emissions price and carbon pricing revenues with no effect on total emissions.

FURTHER DESIGN ISSUES

Several complicating factors are now considered, relating to overlapping environmental problems, the interactions with and roles of other policies, measures to improve the acceptability of policy reform, and relevance for low-income countries. Further issues are touched on in Box 3.6.

Multiple Environmental Problems

As discussed in Chapter 2, energy and transportation systems cause more than one source of environmental harm—fuel combustion leads to both carbon

[13]Studies for the United States (Fell, MacKenzie, and Pizer, 2008) suggest that an ETS scaled to achieve the same cumulative emissions reduction as a carbon tax would be moderately (about 15 percent) more costly over time if the ETS lacked price stability provisions.

[14]In practice, however, policymakers may be more willing to tighten an emissions cap if emissions prices are reduced through other policies.

BOX 3.6

Unintended Consequences and Market Price Distortions

This box discusses examples of unintended consequences from tax reform and the implications of market price distortions. An illustration of unintended consequences is when environmental taxes cause increased use of substitute fuels with environmentally harmful effects that cannot themselves be priced.

For example, fossil fuel taxes can lead to excessive reliance on nuclear power, with its consequent risks of meltdowns and unsafe waste disposal. In the absence of effective regulatory and liability frameworks to adequately minimize these risks (they are difficult to address through taxes on nuclear power, primarily because of uncertainty about the probability and scale of disasters), taxes on fossil fuels for generation should be phased in more cautiously. Similar issues arise if heavy taxation of coal use leads to extraction of domestic shale gas reserves, which, without safeguards, could pose significant environmental risks (e.g., from groundwater pollution or escape of methane—a potent greenhouse gas).

To take another very specific example, fine particulate concentrations are especially high in Ulaanbaatar, Mongolia as the result of coal use for winter home heating. However, if residential coal prices were significantly increased through taxation, households may be induced to instead burn highly toxic plastics, rubber, or other difficult-to-price garbage, with possibly even worse consequences for human health (World Bank, 2011). The problem is the lack of viable cleaner alternative fuels—until such alternatives, perhaps imported oil or liquefied natural gas, are provided, high residential coal taxes may not make sense (although taxation of coal for power generation should not be precluded). In principle, the corrective fuel tax in this instance would be adjusted downward by the increase in the use of other fuels per unit decrease in the taxed fuel, times the per unit environmental damage from the other fuel.

Another example is related to tax competition. Higher diesel fuel taxes in one European country could induce truckers to refuel in neighboring countries with lower tax rates, offsetting some of the domestic pollution and congestion benefits. One response is for countries to coordinate their minimum fuel tax rates (T&E, 2011). Another is to partially transition to kilometer-based tolls that truckers must pay regardless of where they purchase fuel.

Environmental taxes can also interact with market price distortions. If, because of limited competition, product prices exceed per unit production costs, consumption of the product will be too low from an economic perspective. In principle, a lower environmental tax affecting such an industry might be called for, though in practice any adjustments may be very modest (Oates and Strassmann, 1984). In other cases, such as at state-owned enterprises, product prices may fall short of per unit production costs, though whether this justifies tax levels significantly higher than environmental damage is an open question (especially because of lack of transparency about the extent of price distortions). In either of these cases, however, the ideal policy would be to remove the market price distortion and set the environmental tax on environmental grounds.

emissions and local air pollutants, while broader adverse side effects of vehicle use include, for example, road congestion. The implications for fiscal policy design are discussed below, taking in turn power generation, heating, and transportation fuels.

Power generation fuels

Fossil fuel combustion at power plants causes carbon emissions and local air pollutants, the most important of which is fine particulates (particulate matter with diameter of up to 2.5 micrometers, or $PM_{2.5}$). These particulates are emitted directly (e.g., during coal combustion) and are formed indirectly from chemical transformations of sulfur dioxide (SO_2) in the atmosphere, and to a lesser extent (because it is less reactive), nitrogen oxides (NO_x). SO_2 is primarily caused by coal combustion, and NO_x is produced from all fossil fuels.

Damage from these emissions is generally additive (with some caveats—see Chapter 4) and can be addressed either through taxes imposed on fuel supply in proportion to emissions factors (with appropriate crediting for any emissions capture at the point of fuel combustion) or taxes imposed directly on emissions.

For coal, the appropriate set of charges on fuel input at power plants includes the following four charges:

- Tons of CO_2 per unit of energy times damage per ton of CO_2
- Tons of $PM_{2.5}$ per unit of energy times damage per ton of $PM_{2.5}$
- Tons of SO_2 per unit of energy times damage per ton of SO_2
- Tons of NO_x per unit of energy times damage per ton of NO_x

Emission rates are defined with respect to energy rather than tons of coal given the variation in energy content across different coal types (discussed in Chapter 4). Default charges could reflect emission rates before any application of emissions control technologies—for which reasonable data are generally available by country from independent sources (Chapter 4)—with the onus on the plant operator to demonstrate, through use of continuous emissions monitoring technologies, any reduction in emission rates from application of control technologies to receive an appropriate tax credit.

