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Instrument Choice and Design

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Carbon Taxes or Emissions Trading Systems? Instrument Choice and Design

Ian Parry, Simon Black, and Karlygash Zhunussova
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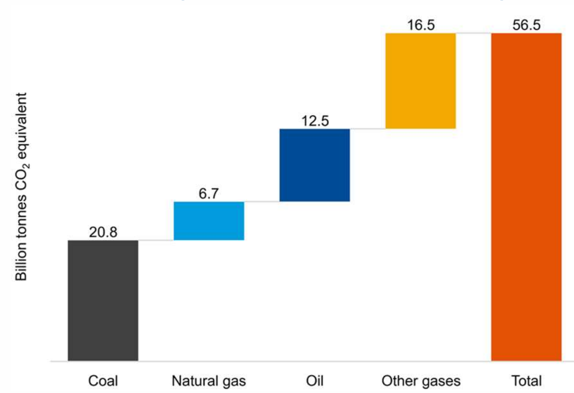
Summary

Carbon pricing should be a central element of climate mitigation strategies, helping countries rapidly transition to “net zero” greenhouse gas emissions. Policymakers considering carbon pricing face choices between carbon taxes and emissions trading systems (ETSs) and in their design. This includes administration, price levels, emissions coverage, relation to other mitigation instruments, use of revenues to address efficiency and distributional objectives, supporting measures to address competitiveness concerns, political economy aspects, and coordination at the global level. This paper discusses these issues, providing guidance on the choice between carbon taxes and ETSs and their design. Overall, carbon taxes have significant practical, environmental, and economic advantages (especially for developing countries) due to ease of administration, price certainty which promotes investment, the potential to raise significant revenues, and coverage of broader emissions sources. However, ETSs provide more certainty over emissions levels, can be implemented by environment ministries, and some free permit allocations might garner political support from affected firms (at a fiscal cost).

Introduction

Global greenhouse gas (GHG) emissions need to be reduced by 25 to 50 percent over this decade to get on track with containing global warming to 1.5–2ºC.[1] In a business-as-usual (BAU) case without additional mitigation measures, global GHGs are expected to grow to 56 billion tonnes of carbon dioxide equivalent (CO_2e) in 2030. CO_2 emissions from coal, oil, and gas combustion account for 37, 22, and 12 percent of these emissions respectively, with other GHGs (for example, methane from extractive industries and agriculture) accounting for 29 percent (Figure 1). About 130 countries, covering 90 percent of GHGs, have set or proposed zero net emissions targets for around mid-century[2] but near-term ambition and policy action falls well short of what is needed.[3]

Figure 1. Projected Global GHG Emissions by Source (2030, billion tonnes CO_{2e})



Source: IMF staff calculations.
Note: Shows CO_2 from fossil fuels and other global greenhouse gases (GHGs), excluding land use and land use change emissions.

From an environmental effectiveness and economic efficiency perspective, gradually raising fossil fuel prices through carbon pricing should be the centerpiece of countries’ mitigation strategies. Carbon pricing applies charges on fossil fuels based on their carbon content, or on their emissions when they are burned, and has multiple economic rationales:

[1] Black and others (2021).

[2] See www.zerotracker.net.

[3] Black and others (2021).

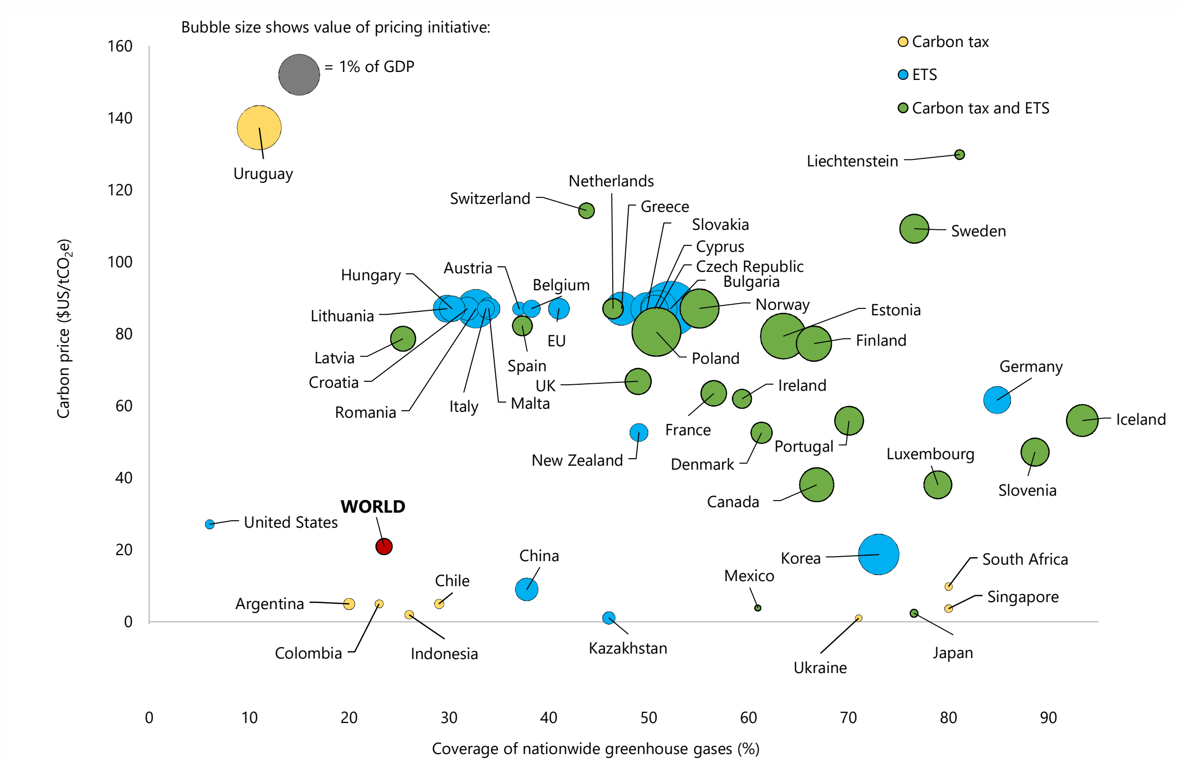
- *Emissions reductions*: Pricing promotes the full range of behavioral responses for reducing energy use and shifting to low carbon fuels—see Annex 1;
- *Clean energy investment*: The expectation of rising fuel prices incentivizes innovation and adoption in new low-carbon technologies now—especially if a clear and credible path of rising prices is specified; and
- *Fiscal*: Pricing mobilizes a valuable source of revenue which can be used for achieving various economic and distributional objectives.

Pricing can also generate significant domestic environmental co-benefits, for example, human health improvements from reductions in local air pollution (though the same applies to other mitigation instruments).

Carbon pricing can take the form of carbon taxes or emissions trading systems (ETSs). Carbon taxes are usually implemented through a tax on the carbon content of fossil fuel supply. ETSs require firms to acquire allowances for their emissions or the carbon content of their fuel supply with the government controlling the supply of allowances and market trading of allowances establishing the emissions price.

Momentum for carbon pricing is increasing globally, though there are large cross-country differences in coverage rates and prices. To date, 30 carbon taxes and 9 ETSs have been implemented at the national level while the European Union (EU) ETS prices emissions in EU and European Free Trade Association countries. Many subnational pricing schemes are also operating, the largest being California's ETS. GHG emissions subject to (national and subnational) carbon pricing, however, vary from below 30 percent in some cases to more than 70 percent in others (for example, Canada, Germany, Korea, Sweden) while economywide average prices vary from below $5 to over $100 per tonne.[4] See Figure 2 and Annex 2, Annex Table 2.1.

Figure 2. Subnational, National and Regional Carbon Pricing Schemes by Country, 2022



Sources: Government websites; WBG (2022); and IMF staff calculations.
Notes: EU ETS includes Iceland, Liechtenstein, and Norway. Prices are emissions-weighted averages between schemes at national, subnational and, if applicable, EU level. At present, China's system takes the form of a tradable emissions intensity standard with no fixed cap on emissions. Mexico does not include subnational schemes due to lack of coverage data.

[4] All prices in this paper are expressed in year 2021 US dollars or thereabouts.

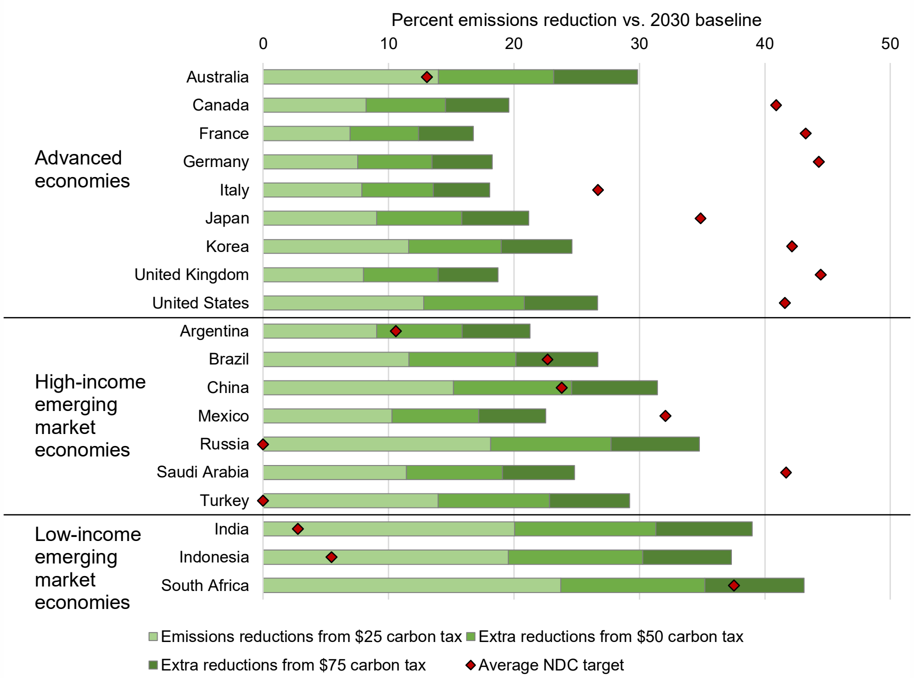
Policymakers considering introducing or scaling up carbon pricing face multiple technical choices in pricing instruments and their design. This includes: their administration, price levels, relation to other mitigation instruments, use of revenues to address efficiency and distributional objectives, supporting measures to address competitiveness concerns, extension to broader emissions sources at the domestic and international level, and coordination at the global level.

After a brief exposition of the rationale for carbon pricing, this note elaborates on basic design issues for carbon taxes and ETSs, some broader considerations, and summarizes policy lessons. The general theme is that carbon taxes have various practical advantages over ETSs, for example, in regards administration, price certainty, exploiting fiscal opportunities, and application to broader emissions sources, though ETSs are a more natural instrument for environment ministries, provide more certainty over emissions, and free allowance allocations can garner firm support.[5]

Benefits of Carbon Pricing: A Quick Quantitative Update

Carbon pricing can produce large emissions reductions, though it is likely insufficient by itself to meet aggressive mitigation pledges. The impact of an economy-wide carbon price on emissions and other metrics is estimated using the IMF-WB Climate Policy Assessment (CPAT).[6] A $50 carbon price, for example, would cut CO_2 emissions in Group of Twenty (G20) countries by around 15-35 percent below BAU levels in 2030, but this is below commitments many countries have made in their nationally determined contributions (NDCs) submitted for the 2015 Paris Agreement.[7] See Figure 3. Carbon pricing will therefore need to be reinforced with non-pricing measures like feebates (see below).

Figure 3. CO_2 Reductions below BAU for Mitigation Pledges and Carbon Pricing, G20 Countries 2030



Source: IMF staff using the Climate Policy Assessment Tool.
Note: Pledges assume CO_2 emissions are reduced in the same proportion to pledged reductions in greenhouse gases. BAU = business as usual; NDC = nationally determined contribution.

[5] The paper differs from previous contributions to this topic (for example, Goulder and Parry 2008, Stavins 2022) by providing (where feasible) supportive cross-country quantitative analysis and by considering a more diverse range of design issues.

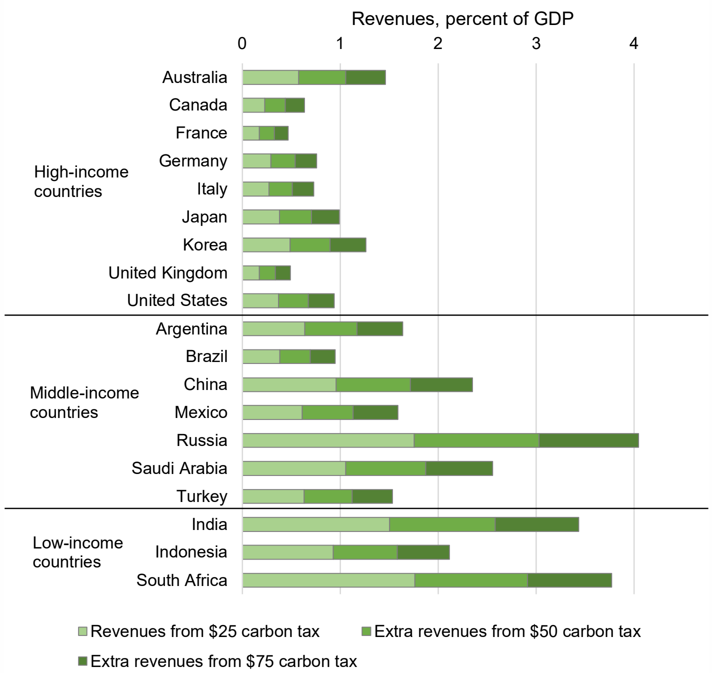
[6] CPAT has been developed jointly by IMF and World Bank staff and evolved from an earlier IMF tool used, for example, in IMF (2019a and b). For descriptions of the model and its parameterization, see IMF (2019b) Appendix III, and the Appendix of Black and others (2021).

[7] CO_2 reductions depend on the proportionate impact of carbon pricing on the prices of fuels in different sectors and countries and assumptions about the price responsiveness of fuel use in different sectors (Black and others forthcoming). Proportionate emissions reductions are larger in countries where coal accounts for a large share of emissions, given carbon pricing has a disproportionately large impact on coal prices.

The potential medium-term revenues from carbon pricing are sizable. For example, carbon prices of $50 per tonne would raise revenues of about 0.5–2 percent of GDP in 2030 (Figure 4)—revenues are larger in countries with higher emissions intensity of GDP. New sources of fiscal revenues are especially appealing in countries where revenue mobilization from broader fiscal instruments is insufficient due to large informal sectors. Ultimately revenues from carbon pricing will need to be replaced by other sources, though this will not be an issue until the latter part of the clean energy transition.

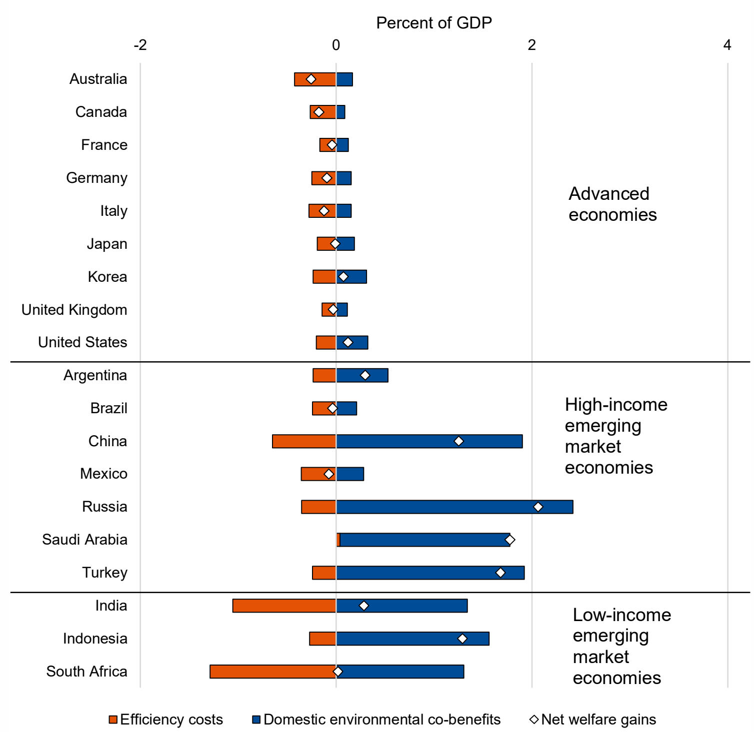
The economic costs of pricing regimes can be manageable, equitably distributed across countries, and are partially or more than fully offset by domestic welfare co-benefits. Economists usually measure the economic costs of climate mitigation policies by their welfare costs, which reflect the annualized costs of using low carbon technologies in place of fossil fuel technologies. Welfare costs from a $50 carbon price in 2030 are mostly between 0.1 and 0.6 percent of GDP (Figure 5) depending primarily on the carbon price, the BAU emissions intensity of GDP, and the proportionate reduction in emissions induced by pricing. However, the domestic environmental co-benefits of carbon pricing, most notably reductions in mortality from local air pollution substantially exceed mitigation costs in some cases (for example, China, Indonesia, Turkey) before even counting the climate benefits.

Figure 4. Fiscal Benefits from Carbon Pricing, 2030



Source: IMF staff using the Climate Policy Assessment Tool.
Note: Estimates are net of revenues losses due to the erosion of bases for pre-existing fuel taxes.

Figure 5. Welfare Costs and Domestic Environmental Co-Benefits from $50 Carbon Price, 2030



Source: IMF staff using Climate Policy Assessment Tool.
Note: Domestic environmental co-benefits principally include reductions in local air pollution mortality but also and road congestion and accident externalities—see Parry and others (2015) for justification.