Alternatively, if charges are levied on emissions rather than fuel input, the appropriate rate per ton of emissions would simply reflect environmental damage per ton, with separate charges applicable to each of the four pollutants. This approach might be more complex to monitor and enforce because governments need to assemble local air emissions data themselves by ensuring that all plants install, and correctly operate, continuous emissions monitoring technologies.

The same design principles apply to natural gas plants, though emissions damage is much lower, and charges for primary particulates and SO_2 may not be needed because the emission rates for these pollutants are, at most, very small.

Heating fuels

A fuel charge is likely the preferred regime for heating fuels such as natural gas, given the large number of small-scale emissions sources in the household sector. Again, the same principles for aggregating over emissions sources (though perhaps for just CO_2 and NO_x) as just discussed would apply.

Transportation

Fuel taxes are discussed first (the focus of this volume) followed by kilometer-based taxes, which are a possibility for the longer term.

Motor fuel taxes: Consider first gasoline taxes for passenger vehicles, for which there are four main environmental side effects: CO_2, local air pollution, traffic congestion, and traffic accidents.[15]

If fuel taxes are the only fiscal instrument available, the corrective tax, expressed in fuel units following normal practice, is given by Parry and Small (2005):

[CO_2 damage per liter] (3.1)
+
[(congestion, accident, and local pollution costs imposed on others per extra kilometer of driving)
×
(kilometers per liter)
×
(fraction of the fuel reduction resulting from reduced driving rather than from higher fuel efficiency)]

The first component in this formula charges for CO_2 emissions and is calculated by CO_2 emissions per liter—essentially the same for gasoline across all countries[16]—times CO_2 damage per ton.

The second component reflects effects varying with vehicle-kilometers—congestion, accidents, and local pollution (see below)—rather than fuel use. Multiplying their combined, economy-wide average costs per kilometer by fuel efficiency (kilometer per liter) expresses the effects in costs per liter.[17]

Distance-related costs are also multiplied by the fraction of the tax-induced reduction in gasoline use resulting from reduced driving, as opposed to the

[15]For further discussion of these side effects, see de Borger and Proost (2001); CE Delft, Infras, and Faaunhofer ISI (2011); Delucchi (2000); Maibach and others (2008); Quinet (2004); Santos and others (2010); US FHWA (1997).

[16]This discussion focuses on the taxation of pure gasoline and leaves aside the taxation of ethanol (which is sometimes blended with gasoline) and compressed natural gas, both of which are relevant for specific countries.

[17]Ideally, account should be taken of how fuel efficiency responds to changes in fuel taxes, though for simplicity the calculations below omit this complication.

fraction resulting from fuel efficiency improvements. (As a rough rule of thumb this fraction is 0.5.) The smaller this first fraction, the smaller the benefits per liter of fuel for reduced congestion, accident, and local pollution, implying a smaller corrective fuel tax would be appropriate.

Note that in the second component in equation (3.1) costs could alternatively be expressed per unit of fuel use, rather than per kilometer, skipping the need to measure fuel efficiency (for which accurate data are often lacking)—so long as these costs are scaled by the driving fraction of the fuel response.

For gasoline (as for natural gas) the major local air pollutant is NO_x. Equation (3.1) assumes that reductions in kilometers driven reduce these emissions, while fuel efficiency improvements do not. This assumption is reasonable in countries such as the United States, where the same emissions per kilometer (or mile) standards are imposed on all vehicles, irrespective of their fuel efficiency, and emission rates are maintained, at least to some extent, throughout the vehicle life by inspections programs (Fischer, Parry, and Harrington, 2007). In countries lacking these regulations, local emissions would instead be proportional to fuel use, and would therefore enter the first component in equation (3.1).

Equation (3.1) applies to motor diesel used by commercial trucks, but with some modifications (aside from different input values). Local air emissions from trucks have not traditionally been regulated on an emissions per kilometer basis and are therefore proportional to fuel use (i.e., they should not be multiplied by the driving portion of the fuel demand response). In addition, trucks are almost entirely responsible for vehicle-induced wear and tear on roads given that road damage is a rapidly escalating function of a vehicle's axle weight (Evans, Winston, and Small, 1989), and this damage should enter the second component of the corrective fuel tax.[18]

In practice motor diesel is used by both cars and trucks. Given administrative complications in differentiating the price at the pump paid by these different vehicles, the main corrective tax estimates presented in this analysis average car and truck fuel use, though it turns out not much differentiation would be warranted anyway. However, a much lower tax rate would be appropriate for off-road uses of diesel, such as in farm and construction vehicles, though differentiation in this case is more feasible (e.g., by putting dyes into fuels).