Basic Design Issues: Comparison of Taxes and ETS

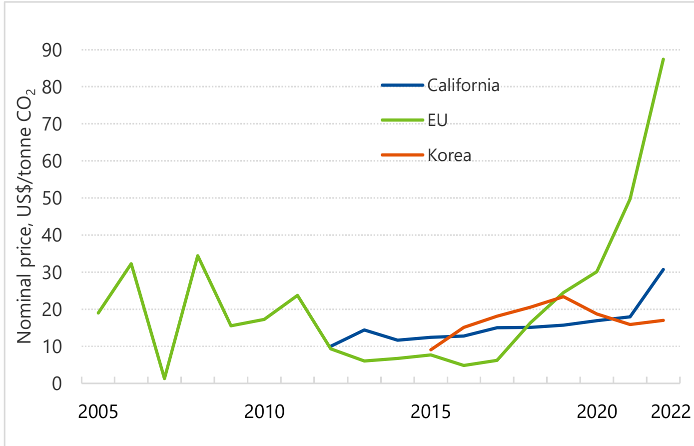
Basic Comparison under Uncertainty

In their pure forms, carbon taxes provide certainty over emissions prices while emissions are determined by market factors, and vice versa for ETSs. In the absence of uncertainty, the tax rate in a carbon tax could be set to induce the same emissions outcome as set by a cap under an ETS given the marginal abatement cost schedule—for the same carbon price, both instruments would then also have the same revenue potential (if ETS allowances are auctioned). Future abatement costs are however uncertain (for example, due to uncertainty over fuel prices and the availability and costs of clean technologies) and governments cannot choose certainty over both prices and emissions. Under carbon taxation, governments can provide certainty over future emissions prices by specifying the future trajectory of tax rates (for example, in Ireland the carbon tax is slated to rise €7.50 a year to reach €100 per tonne by 2030) leaving emissions to be market determined. Under a pure ETS, emissions are fixed by the cap and prices vary with market conditions.

Certainty over emissions is attractive if policymakers want to meet an emissions target in a future year but price uncertainty may deter clean technology innovation and adoption. Policymakers can ensure legally binding climate commitments in a particular year are set through appropriate setting of an ETS cap. Allowance prices in ETS schemes have however shown significant volatility to date—see Figure 6. This volatility:

- Can cause dynamic inefficiency if there are significant divergencies in emissions prices, and hence in incremental abatement costs, at different points in time;[8]
- More importantly, price uncertainty can deter private innovation in, and adoption of, clean technologies, especially those (for example, renewables plants) with high upfront costs and long-range emissions reductions.

Figure 6. Allowance Price Volatility in ETSs



Sources: CarbonCredits.com; Korea Exchange; and WBG (2022).

Over time however, both taxes and ETSs can, at least to some degree, balance uncertainly over emissions and prices, so in practice the differences between the two approaches may be less pronounced. In most carbon tax schemes, tax rates are fixed and adjusted on a discretionary basis according to progress on emissions goals. ETSs may include price stability mechanisms like price floors[9] and banking/borrowing provisions, while future emissions caps could also be adjusted, if needed, to help stabilize prices.

Administration and Coverage

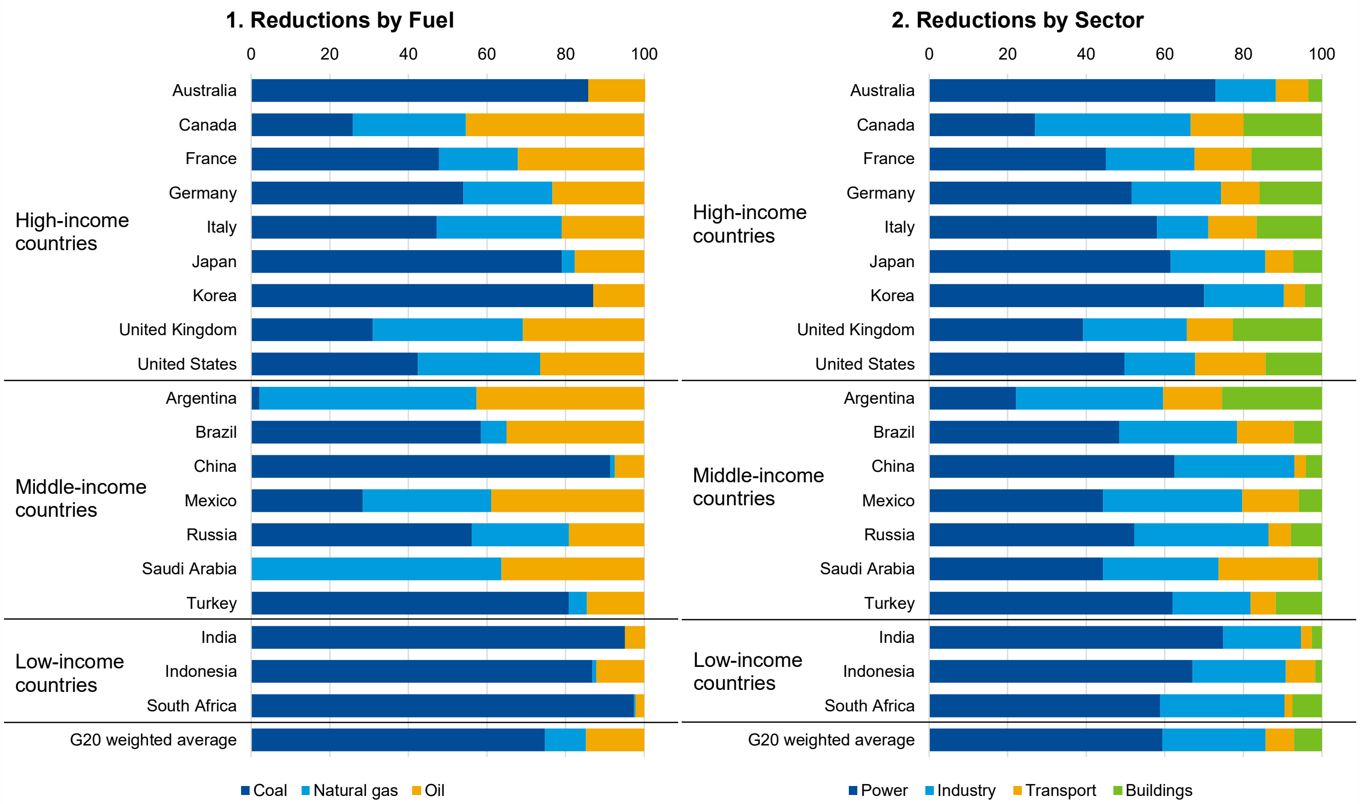
In principle, carbon pricing should comprehensively cover CO_2 emissions across all fuels and sectors, though in practice pricing emissions from coal, or from the power and industrial sectors, are usually the

8 Studies suggest this price volatility increases mitigation costs by about 15 percent over time for a given cumulative emissions reduction (for example, Fell, MacKenzie, and Pizer 2021).

9 These mechanisms can be implemented, for example, through minimum prices when allowances are auctioned (for example, the California ETS has a reserve price rising annually at 5 percent in real terms, while the Korea ETS links auction prices to historical prices). In the EU, the Market Stability Reserve withdraws allowances from the system during periods of downward pressure on allowance prices. See Flachsland and others (2018) for further discussion of price floor mechanisms.

biggest priorities. At the fuel level, reduced coal use would account for about 50 percent or more of the fossil fuel CO_2 reductions from comprehensive carbon pricing for 12 G20 countries. At the sectoral level, reduced emissions from power and industry would account for 60 percent or more of emissions reductions from comprehensive carbon pricing for all G20 countries. See Figure 7.

Figure 7. Breakdown of CO_2 Reductions by Fuel/Sector under Carbon Pricing, 2030



Source: IMF staff using the Climate Policy Assessment Tool.
Note: Estimates are for a $75/50/25 carbon price for high/medium/low-income countries. Panel 1 is for direct emissions (not emissions embodied in electricity use). Buildings corresponds to the definition countries use in reporting their emissions to the United Nations Framework on Climate Change and includes fossil fuel CO_2 emissions from residences, services, agriculture, and forestry; emissions from industrial buildings are included under industry.

Carbon taxes, which are generally under the purview of finance ministries, are easy to administer. They can be integrated midstream (that is, after fuel refining and processing) into collection procedures for existing fuel taxes and extended to other fossil fuels—much of the legal and administrative infrastructure needed for carbon taxes already exists. Indeed, fuel taxes are well established in over 160 countries[10] and are among the easiest of all taxes to collect. All but one of the 21 existing national carbon taxes are applied midstream (Annex Table 2.1).

Carbon taxes also could be applied at different points of the production chain. The easiest point to tax would be upstream (that is, at the point of fuel extraction), integrating carbon taxes into existing regimes for coal, gas, and oil producers plus[11] fuel imports. Rebates could be provided for fuel exports, however, as under the Paris Agreement countries are responsible for emissions released within their own borders. In principle, carbon taxes could also be applied downstream (that is, at the point of fuel combustion) to large emitters in the power

[10] From www.imf.org/-/media/Files/Topics/Environment/energy-subsidies/fuel-subsidies-template-2021-updated-131021.ashxSubsidy.

[11] China, India, and the United States, for example, levy excises on coal at the mine mouth which could be converted into explicit carbon taxes.

and industry sectors, while maintaining midstream collection for transportation and building fuels—this would require capacity for monitoring downstream emissions and offers no obvious advantage over midstream collection.[12] In upstream and midstream approaches, rebates should be provided to downstream firms that adopt abatement technologies like carbon capture (though these technologies are rare at present). The point of regulation should not matter for the impact of the carbon tax on fuel prices, fuel use, or emissions (aside from cases where fuel price regulations prevent full pass through of carbon charges into fuel prices). Revenues from carbon taxes typically accrue directly to finance ministries as with existing fuel taxes and hence can be used for a broad range of purposes such reducing other distortionary taxes like those on labor, funding productive public investments, or for deficit reduction, with significant political, economic and environmental tradeoffs (see below).

ETSs, which are generally under the purview of environment ministries, typically require more sophisticated administration and may have more limited coverage. These schemes are usually applied downstream to large stationary sources in the power and industrial sector. One possible reason for a downstream focus among ETSs is that they extend pre-existing regulations to address local pollution by regulated entities (firms and plants). Another might be pressure for free allowance allocation from downstream firms. For administrative reasons, small-scale emitters in sectors covered by the ETS are generally excluded, but their share in emissions are usually modest.[13] Downstream ETSs can also be extended midstream to transportation and building fuel suppliers—for example, these sectors are covered in the German and Korean ETSs and are proposed for inclusion in the EU ETS.

New capacity is required for ETSs to monitor downstream emissions and supervise allowance registries and market trading.[14] Indeed ETSs may not be viable in countries with limited institutional capacity—as is the case with many developing countries—or where the permit trading market would be concentrated due to a limited number of firms. Once implemented, changes to the rules governing an ETS tend to require changes to regulations and legislation, which may involve a lengthy process of notice and consultation. By contrast, under a carbon tax, changes to rates or coverage can often be made as part of a budget and related finance bill.

Both carbon taxes and ETSs apply simultaneously in some countries. In several EU countries domestic carbon taxes apply to sectors not covered by the EU ETS (Denmark, Finland, France, Ireland, Norway, Portugal, Sweden). In Canada, some provinces (for example, British Columbia) have implemented carbon taxes to meet a federal pricing requirement, others have implemented ETSs (Quebec), while still others are subject to a federal carbon tax (Alberta). In some cases, taxes have been applied to the same emissions sources as ETSs to establish a more robust price signal. For example, the United Kingdom imposes a 'price floor' through a variable tax on power sector emissions equal to the gap between a target emissions price and the prevailing ETS price (though of late the trading price has exceeded the target price). Denmark is considering a similar scheme to put a domestic floor price under its emissions covered by the EU ETS.

ETSs have sometimes been chosen over carbon taxes for constitutional and legal reasons such as restrictions on new taxes. For example, the EU does not have a fiscal union, and tax measures require unanimity whereas regulations like an ETS require a qualified majority—hence implementing an EU-wide carbon tax was not deemed politically feasible. Similarly, in California an ETS was more feasible because it required half of the legislature to approve it, compared to two-thirds for taxes. Germany has constitutional constraints on new taxes and hence opted for an ETS in buildings and transport (though it has similar characteristics to a tax as it uses a price collar). The United Kingdom has split competences at the national and subnational level, with

[12] Emissions could be measured through continuous emissions monitoring systems installed in smokestacks, or collection of data on firms' fuel inputs which can be mapped to CO_2 emissions factors. Compliance costs are moderately larger for downstream systems due to the greater number of taxpayers—for example, about 13,000 firms would be covered in a downstream pricing system in the United States compared with 2,000 in a midstream pricing system (Calder 2015).

[13] For example, in the EU ETS exempted small-scale emitters with annual emissions less than 50 kilo-tonnes account for about 7 percent of emissions from the power and industry sectors (see www.eea.europa.eu/data-and-maps/dashboards/emissions-trading-viewer-1).

[14] Usually a pilot phase establishes emissions measurement, reporting and verification systems, and allowances exchange platforms and simulates trading.

nations such as Scotland having responsibility for emissions levels but the UK government having responsibility over fiscal instruments—one of the reasons an ETS was seen as more aligned with existing institutional setup (alongside continuity for firms used to the EU's ETS). However, even in countries with divergent arrangements for political decision-making, complementary carbon pricing regimes are possible.

Lastly, it should be noted that ETSs and carbon taxes exist on a continuum and can theoretically be designed to replicate each other. For example, an ETS with a price floor and/or a price ceiling (which, when combined, entail a "price collar") makes the ETSs look more like a carbon tax, loosening the quantity restriction on emissions (and hence the emissions certainty) to enhance price certainty within the system. Additionally, carbon taxes could entail a tradeable element, allowing tax burdens to be exchanged between downstream entities, which would make them operate more like an ETS. However, in practice the choice between ETSs and carbon taxes remains substantive, with the choice between them usually determining key design choices of the carbon price instrument (for example, whether it is upstream or downstream, raises revenues, or fixes emissions quantities or prices).

Allocation of Policy Revenues/Rents: Efficiency

Revenue raising and using practices may differ, with carbon tax revenues more likely to be used in general budgets and ETS revenues more likely to be earmarked for environmental purposes. Revenues have been fully used for general purposes in 16 carbon tax schemes and partially or fully earmarked for environmental spending in only five cases (Annex Table 2.1). In the early phases of ETSs (for example, EU, Korea), allowances have been freely allocated to affected firms to help build support for the program and address competitiveness concerns (see below)—however, where free allowances are granted to power generators this can result in large windfall profits as firms may have greater scope for passing allowance prices forward in higher consumer prices.[15] In other ETS cases (for example, California, Germany) allowances have been auctioned from the start. Where allowances in ETSs are auctioned, the revenues are more often earmarked for environmental spending—this applies, at least partially, in five of the seven ETS schemes (Annex Table 2.1).

There is much at stake in terms of economic efficiency in how carbon pricing revenues are used.[16] Productive uses of revenues can produce large gains in economy efficiency which can help to offset the negative effects of higher energy prices on economic activity. For example, using revenues to reduce payroll, personal income, consumption, or corporate income taxes improves economic efficiency through various channels like increasing work effort and investment and reducing tax-sheltering activities, while other public investments (for example, in health, education, infrastructure) also strengthen the economy. Earmarking revenues for environmental investment can be efficient if such investments are fully integrated in robust public investment management systems. Depending on overall economic conditions, it could also be efficient to use revenues for deficit reduction. In contrast, returning revenues in universal or targeted lump-sum transfers to households or firms forgoes efficiency benefits. See Table 1.

Allocation of Policy Revenues/Rents: Distributional

There is also much at stake in terms of distributional outcomes in the use of carbon pricing revenues. Use of some revenues for targeted assistance (for example, means-tested transfers to compensate for energy price increases where administrative capacity is available) benefits low-income households the most, reductions in payroll/consumption taxes and funding general investments spreads the benefits more evenly across the population, while reducing corporate taxes benefits shareholders and workers (Table 1). Revenue recycling

[15] See Bushnell, Chong, and Mansur (2013). Even with free allowances, however, a significant portion of the potential carbon pricing revenues could accrue indirectly to the finance ministry to the extent windfall profits are subject to corporate, and ultimately personal, income taxes.

[16] IMF (2019), Figure 1.10.

strategies should balance assistance for low-income households with fiscal needs for alleviating other tax burdens or funding investment goals.

Table 1. Options for Use of Carbon Tax Revenues

Instrument		Metric			
		Impact on Economic Efficiency	Impacts on Income Distribution	Administrative Burden	Political Feasibility
General Revenue Uses	Public investment	Potentially significant (high fiscal multipliers, especially for low-carbon investments)	Can disproportionately benefit low-income households (for example, if provides basic education, health, infrastructure), but depends on implementation	Modest; requires strong public investment management	Can be popular, with green investment especially favored in climate-concerned countries
	Tax reductions	Can improve incentives for work effort and investment and reduce incentives for the black economy and tax evasion	Can be designed to be progressive (for example, via increases in personal income tax thresholds)	Minimal	Popular with beneficiaries (for example, households for personal cuts, firms for corproate income tax cuts)
	Deficit reduction	Lowers future tax burdens and macro-financial risk	Depends on country circumstances	Minimal	Does not garner politcal support
Assistance to Households	Universal lump-sum transfers	Forgoes efficiency benefits (for example, no enhanced incentive for work effort)	Progressive (disproportionately benefits the poor)	New capacity may be needed (but should be manageable)	Mixed, with some households/firms favouring or disliking lump-sum transfers
	Means-tested cash transfers or social assistance	Forgoes efficiency benefits, but typically requires only a small share of revenues	Effective at helping low-income groups if transfers are well targeted or if social safety nets are comprehensive	Low if builds on existing capacity, otherwise significant	Generally popular
	Direct assistance for household energy bills	Forgoes efficiency benefits; reduction in environmental effectiveness depending on design	Provides partial relief for households (but does not help with indirect pricing burden)	Low if builds on existing capacity, otherwise significant	Generally popular

Source: IMF staff.
Note: Green, orange, and red indicate an advantage, neither an advantage or disadvantage, and a disadvantage of the revenue use, respectively.