Distance-based taxes: In the longer term, countries ideally should be partially shifting away from fuel taxes toward kilometer-based taxes to more effectively address side effects that vary directly with distance traveled (Johnson, Leicester, and Stoye, 2012).

For congestion, per kilometer tolls on busy roads that progressively rise and fall during the course of the rush hour exploit all possibilities, given existing transportation infrastructure, for inducing behavioral changes to alleviate congestion (see Box 3.1).

For accidents, per kilometer charges might be scaled according to driver risks (e.g., higher for those with higher insurance company rating factors based on age,

[18]Noise is sometimes discussed as another adverse side effect from trucks, though is ignored here because the damage costs appear modest relative to other effects (US FHWA, 2000).

prior crash records, and the like) and perhaps would be higher for larger vehicles posing greater crash risks to others.[19] Even for local air emissions, a better corrective tax might be a per kilometer toll, the rate for which depends on the emissions characteristics of the vehicle and on local population exposure to those emissions.

Finally, road damage is most efficiently addressed through per kilometer tolls on heavy trucks, scaled by their axle weight, which would encourage truckers to seek vehicle fleets that carry goods efficiently over more axles.

Thus, in principle, the ideal fiscal system for motor vehicle transport would involve charging motorists for each kilometer driven, and the charge would be scaled according to factors affecting the congestion, accident, local pollution, and possible road damage costs imposed on others by that kilometer driven, and a fuel tax component would be retained to address carbon emissions. Developments in metering technologies such as global positioning systems (GPS) suggest that kilometer-based tax systems are now feasible (see Box 3.7). The trade-offs between policy effectiveness and administration costs need careful study, however—for example, extra administration required to fine-tune local kilometer charges to emission rates and population exposure may not be worthwhile if emissions are being controlled effectively by direct regulations.

BOX 3.7

Examples of Distance-Based Charging for Vehicles

This box describes some examples of per kilometer charging systems; only the last is a nationwide scheme.

Singapore introduced an area license (or day-pass) scheme in 1975 that dramatically raised travel speeds within the restricted zone, though also initially increased congestion outside of the zone (Santos, 2005). In 1998 area licensing was replaced with an electronically debited toll on certain links, with the objective of maintaining average speeds of 30–40 miles per hour on expressways and 12–18 miles per hour on major roads. Charges rise and fall in 30-minute steps during peak periods, based on congestion levels observed in the previous quarter.

Norway experimented with cordon tolling, though with little effect on congestion given that the objective was to raise a modest amount of transportation revenue rather than deter congestion.

London introduced an area licensing scheme in 2003 with a daily congestion charge on weekdays of £8. Collection is enabled by video cameras at checkpoints into and within the priced area that record each vehicle's license plate. Penalties are mailed to drivers who have not prepaid. In the first two years, congestion fell 30 percent within

[19]Distance-based charges for congestion and accidents should apply equally to similar-size vehicles, regardless of their fuel type or fuel efficiency (i.e., besides traditional fuel vehicles they should also cover hybrid, electric, and natural gas vehicles).

the priced zone, though by 2008 average speeds had fallen back to previous levels because of more traffic from exempt vehicles and because some roads were reserved for the exclusive use of buses, pedestrians, and cyclists (Transport for London, 2008). A similar scheme now operates in Milan, with a fixed daily charge of €5.

Stockholm implemented a cordon toll in 2007 covering an area of about 36 square kilometers (again, enforcement is based on license plate recognition). Fees for passing the cordon vary between 10 and 20 Swedish krona with time of day, though some vehicles are exempted (emergency vehicles, buses, motorcycles, alternative fuel vehicles). Congestion initially dropped by 50 percent on the main routes approaching the city center, and 20 percent within the city center, though it subsequently deteriorated (Eliasson, 2009).

Congestion pricing is gaining limited momentum in the United States, with federal funding for pilot schemes under the Value Pricing Program and the reduction of regulatory obstacles to freeway pricing. Some schemes open up links previously reserved for high-occupancy vehicles to single-occupant vehicles in exchange for a fee (e.g., Interstate 15 in San Diego, California) while others use tolls to fund new infrastructure (e.g., lanes added to State Route 91 in Orange County, California, in 1995).

Germany introduced a nationwide tolling system (metered by GPS) for highway use by trucks weighing 12 tons or more in 2005. Charges vary between €0.14 and €0.20 per kilometer according to vehicle type, number of axles, and emission rates—eventually, the tolls will also vary with time of day and region.

Given that widespread applications of kilometer-based taxes appear to be a long way off,[20] in the interim it is still appropriate (it produces significant net economic benefits) to reflect all adverse side effects of vehicle use in fuel taxes.