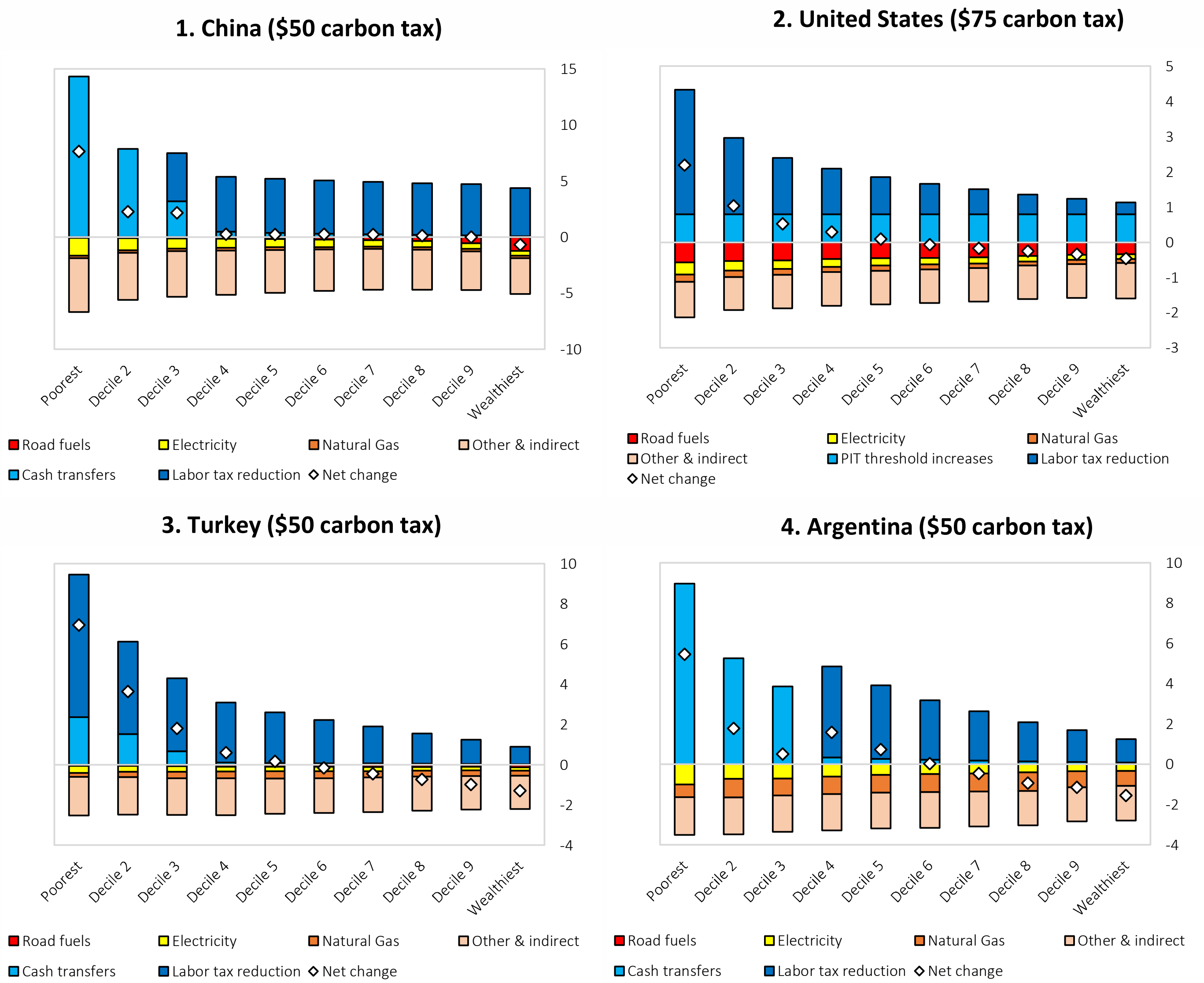
In principle, a carbon tax and ETS—if applied to the same sectors, with the same price, and prior to allocation of revenues—would impose the same distributional burdens across household income groups. This is because a carbon price generally has the same impact on the price of fuels, electricity, and other consumer goods regardless of whether it takes the form of a tax or an ETS. Distributional burdens, when measured against households' annual consumption, tend to be mildly regressive (that is, imposing a slightly larger burden relative to consumption on lower income households than wealthier households)—see the examples for Argentina, China, Turkey, and the United States in Figure 8. Although household budget shares for electricity and fuels tend to be somewhat higher for lower income households than wealthier households, much of the burden on households comes indirectly from the pass through of carbon charges into prices of consumer goods in general and budget shares for the latter are more evenly distributed across household income groups.[17]

An ETS does not provide the same opportunities for addressing distributional concerns if allowances are freely allocated or auction revenues are earmarked (though this can help with acceptability). Indeed, where free allowance allocations create windfall profits, ultimately allowance rents may accrue to shareholders and workers in these industries (the former at least are concentrated in higher income households). Revenue from allowance auctions in the German ETS are used for just transition assistance to vulnerable households, workers, and regions which largely forgoes efficiency benefits but has helped to enhance the acceptability of the pricing scheme.

[17] Carbon pricing can be progressive in cases where vehicle ownership and connectivity to the power grid are limited among low-income households (for example, IMF 2019, Figure 1.7).

Figure 8. Household Burdens from Carbon Pricing 2030, Selected Countries

(Expressed as a percent of household consumption)



Source: IMF staff using Climate Policy Assessment Tool.
Note: Burden is the loss in consumer surplus from higher prices less the benefit from recycling revenue in labor tax reductions and cash transfers divided by total consumption. For the United States, 50 percent of revenues are used for increasing personal income tax thresholds and 50 percent for a general labor tax reduction (proportionate to pre-policy tax burden). For China, 85 percent of revenues are used for a proportionate reduction in labor taxes (proportionate to pre-policy consumption) and 15 percent for a targeted transfer for the poorest 25 percent of households. For Turkey, 85 percent of revenues are used for labor tax transfers and 15 percent for a targeted transfer for the poorest 25 percent of households. For Argentina, 75 percent of revenues are used for labor tax reductions, and 25 percent for targeted transfers to bottom 30 percent of households. In China and Argentina bottom income deciles do not pay labor income tax.

The different potential allocation of carbon pricing revenues or rents across carbon taxes and ETSs has strong implications for distribution. Carbon tax revenues can be recycled in ways that make the overall reform distribution neutral, or progressive, through using some revenue for targeted measures. For example, recycling schemes considered in Figure 8 benefit the bottom four income deciles on net (see note in Figure 8 for details). Alternatively, the bottom four deciles can be fully compensated for price increases by recycling 25-30 percent of the carbon pricing revenues in targeted measures.

Political economy

Political economy is a major factor in determining choice between carbon pricing instruments and their respective designs. ETSs may be more feasible politically than taxes, especially where permits are freely allocated to affected firms. The benefits of carbon pricing policies (from revenue recycling, domestic environmental co-benefits, and climate benefits) can be diffuse, benefitting most of society when designed and implemented effectively, while the costs (from higher energy costs and employment impacts) can be concentrated, falling on energy and carbon-intensive sectors and firms. Such firms may wield significant political power due to better coordination and effective lobbying of policymakers. Affected firms also tend to prefer receiving freely allocated permits due to the windfall gains. Some jurisdictions have progressively reduced free allocations (for example, 30 percent of allowances in the EU ETS were freely allocated in 2020 compared with 80 percent in 2013).[18] To some degree, carbon taxes can be designed to mimic the effect of free allocation by using revenues for targeted relief to firms.

As with all taxes, carbon taxes can be politically challenging to implement, though revenue recycling, communications strategies, and identification of key stakeholders can build support. While carbon taxes (and broader reforms of energy prices) have sometimes faced political backlash from affected firms and citizens[19], the same can be said for many other reforms to fiscal systems. Additionally, ETSs are not necessarily more or less popular politically with households (for example, Australia's ETS was repealed in 2014 in response to opposition). However, what does appear to be important for ensuring the durability of carbon tax and fossil fuel subsidy reforms is effective and inclusive communication alongside pragmatic use of revenues. "Soft earmarking" revenues partly to environmental as well as social objectives appear to be more popular than using for deficit reduction or corporate tax reductions, for example. The anticipation of negative distributional outcomes creates an incentive for affected groups to oppose carbon pricing and makes the design of targeted measures critical, underscoring the need for thorough analysis (for example, to determine stakeholders respective "carbon positions" to quantify the targeted measures required).