Implications of Other Policies for Environmental Tax Design

The discussion now turns to a variety of other commonly implemented, mostly regulatory, policies aimed at reducing fossil fuel emissions and that may have implications for the impact or design of environmental taxes.[21]

Renewables and energy efficiency regulations: Renewables and energy efficiency regulations (for the power sector) do not affect environmental damage per unit of coal or natural gas and therefore do not change corrective taxes for these fuels. Their effect is to reduce environmental benefits from tax reform because some of the potential behavioral responses (shifting from fossil fuels to renewables, adoption of electricity-saving technologies) will already have been induced by the regulation.

Emissions trading systems (ETSs): Taking the example of a carbon tax, if the tax is targeted to the same base to which an ETS (without price floors) already

[20]For example, proposals for nationwide distance-based taxes in the Netherlands and the United Kingdom have been put on hold.

[21]Subsidies for fossil fuel consumption are not considered here because they act like negative fuel taxes (though existing subsidies are factored into estimates of the impacts of policy reform in Chapter 6).

applies, the tax will reduce allowance prices rather than affect emissions (which are fixed by the cap). On net, government revenues from the tax and the ETS should be unaffected if allowances are auctioned, or increased if allowances are freely allocated. In the latter case, the tax appropriates rents that would otherwise have accrued to allowance holders.[22]

Air emissions regulations: Regulations may include requirements that new plants incorporate control technologies, such as flue gas desulfurization technologies, or maximum allowable rates for emissions per kWh averaged across generators' plants (see Box 3.1). Again, these policies do not affect the appropriate charge per ton for the remaining emissions, though they do affect the appropriate tax credit needed to reflect differences between uncontrolled and controlled emission rates in a fuel charge system. They also shave off some of the effectiveness of emissions charges.

Vehicle fuel efficiency and emissions standards: Fuel efficiency standards also dampen some of the environmental effectiveness of fuel taxes. In addition, they can raise corrective motor fuel taxes by increasing the fraction of a given tax-induced reduction in fuel use that comes from reduced driving, thereby multiplying the contribution of kilometer-related costs to the corrective fuel tax (based on equation (3.1)). Emissions per kilometer standards (applied to new vehicles) have the opposite effect: by reducing average emission rates they lower the local pollution component of the corrective fuel tax.

Other Policies to Address the Limits of Environmental Taxes

Regulatory policies could potentially complement environmental taxes, for example, if practical constraints reduce the ability to implement pricing reforms, or if the policies promote responses beyond the reach of fuel taxes (e.g., emissions regulations encourage vehicle manufacturers to reduce emissions per liter, whereas fuel taxes do not). This subsection briefly discusses the design of these policies, focusing first on traditional regulations and then on more novel policies.

Traditional regulatory approaches

Desirable features of regulatory policies include the following:

- Broad coverage to promote the widest possible range of opportunities for reducing environmental harm. As mentioned earlier, for example, a CO_2 per kWh standard for power generation is much more effective than a renewables policy, because the emissions standard addresses all fuel-switching possibilities to reduce emissions rather than just a shift to renewables.
- Credit trading provisions to allow some firms to fall short of the standard, especially if meeting the standard is prohibitively costly, by purchasing credits from other firms that exceed the standard.

[22]This occurs in the European Union ETS because the U.K. government collects revenue from its carbon tax floor partly at the expense of allowance holders elsewhere in the European Union.

- Price ceilings and floors (despite their tendency to reduce the urgency of credit trading provisions). The ceiling allows firms to pay fees instead of fully meeting the standard, which they might do in periods when compliance costs are relatively high, while the floor allows firms to receive subsidies if they exceed the standard in periods when compliance costs are relatively low. Ideally, these price ceilings and floors would be harmonized across different regulations and they would be set so implicit prices on emissions are in line with estimated environmental damage.

These price-stability features would make regulations look more like corrective environmental taxes. However, regulations would still differ from taxes in that they do not exploit all emissions mitigation opportunities, and they do not, on average, increase revenue. They might be more politically acceptable, however, because they have smaller impacts on energy prices given that they do not involve the pass-through of taxes in higher prices.

Novel alternatives to environmental taxes

More novel options for mimicking the effects of environmental taxes, again without a large, politically difficult increase in energy or product prices, are considered below.

"Feebates" are a combination of fees and rebates. Such policies have mainly been discussed as an alternative to CO_2 emissions per kilometer (or equivalently, fuel efficiency) standards on new vehicles (Small, 2010). Feebates would involve a fee on new vehicles with above-average CO_2 per kilometer and a rebate to vehicles with below-average CO_2 per kilometer, and fees and rebates are levied in proportion to the difference between the vehicle's CO_2 per kilometer and some "pivot point." If the pivot point is the average CO_2 per kilometer of, say, last year's new vehicle fleet, the policy would be approximately revenue neutral. If revenue from vehicles is a priority, perhaps because of constraints on broader fiscal instruments, feebates can be combined with vehicle excise taxes (see Box 3.8).