Competitiveness

The main concern with competitiveness is burdens on a limited number of energy-intensive, trade-exposed (EITE) industries. These industries have relatively high embodied carbon and limited ability to pass production cost increases forward into higher consumer prices. Direct cost increases are between 5 and 10 percent in most cases for aluminum and steel though and up to 30 percent for cement and relatively large indirect cost increases can emerge from charges on carbon embodied in electricity inputs (Figure 9).[20]

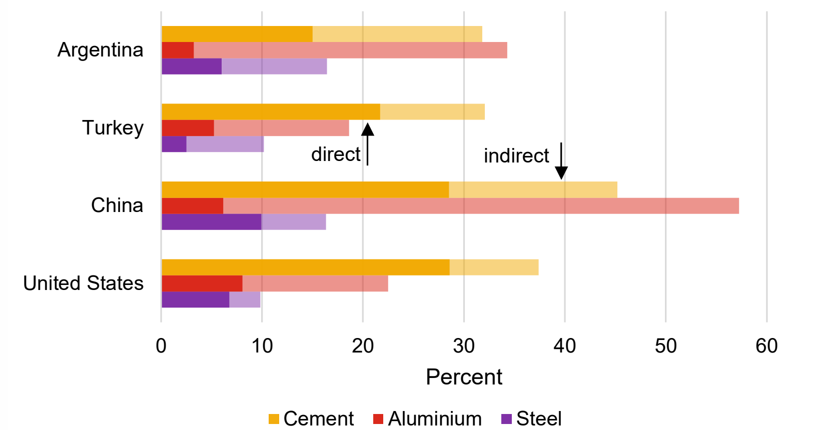
In the absence of international coordination, there are several unilateral possibilities for competitiveness assistance measures under a carbon tax. One is to only impose carbon taxation on firm emissions above a threshold level (as in South Africa)—although this partial exemption effectively lowers the average carbon charge for emissions intensive firms, which undermines mitigation incentives. Another possibility is to return revenues from charges in EITE industries in the form of output-based rebates to those industries—operationally, this scheme acts like a tradable emission rate standard for industry, which is part of the federal backstop in Canada. All these approaches become less robust at deeper levels of abatement, as they do not compensate for abatement costs. Another more robust possibility, currently receiving much attention, is therefore border carbon adjustments (BCAs) which impose charges for embodied carbon in imports net of any pricing on those emissions by foreign countries and perhaps matched by rebates for carbon embodied in domestic exporters. Basing the BCA on domestic emissions factors, at least initially, may help address the concern that if imposed by high income countries they would disproportionately affect developing countries due to the latter's generally higher embodied carbon in EITE industries.

[18] Refer to https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets/free-allocation_en

[19] For example, the ramping up of France's carbon tax was suspended in 2018 following the gilets jaune protests.

[20] In the EU, EITE industries receive financial compensation for charges on indirect emissions.

Figure 9. Production Cost Increases for Selected EITE Industries, 2019



Sources: Andrew (2019); Brown et al. (2019); IEA (2022); Statista (2022); USGS (2020); World Steel Association (2022); IMF staff calculations.
Note: All data are for 2019. Assumed price for cement $123 per tonne ($62 per tonne for China), price of aluminum $1,794 per tonne, price of steel $604 per tonne (the United States and Argentina), $651 per tonne (China) and $530 per tonne (Turkey). Carbon prices are $75 per tonne in the United States and $50 per tonne in other cases.

Under ETSs, a common approach for addressing competitiveness concerns has been free allowance allocation. Again, however, this approach does not compensate for abatement costs. And again BCAs (in the form of allowance purchase requirements for imports) are another possibility though uncertainties over the compatibility of BCAs with World Trade Organization (WTO) rules could be larger for ETSs.[21]

International (see below) or regional cooperation over carbon pricing would reduce the need for competitiveness assistance measures. Coordination over carbon pricing might emerge at the regional level, for example in Asia where carbon pricing schemes are in place (China, Japan, Kazakhstan, Korea, Singapore) or under consideration (Indonesia, Philippines, Thailand, Vietnam).

Price Levels

Under a carbon tax, the government can align the price trajectory with emissions targets, while alignment can be automatic under an ETS. Carbon tax trajectories can be set equal to price paths needed to bring emissions in line with mitigation targets, which can be inferred with some confidence for the near to medium term from estimates of future BAU emissions (or emissions with complementary instruments) and the responsiveness of emissions to pricing.[22] Periodic forward-looking adjustment of tax rates can maintain alignment with emissions goals. For an ETS, price alignment is automatic if the emissions cap is set to meet a country's mitigation commitment (for example, the EU ETS cap is reduced by 2.2 percent a year in line with 2030 emissions targets for the power/industrial sector).

Scaling up carbon pricing offers an opportune time to reform prior fuel taxes and an ETS can automatically preserve alignment with emissions targets. Accounting for fuel taxes (or subsidies) expressed in CO_2 equivalent taxes, there is wide divergence in pre-existing carbon charges across not only countries but

[21] ETSs might be viewed as regulations whereas carbon taxes might be viewed as indirect taxes that in principle can be border adjusted. Rebating exporters for domestic carbon charges is also likely to be at greater risk of legal challenge under an ETS than a carbon tax. See Parry and others (2021a).

[22] Emissions projections boil down to assumptions about future GDP growth, income elasticities for energy products, rates of technological change (for example, that improves energy efficiency or the productivity of renewables), and future energy prices (Black and others forthcoming, Annex B).

also fuels/sectors within countries—see Table 2. This trend suggests there is ample scope for better harmonizing combined carbon prices (from formal pricing and prior taxes) across fuels/sectors at the same time as scaling up the general level of carbon pricing. The total CO_2 tax per tonne should still differ, however, to the extent additional fuel taxes are needed to reflect domestic environmental externalities (for example, local pollution, road congestion).[23] If fuel taxes are reformed, the carbon price under an ETS automatically adjusts to keep emissions the same whereas under a carbon tax the carbon charge would need to be manually adjusted to preserve alignment with an emissions target.

Table 2. Excise Taxes by Fuel and Sector in 2020, G20 Countries

(Expressed in charges per tonne CO_2)[1]

	power			industry			transportation[b]		buildings[c]	
	coal	natural gas	oil	coal	natural gas	oil	gasoline	diesel	natural gas	oil
Argentina	0	- 31	19	5	0	33	105	45	- 41	1
Australia	0	0	79	6	24	96	157	99	- 54	68
Brazil	5	106	20	42	106	23	149	42	203	65
Canada	5	- 34	14	5	- 45	90	157	83	- 9	97
China	3	70	6	4	70	35	168	65	- 24	49
France	- 7	113	79	29	111	192	377	262	93	208
Germany	14	- 22	31	- 3	- 18	167	364	218	- 60	213
India	4	- 99	101	4	- 99	50	232	130	0	- 2
Indonesia	0	33	- 7	0	11	- 10	38	- 11	- 65	-93
Italy	- 11	- 51	7	16	- 3	191	396	278	- 120	201
Japan	0	- 25	21	3	80	98	270	148	218	178
Korea	0	39	12	24	78	92	296	175	- 43	108
Mexico	0	- 16	8	1	0	44	112	103	- 71	18
Russia	0	- 34	2	0	- 33	2	49	5	- 158	- 25
S. Arabia	0	- 68	-13	0	- 68	- 26	- 46	- 159	0	- 88
S. Africa	0	79	90	0	79	107	204	101	0	75
Turkey	0	20	0	5	14	43	219	74	- 133	111
UK	20	- 35	53	37	73	176	341	285	- 103	93
US	0	0	10	0	0	39	71	46	- 19	33
simple average	**2**	**2**	**28**	**9**	**20**	**76**	**193**	**105**	**-20**	**69**

Source: Black and others (2022). [1]Tax rates include fuel excises and subsidies but not general consumption taxes. [2] For light-duty vehicles. [3] For fuels used in residential buildings.

Compatibility with Overlapping Mitigation Instruments

Carbon taxes are compatible with overlapping non-pricing instruments. Instruments employed at the sectoral level, such as emission rate regulations, feebates, and clean technology subsidies, frequently overlap with carbon pricing policies[24] and, while they are less efficient, may have greater acceptability as they do not impose a new tax burden on the average household or firm. When combined with a pure carbon tax, these other instruments further reduce emissions without lowering the emissions price.

ETSs are typically less compatible with overlapping instruments, although they could be modified to improve compatibility, or can act as a backstop for regulatory approaches. Overlapping instruments imposed on top of an ETS do not reduce emissions, as emissions are fixed by the cap—instead they act to lower the emissions price (and thereby undermine ETS revenue and investment incentives across all covered sectors). Underpinning the ETS with a price floor can help to address this issue, however. In addition, the ETS emissions cap can be adjusted over time to account for the effect overlapping instruments if the main objective is price stability. In California, the mitigation strategy includes a regulatory framework (including renewable portfolio standards, vehicle emission rate standards, and energy efficiency requirements) and the ETS ensures

[23] Indeed, although transportation fuels are heavily taxed in many counties, in general they still fall short of levels required to address the full range of domestic externalities. See Parry and others (2021b).

[24] Black and others (forthcoming).

emissions reductions are achieved regardless of the effect of regulations—at the same time, there is also a floor price under the ETS to maintain a robust price signal from the system. From the point of view of economic efficiency, however, it is best to have the ETS play the central role, with complementary regulations if needed in "hard-to-abate" sectors such as transport and buildings.