BOX 3.8

Reconciling Fiscal and Environmental Objectives in Vehicle Taxation

Vehicle excise taxes are often related to CO_2 per kilometer, with vehicles classified into different brackets and more favorable taxes applied to the lower emission rate brackets. These excise taxes are an improvement over tax systems related to engine capacity because they address some emissions-saving opportunities (e.g., reducing vehicle weight or improving rolling resistance) that the latter do not.

But one problem with these schemes is that they set up a tension between revenue and environmental objectives—the more successful the policy in shifting people to lower emissions vehicles, the lower the tax receipts. Moreover, tax brackets do not provide ongoing incentives for manufacturers to reduce the emission rate of the vehicle once it has fallen into the next lower tax bracket.

Both problems are avoided by combining an ad valorem tax on vehicle sales with a feebate. The tax provides a stable source of revenue that does not decline as emission rates fall, and it does not distort the choice among vehicles because all vehicle prices rise in the same proportion. In addition, the feebate provides ongoing rewards for all opportunities to reduce emission rates for all vehicles.

Feebates might also be used to reduce the emissions intensity of power generation. Generators with high emissions intensity would pay fees in proportion to the difference between their emissions per kWh (averaged over their portfolio of plants) and a pivot point emissions per kWh, while generators with low emissions intensity would receive corresponding rebates.

Feebates have several attractive features, although regulations can have similar merits if accompanied by design features such as price ceilings and floors.

First, feebates are cost-effective because all firms face the same rewards for reducing emissions. Second, feebates automatically provide ongoing incentives to continually reduce emissions, whereas traditional regulations do not, because once firms have met the standard they have no incentives to exceed it. Third, fees and rebates can be set such that the implicit reward for reducing emissions approximately reflects environmental damage. Fourth, they create some winners (those receiving subsidies) in the affected industry, which could help with acceptability.

Another novel policy—one that encourages people to drive less (a response that is difficult to regulate) and without a politically difficult increase in tax burden for the average motorist—is to change automobile insurance from lump-sum payments into payments proportional to kilometers driven. This possibility is discussed in Box 3.9.

BOX 3.9

Pay-as-You-Drive Auto Insurance

One promising way to reduce vehicle-kilometers traveled in countries with well-established automobile insurance systems—but in which premiums take the form of lump-sum annual payments—is to transition to pay-as-you-drive (PAYD) insurance, under which premiums vary in proportion to the policyholder's annual kilometers.[1] Existing rating factors, as determined by insurance companies, would be used to set per kilometer charges for different drivers: inexperienced drivers, or those with prior crash records, for example, would pay higher per kilometer charges. This approach would maximize the road safety benefits because those with the greatest crash risks would have the greatest incentives to drive less.

The transition to PAYD could occur on a voluntary basis, with the government kick-starting the process using tax incentives.[2] Drivers with below-average annual kilometers would have the strongest incentives to take up PAYD (under the current system, low-kilometer drivers subsidize high-kilometer drivers) and as they switched, premiums would rise (to maintain insurance company profits) for the remaining pool of drivers with lump-sum insurance, encouraging further shifting to PAYD. Global positioning systems and nearly tamperproof odometers (with appropriate safeguards) now provide a potentially reliable and accurate way to collect information on kilometers driven.

[1]Existing systems often provide a modest discount for drivers with annual kilometers below a certain threshold. However, if motorists are below, or well above, this threshold they have no incentive to reduce driving.
[2]Government incentives may be needed to overcome obstacles to the private development of PAYD. When an insurer charges by the kilometer, its costs are reduced to the extent that its own customers reduce their accident risk by driving less. However, the costs to other insurance companies also are lowered because the risk of two-car accidents for their own customers is lower but savings cannot be captured by the company offering the kilometer-based insurance.

Policies to Address Obstacles to Clean Technologies

Even if corrective environmental taxes are feasible, most likely, owing to various obstacles that prevent sufficient investment in clean technologies, they are not sufficient. However, addressing technology barriers is largely tangential to the focus here on environmental tax design.

First, the most important policy, meaning the one yielding the biggest net benefits, usually is getting the prices right through corrective fiscal instruments, mainly because doing so provides across-the-board incentives for clean technology development and deployment. Further innovation incentives can yield significant, additional benefits, though studies suggest they are on a smaller scale (Goulder and Mathai, 2000; Nordhaus, 2002; Parry, Evans, and Oates, 2014; and Parry, Pizer, and Fischer, 2003).[23]

Second, because barriers vary in severity across different technologies, targeted measures are called for rather than setting environmental taxes in excess of environmental damage, which would encourage all technologies equally.[24]

The remainder of this subsection discusses the nature of technology barriers and possible responses, to complement environmental taxes, in the context of private sector research and development (R&D) and technology deployment.[25]

[23]A caveat is that delaying clean technology transitions is costly—and the costs grow if economies become even more locked into emissions-intensive capital and infrastructure (Acemoglu and others, 2012).
[24]Studies indicate that it is much less costly to promote emissions reductions and cleaner technologies by combining environmental taxes with technology incentives, rather than relying exclusively on taxes (Goulder and Schneider 1999; Fischer and Newell, 2008).
[25]Governments also conduct basic research into new technologies, the fruits of which are then used by the private sector. For example, the U.S. federal government spends about $4 billion a year on energy-related technologies, though a number of analysts believe that significantly more spending is warranted (Newell, 2008).