Broader Considerations

Pricing Broader Sources of GHGs

Carbon pricing, or proxy pricing, may be extended to other sources of GHGs, and taxes are a more natural instrument if these regimes build off existing capacity for business tax regimes. For example:

- *Extractive emissions*: Although metering technologies (particularly remote sensing) are evolving, it is not presently feasible for government agencies to comprehensively monitor methane leaks from extractive industries (for example, from venting, pipeline leaks). Proxy pricing schemes can, however, be applied based on fuel supply and either mandated emissions monitoring by firms (as in, for example, Norway) or default emissions factors (in the latter case with rebates for firms demonstrating they have taken steps to lower emissions below the default rate).
- *Agricultural emissions*: Similarly in agriculture, pricing might be applied to methane from livestock based on farm outputs and inputs (for example, type of herd and feed) and default emissions factors, which would promote reductions in emissions intensity and shifting from livestock to crops. Methane emissions for agriculture, however, are less responsive to pricing than for extractives,[25] and to address competitiveness concerns for this sector pricing revenues might need to be returned to farmers (for example, in proportion to output values) or pricing combined with border adjustments.
- *Process emissions*: Pricing for GHGs from industrial processes might be implemented through direct monitoring of smokestack emissions (for example, CO_2 released in the production of cement) or default emissions factors (for example, for hydrofluorocarbons (HFCs) embodied in refrigerants, foams, aerosols, and fire extinguishers).

These sorts of pricing schemes have greater practicality where they can be implemented building off existing capacity for business tax regimes, whether that is fiscal regimes for rent extraction from extractives or the taxation of farm income. CO_2 emissions from industrial processes are amenable to coverage under a downstream ETS, though some countries have implemented taxes on HFCs and similar gases.[26]

In the case of international transportation fuels, carbon taxes may be a more robust instrument for promoting the advancement of critical technologies than ETSs, though feebates are probably the most practical way forward. For example, in the international maritime sector the more pressing priority is to develop and deploy zero emission (for example, hydrogen) vessels into the shipping fleet. Given the long-lived nature of the investment (the lifetime of ships is typically around 30 years) the certainty over the future emissions price, and hence over lifetime fuel costs, that a carbon tax can provide seems best suited to promoting this deployment. A pure carbon tax with the needed price signal would however likely raise far more revenue than could be efficiently absorbed by the IMO. A feebate with operators taxed in proportion to the difference between their emissions rate and a benchmark emission rate could maintain the price signal while the benchmark

[25] UNEP (2021).

[26] For example, Denmark, Norway, Poland, Slovenia, and Spain (Brack 2015). The case for taxing methane emissions from waste sites (landfills and wastewater systems) may be less compelling. There is a limited number of (readily observable) mitigation responses (for example, collection and flaring of landfill gas), which makes it easier to mimic the effects of pricing with regulation, and waste sites are largely under public management (where it may be more natural to set standards rather than apply pricing).

emission rate could be set to limit revenue to the amount needed for clean vessel R&D programs—this would also promote international acceptability by reducing industry costs.[27]

The forestry sector is also more amenable to a feebate scheme (or equivalently a carbon tax with negative payments for sequestration) than pure carbon taxes or ETSs. Here the need is for a nationwide incentive scheme that penalizes landowners reducing carbon storage over time (through deforestation) while rewarding landowners that increase carbon sequestration (through afforestation and forest management practices). The latter incentive cannot be provided under a pure carbon tax or ETS that only charges, or requires permits for, emissions releases but it can be under a feebate that provides subsidies to landowners increasing carbon storage over time (while taxing those reducing storage)—this is equivalent to a carbon tax with negative symmetric payments for net sequestration.[28]

Alternative approaches for agriculture and forestry of combining carbon taxes and ETSs with domestic offsetting provisions can be problematic. With offsets, entities covered by carbon taxes and ETSs can partially avoid cutting their own emissions by paying for mitigation projects in other sectors, for example a reforestation project, to offset their emissions. The purpose of the offset is not to reduce total emissions but rather to promote a more cost-effective balance of mitigation between sectors that are, and are not, covered by formal pricing schemes. One problem however is that offsets may not always be additional (that is, a project might have gone ahead anyway even without the offset payment) and this can be difficult to verify.[29] Also, the offset may not be permanent, for example, forests may subsequently burn down, releasing the sequestered carbon. In either case of non-additionality or impermanence, the offset provision will increase emissions overall. Moreover, no automatic mechanism exists to ensure that the most cost-effective projects in other sectors are those that receive offset payments.

Global Coordination Regimes

Carbon taxes or ETSs would allow countries to participate in an internationally coordinated pricing regime to reinforce the Paris Agreement, which could facilitate a scaling up of global mitigation. An internationally coordinated regime would focus on: (1) a small number of large emitters to facilitate negotiation while still covering the bulk of emissions and (2) a minimum carbon price that participants should implement, as carbon pricing is an efficient and easily understood parameter and joint action to scale up carbon pricing would be the most effective way to address competitiveness concerns.

Such a regime could account for equity concerns through differentiated carbon prices between developed and developing economies. A price floor of $75, $50, and $25 per tonne for high-, medium- and low-income countries, respectively would be sufficient to align global CO_2 emissions in 2030 with keeping global warming below 2°C even with just six participants (Canada, China, India, EU, United Kingdom, United States).[30] And countries where carbon pricing is difficult could be accommodated so long as they achieved equivalent emissions reductions through other approaches as they would have achieved from meeting the price floor.[31] Pricing might be established initially for the power and industry sectors—given that most emissions reductions

[27] See Parry and others (2022).

[28] Measures of forest carbon storage by land parcel can be obtained using a combination of remote sensing, aerial photography, and on-the-ground tree sampling. These inventories are being established for 47 developing countries under the REDD+ program (see www.forestcarbonpartnership.org/what-redd).

[29] This problem appears to be systematic. For example, an EU study found that 85 percent of offsets allowed into the EU ETS were non-additional (Cames and others 2017).

[30] This assumes all G20 countries met their NDCs and countries in the agreement met, whichever is the more stringent of the price floor or their NDC (Parry and others 2021c).

[31] Black and others (2022) have developed and implemented for G20 countries a methodology for mapping alternative approaches into their CO_2 reductions and carbon price equivalent.

under comprehensive carbon pricing come from these sectors (Figure 5) and many countries already price emissions from these sectors.

International price coordination requirements would be most naturally met through a carbon tax but ETSs are readily accommodated. ETSs could be accommodated (as they are under the prototype federal pricing requirements in Canada) by underpinning the ETS with a floor price or by setting caps to generate expected domestic emissions prices, in line with international pricing requirements.

In theory, global price coordination could also be built up through linking existing ETS and carbon tax systems, but there are major downsides. Linking carbon prices such as ETSs (for example, where permits traded under one ETS are allowable under another) would theoretically promote cost effectiveness at the international level through harmonizing permit prices across countries. However, linking also perpetuates design characteristics (for example, a carbon price ceiling in one ETS becomes the price ceiling in the linked ETS), reduces the ability of governments to achieve domestic targets, and can create significant administrative complexity and uncertainty.[32] Additionally, a global temperature-aligned regime would need to include large emitters that do not have ETSs. Equity concerns would also need to be addressed, for example, through permit trading ratios (for example, a permit from a low-income country might be worth three permits from a high-income country). And the regime would need to specify a concrete trajectory of emissions caps or prices which, if implemented, would deliver required reductions in global CO_2 emissions in 2030.

Conclusion

In summary (see Table 3) absent political constraints, carbon taxes have appeal on practical grounds. They can provide certainty over future emissions prices (which is needed to promote emissions saving investments), revenues accrue automatically to finance ministries, and they easily build off existing fuel tax collection. Tax trajectories can be aligned, and periodically adjusted, to maintain consistency with emissions goals. Carbon taxes are compatible with reinforcing mitigation instruments (for example, feebates) that will be needed for hard-to-abate sectors like buildings and transport and potentially border adjustments. Revenues from carbon taxes can provide robust assistance for low-income groups while still leaving the bulk of revenues for cutting other burdensome taxes or boosting productive investments. Carbon taxes can also be extended to broader emissions sources, building off existing business tax regimes in some cases, though sometimes proxy taxes may be needed (for example, for extractives or agriculture where the government is unable to monitor emissions) or feebate variants that limit revenue collection (for example, by international regulatory bodies) or reward carbon sequestration (for example, for forestry).

ETSs may also have their own appeal, but they suffer from some limitations. ETSs help achieve emissions targets with more certainty, are a more natural instrument where mitigation policy is under the purview of environment ministries, and free allowance allocation to build political support seems to be a key decision factor for many countries as testified by the increasing number of ETSs (Europe, Asia). Price stability mechanisms in existing ETSs have not, however, prevented significant price volatility, to the extent revenues have been raised they have been largely earmarked, and ETSs are not practical in some (for example, capacity-constrained) countries. In addition, ETSs are not automatically compatible with reinforcing mitigation instruments and legal obstacles to border adjustments may be greater (for example, for export rebates) than for carbon taxes. Incorporating broader emissions sectors under an ETS through offsetting provisions may increase emissions on net and provides no automatic mechanism for prioritizing cost-effective projects in the offsetting sector. Linking ETSs into a global carbon market could improve the cost-effectiveness of mitigation across countries but reinforcing the Paris Agreement with a formal international carbon price floor is more effective at scaling up

[32] For discussion see Green (2017). Carbon tax systems could also be linked but this entails other complexities (Metcalf and Weisbach 2012).

global mitigation, could address international equity concerns, and better accommodate alternative approaches at the national level.