The focus is on altering private sector investment behavior rather than public investment (in transportation systems, fuel distribution infrastructure, smart grids, and the like). Generally, public investments should be warranted on cost-benefit criteria, taking into account their potential role in enhancing the effectiveness of environmental taxes, for example, by providing commuters with public transit alternatives (World Bank, 2012).

R&D

Private R&D into cleaner technologies is inadequate, even with corrective environmental taxes, when innovators are unable to capture the new technologies' benefits that spill over to other firms that might copy them or use them to further their own research programs. Uncertainty about future policy also makes firms hesitant to invest in new technologies. Although similar barriers might apply to technology development in other sectors, they seem especially severe for cleaner energy technologies (e.g., renewables plants) where upfront costs are often large and emissions reductions may persist for several decades; even with adequate corrective taxes now, tax rates in the far future are inherently uncertain.

One technology instrument is R&D subsidies, such as tax credits, though subsidies do not distinguish between more promising and not so promising research possibilities. Granting intellectual property rights is better in this respect, because the value of the patent depends on the commercial viability of the technology. But patents set up a tension between R&D incentives and diffusion—if it is easy for other firms to "imitate around" the patented technology, new technologies are more easily diffused, but returns to the original innovator are undermined. Prizes for new technologies may be a useful supplement because they avoid this tension. Awards for critical new technologies might be based on objective analysis (estimating, for example, how much the technology helps lower the costs of meeting climate objectives), or smaller rewards, based on potential emissions reductions, might be paid to the innovator each time the technology is adopted by another firm.

Technology deployment

Clean technologies may also be deployed insufficiently, despite emissions pricing and R&D incentives, for several reasons beyond future policy uncertainty. For example, individual firms may be reluctant to pioneer the use of an immature technology because they will incur the costs associated with learning how to use it reliably and efficiently, while benefits from this learning partially accrue to other firms that subsequently adopt the technology. And a variety of problems could arise at the household level, though the basis for policy intervention remains contentious (see Box 3.10).

BOX 3.10

The Energy Paradox Controversy

The "energy paradox" refers to the observation that seemingly cost-effective energy-saving technologies, whose lifetime fuel savings discounted at market rates exceed their upfront purchase and installation costs, are not always adopted in the marketplace.

Numerous explanations have been proposed for this phenomenon, many of which may justify policy action. For example, consumers may have limited information, limited ability to calculate future energy costs from the information they have, or may have more product characteristics to consider than they can process, and so omit energy savings. They may also be mistrustful of claimed energy cost savings, doubtful about future fuel prices, or short-sighted in their assessment of the future. Information gaps in second-hand product markets could perpetuate such short-sightedness by not allowing people to reap the full advantage of higher energy efficiency when selling used products. Consumers may also be subject to borrowing constraints causing them to underinvest in energy-saving technologies relative to what would be desirable from society's perspective.

Other explanations, however, do not warrant policy intervention. For example, the observed reluctance of consumers to pay for more-energy-efficient products may reflect their awareness of possible undesirable side effects, such as reduced acceleration for cars, inferior quality of lighting for fluorescent bulbs compared with incandescent, or greater likelihood of these products to need repairs.

However, evidence on the extent to which energy efficiency is undervalued, and if so, the extent of warranted policy intervention, remains inconclusive, making it difficult to draw solid recommendations about the appropriate role of additional policies to address the energy paradox (Allcott and Wozny, 2012; Busse, Knittel, and Zettelmeyer, 2012; Gillingham, Newell, and Palmer, 2009; Helfand and Wolverton, 2011; Huntington, 2011; Parry, Evans, and Oates, 2014; Sallee, 2013).

Although additional instruments to spur technology deployment are likely needed, their appropriate form, scale, and phasing in can be tricky to judge. Interventions might include supplementary measures such as feebates or regulations to improve vehicle fuel efficiency or to encourage the penetration of renewables or other technologies. In the latter case, adoption subsidies might be better than regulations that force in the technology regardless of economic conditions; consistent with the previous discussion, subsidies allow firms the flexibility to deploy the technology on a more limited basis should its costs turn out to be greater (relative to other options) than initially expected.

Overcoming Obstacles to Environmental Tax Reform

Implementing environmental tax reform is challenging, and one reason is opposition to higher energy prices. As noted in Chapter 2, rather than tax fossil fuel energy, many countries subsidize it, to the tune of $490 billion in 2011. Moreover, even in countries that tax energy heavily, the taxes are often relatively blunt from an environmental perspective. And, because of overlapping programs and lower rates for favored groups, different fuel users can be charged quite different rates for the same emissions sources.[26]

Opposition to higher energy prices comes from households (a particular concern is low-income households) and from energy-intensive firms, especially in trade-sensitive sectors. Each is discussed briefly below; the issues are extensively covered elsewhere (Clements and others, 2013; Dinan, forthcoming). Clements and others (2013) also use case studies to discuss broader possibilities for enhancing the prospects for energy price reform (e.g., improving transparency, phasing reforms, informational campaigns).

Compensating households

For some countries, one possibility for reducing household opposition to environmental tax reform is to scale back preexisting taxes affecting energy that are, at least on environmental grounds, made redundant by the environmental tax. For example, in most Organization for Economic Cooperation and Development countries, most if not all of the burden of carbon pricing on residential electricity consumers and motorists could be offset by reducing current excise taxes on electricity consumption and vehicle sales (IMF, 2011). Another possibility might be to provide transitory subsidies for the adoption of cleaner energy alternatives such as heat insulation, fluorescent lighting, and solar water heaters.

In advanced countries, poorer households tend to spend a relatively large portion of their income on electricity and fuels for transportation, heating, and cooking. Consequently, relative to their income the burden of higher energy prices tends to be greater for lower-income households than for wealthier households, which runs counter to broader efforts to moderate income inequality. For developing countries, the burden of higher energy prices (relative to income) might be smaller for lower-income groups, owing to limited vehicle ownership or grid access. But any policy that potentially reduces living standards for the poor may require some offsetting compensation.

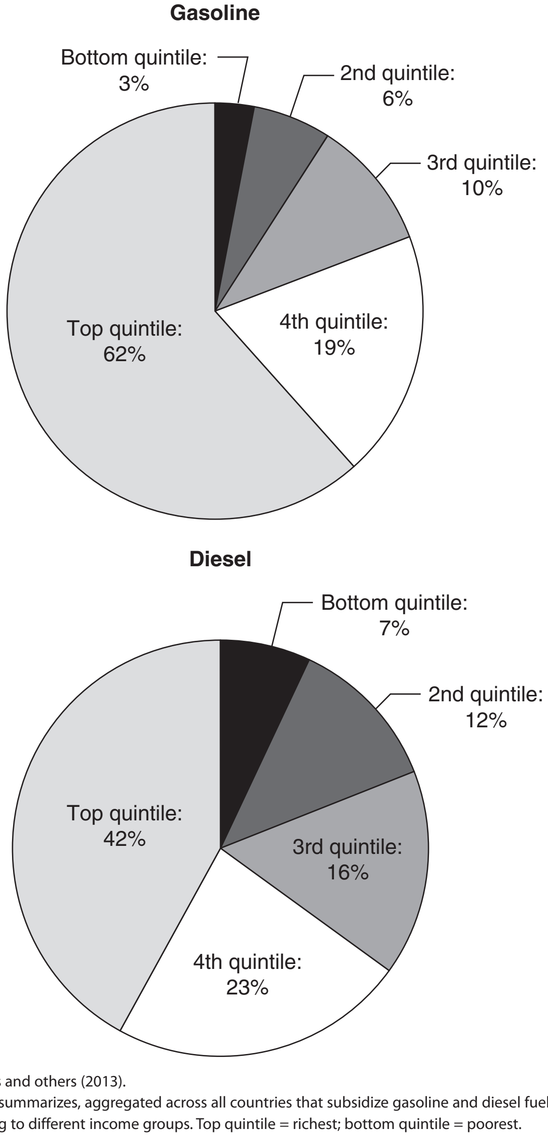
Setting energy prices below levels warranted by production costs and environmental damage is usually a highly inefficient way to help the less well off. According to estimates summarized in Figure 3.3, only 3 percent and 7 percent, respectively, of the benefits from lower gasoline and diesel prices in countries that subsidize these fuels accrue to the bottom income quintile.

In other words, there are much more efficient (i.e., more targeted) ways to help these groups, such as the following:

- Targeted tax cuts like payroll tax rebates, earned income tax credits, and higher personal income tax thresholds in countries where large numbers of low-income, energy-dependent households are covered by such taxes

[26]In the United Kingdom, for example, Johnson, Leicester, and Levell (2010, Table 4.1), estimate that implicit CO_2 taxes in 2009 were £26/ton and £41/ton for natural gas used in domestic and business power generation, respectively, and £0/ton and £9/ton for natural gas used in homes and industry, respectively.

Figure 3.3 Distributional Incidence of Energy Subsidies



Source: Clements and others (2013).
Note: This figure summarizes, aggregated across all countries that subsidize gasoline and diesel fuels, the portion of benefits accruing to different income groups. Top quintile = richest; bottom quintile = poorest.

- Transfer payments, wage subsidies for low-paid jobs, and the like in countries where these compensation schemes are or could be administratively feasible
- Increased government spending (e.g., on schools, education, housing, jobs programs) that disproportionately benefits low-income households.

Recall, however, the caveats about overcompensation, and the preference for schemes that also promote economically desirable behavior.

Compensating firms

Higher energy costs for trade-exposed industries such as steel, aluminum, cement—a particular concern for carbon pricing—can lead to a dual problem: a loss of competitiveness, reflected in firms' relocating to countries where carbon pricing is not applied, and "emissions leakage" (increased emissions in these countries partly offsetting domestic reductions).[27] Possible responses, in the context of carbon pricing, include the following (Fischer, Morgenstern, and Richardson, 2013):

- Using some of the carbon pricing revenues to fund a general reduction in corporate income taxes provides offsetting gains in competitiveness for the economy as a whole, though these reductions are not well targeted to the most vulnerable energy-intensive firms and therefore do little to limit emissions leakage.
- Production subsidies can be used to protect energy-intensive, trade-sensitive firms by roughly offsetting their higher energy costs. These subsidies preserve incentives for reducing emissions per unit of output (though not for reducing their overall level of output). However, subsidies use up some of the carbon tax revenues and complicate administration.
- Border adjustments might be charged on embodied carbon in products imported to a country (or block of countries) with carbon pricing. A key attraction of these adjustments is that they encourage other trading countries to price carbon to avoid bearing some of the burden of tax accruals to other countries. The legality of such charges under free trade agreements is uncertain, however. Moreover, import fees may be tricky to implement (especially if applied to a large number of products, from many different countries) if embodied carbon and the extent to which other countries are mitigating carbon are difficult to measure.
- Yet another possibility is simply to exempt trade-sensitive firms—for example, by providing them a rebate for purchases of electricity and fuels to neutralize the effect of carbon pricing on their input costs. These exemptions also result in forgone revenue and, to a greater extent than for other measures, undermine environmental effectiveness.

In short, each of the above options has its drawbacks. Ideally, countries would coordinate their carbon pricing policies, lessening the pressure for such measures. (In any case, firms that cannot compete when domestic energy is appropriately priced should eventually be allowed to go out of business.)

[27]Studies (e.g., Böhringer, Carbone, and Rutherford, 2012) suggest that leakage offsets about 5–20 percent of the emissions reductions from carbon pricing, depending in part on the size of the coalition of countries taking action. This leakage reflects not only the international migration of economic activity, but also increases in fossil fuel use in other countries as world fuel prices fall in response to reduced demand in countries with carbon pricing. The latter type of leakage is not easily addressed through policy.

Applicability to Low-Income Countries

How applicable is the above discussion to low-income countries, where policymakers' primary concern may be to lift people out of abject poverty (rather than raise the costs of energy and transportation)?

With regard to climate change, low-income countries contribute very little to global emissions, and for practical purposes the case for them to undertake costly mitigation policies is correspondingly weak (Gillingham and Keen, 2012). But pricing for local environmental problems—air pollution, congestion, accidents—is in these countries' own interests because it provides net economic benefits. There are some nuances, however.

One is that the potential fiscal and environmental benefits are less important, in relative terms, for countries with relatively low energy intensity of GDP and that, as is common in Africa, do not use coal. Another is that, even with corrective taxes, and leaving aside the technology barriers already mentioned, private sector investment in green technologies may still be below economically efficient levels in low-income countries because of capital shortages. This is the basic rationale for donor contributions that support other investments such as infrastructure projects, and similar external funding has a complementary role to play in the environmental area. More generally, technology transfers to low-income countries can be promoted through dissemination of know-how acquired in advanced and emerging economies.

SUMMARY

Although this chapter provides a broad overview of instrument choice for environmental protection and policy design issues, for the purposes of the following chapters (which mainly focus on assessing efficient fuel tax levels) the main points are the following:

- For power generation, either (1) taxes should be levied on fuel supply (coal or natural gas) in proportion to emissions factors weighted by environmental damage per unit of emissions, with appropriate crediting for any emissions captured during fuel combustion or (2) charges should be directly levied on emissions released from smokestacks reflecting environmental damage per ton of emissions. The choice between these charging schemes largely hinges on administrative considerations.
- For heating fuels, charges should be levied on fuel supply to reflect emission rates and environmental damage (pricing emissions is not practical given the large number of fuel users).
- For transportation fuels, corrective taxes accounting for a wider range of side effects should be calculated according to equation (3.1).

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