Overall, policymakers will choose between and within carbon pricing instruments depending on their diverse national circumstances, though pricing will need to be part of a comprehensive strategy. Designed and implemented appropriately, carbon pricing can be the centerpiece of climate mitigation strategies for most countries. Pricing promotes the full range of behavioral responses for reducing emissions, mobilizes a valuable source of revenue, and imposes generally manageable transitional costs on the economy which are counteracted by potential economic gains through revenue recycling and significant domestic environmental co-benefits. While there some practical advantages of carbon taxes, policymakers may prefer ETSs for other reasons—there is no 'one carbon pricing instrument that fits all'. In the latter case however, ETSs can be designed (for example through price floors and allowance auctions) to mimic some of the advantages of taxes. Irrespective of carbon price instrument choice, a variety of additional measures will be needed, not least given the difficulty of pricing given its impact on energy prices, compounded by the current macroeconomic context. The strategy will require a balance between pricing and reinforcing instruments like feebates, productive and equitable use of carbon pricing revenues, just transition measures for vulnerable groups, pricing of broader emissions sources, public investment in enabling infrastructure which the private sector may underinvest in, and extensive public communication and stakeholder consultation. Designing and implementing policy packages that cut emissions while ensuring a just transition, ideally with carbon pricing at their core, will be key to achieving climate targets and, ultimately, the Paris Agreement's goals.

Table 3. Summary Comparison of Carbon Taxes and ETSs

Design issue	Instrument	
	Carbon tax	ETS
Administration	Administration is more straightforward (for example, as extension of fuel taxes)	May not be practical for capacity constrained countries
Uncertainty: price	Price certainty can promote clean technology innovation and adoption	Price volatility can be problematic; price floors, and cap adjustments can limit price volatility
Uncertainty: emissions	Emissions uncertain but tax rate can be periodically adjusted	Certainty over emissions levels
Revenue: efficiency	Revenue usually accrues to finance ministry for general purposes (for example, cutting other taxes, general investment)	Free permit allocation may help with acceptability but lowers revenue; tendency for auctioned revenues to be earmarked
Revenue: distribution	Revenues can be recycled to make overall policy distribution neutral or progressive	Free allowance allocation or earmarking may limit opportunity for desirable distributional outcomes
Political economy	Can be politically challenging to implement new taxes; use of revenues and communications critical	Can be more politically acceptable than taxes, especially under free allocation
Competitiveness	Border carbon adjustment more robust than other measures (for example, threshold exemptions, output-based rebates)	Free allowances effective at modest abatement level; border adjustments (especially export rebate) subject to greater legal uncertainty
Price level and emissions alignment	Need to be estimated and adjusted periodically to align with emissions goals	Alignment of prices with targets is automatic if emissions caps consistent with mitigation goals
Compatibility with other instruments	Compatible with overlapping instruments (emissions decrease more with more policies)	Overlapping instruments reduce emissions price without affecting emissions though caps can be set or adjusted accordingly
Pricing broader GHGs	Amenable to tax or proxy taxes building off business tax regimes; feebate variants are sometimes appropriate (for example, forestry,	Less amenable to ETS; incorporating other sectors through offsets may increase emissions and is not cost effective
Global coordination regimes	Most natural instrument for international carbon price floor	Can comply with international price floor; mutually advantageous trades from linking ETSs but does not meet global emissions requirements

Source. IMF staff.
Note: Green indicates an advantage of the instrument; orange indicates neither an advantage nor disadvantage; red indicates a disadvantage of the instrument.

Annex 1. Behavioral Responses Promoted by Alternative CO_2 Mitigation Policies

Comprehensive carbon pricing cost-effectively promotes a broader range of behavioral responses for reducing CO_2 emissions than non-pricing instruments. These responses include:

- *Power generation*: shifting (both in terms of new investment and the daily dispatch mix) from coal to natural gas, from these fuels to renewables, and perhaps to nuclear and fossil generation with carbon capture and storage;
- *Industry*: reducing CO_2 and electricity intensity (for example, through alternative heating sources than coal, enhanced recycling of scrap metal) and output levels
- *Transportation*: shifting to more efficient internal combustion engine vehicles, from these vehicles to electric (or other zero emission) vehicles, and reducing vehicle miles travelled
- *Buildings*: reducing CO_2 intensity, electricity intensity, and energy demand (for example, through energy efficient constructions, upgrading insulation of existing buildings, switching from fossil to electric heat pumps, improving the energy efficiency of appliances, turning down the heating).

Pricing strikes the cost-effective balance across these responses as the reward for reducing emissions by an additional tonne—the carbon price—is equated across them.

Non-pricing mitigation instruments promote a narrower range of behavioral responses or lagged rather than immediate responses. Even within a sector, these instruments do not promote the full and immediate range of behavioral responses, for example:

- Renewable portfolio standards and feed-in tariffs for renewables only promote shifting from fossil to renewable generation
- Emission rate regulations, or feebates, for new vehicles reduce emissions from the on-road fleet gradually over time as the fleet turns over (for example, they do not accelerate retirement of old vehicles) and they do not reduce vehicle miles travelled—additionally, electric vehicle subsidies do not promote shifting to more efficient internal combustion engine vehicles
- Incentives for net zero new buildings reduce emissions from the building stock very gradually (given that typically less than 2 percent of the building stock is replaced each year)

A combination of non-pricing measures across sectors, and across new and existing capital, can promote many of the behavioral responses of carbon pricing, though not all of them—for example, regulations cannot encourage people to drive less or turn down the heating. Moreover, cost-effectively coordinating policies can be challenging—under regulatory approaches it would require extensive credit trading provisions across firms, programs, and sectors.

In practice, other mitigation instruments will be used to complement and reinforce carbon pricing. Although less efficient, non-pricing instruments may have greater acceptability as they avoid significant and politically sensitive increases in energy prices—unlike carbon pricing, they do not involve the pass through of carbon tax revenues or allowance rents in energy prices. Non-pricing instruments like feebates may have a key role in kick-starting de-carbonization of hard-to-abate sectors, particularly transportation and buildings. Policymakers need to strike a balance between carbon pricing (the most efficient but perhaps most politically challenging instrument) and other (less efficient but perhaps more acceptable) reinforcing instruments.

Annex 2. Additional Details on Carbon Pricing Schemes

Annex Table 2.1. Further Details on National, Subnational and Regional Level Carbon Pricing Schemes in Operation

Country/ Region	Year Introduced	Coverage of Energy Sectors: Power	Industry	Transport	Buildings	Coverage Rate, all GHGs (percent)	Price, $/tonne	Revenue/ Rent, % GDP	Point of Tax/ Regulation	Revenue Use
Carbon Taxes										
Argentina	2018	✓	✓	✓		20	5	0.070	Midstream	General budget
Colombia	2017	✓	✓	✓	✓	23	5	0.04	Midstream	Environmental spending
Chile	2017	✓	✓			29	5	0.05	Downstream	General budget
Indonesia	2022	✓				26	2	0.05	Midstream	General budget
Singapore	2019	✓	✓			80	4	0.04	Midstream	General budget
South Africa	2019	✓	✓	✓	✓	80	10	0.04	Midstream	General budget
Ukraine	2011	✓	✓		✓	71	1	0.05	Midstream	General budget
Uruguay	2022		✓	✓		11	127	1.15	Midstream	General budget, environmental spending
ETSs										
EU	2005	✓	✓			41	87	0.26	Downstream	General budget, environmental spending
Austria	2005	✓	✓			37	87	0.11	Downstream	General budget, environmental spending
Belgium	2005	✓	✓			38	87	0.19	Downstream	General budget, environmental spending
Bulgaria	2005	✓	✓			52	87	1.82	Downstream	General budget, environmental spending
Croatia	2005	✓	✓			32	87	0.33	Downstream	General budget, environmental spending
Cyprus	2005	✓	✓			51	87	0.43	Downstream	General budget, environmental spending
China	2013, 2014, 2016, 2021	✓				38	9	0.32	Downstream	Environmental spending proposal
Czech Republic	2005	✓	✓			51	87	0.78	Downstream	General budget, environmental spending
Germany	2005, 2021	✓	✓	✓	✓	85	62	0.44	Mid & Downstream	Environmental spending
Greece	2005	✓	✓			47	87	0.66	Downstream	General budget, environmental spending
Hungary	2005	✓	✓			30	87	0.39	Downstream	General budget, environmental spending
Italy	2005	✓	✓			34	87	0.18	Downstream	General budget, environmental spending
Kazakhstan	2013	✓	✓		✓	46	1	0.10	Downstream	General budget
Korea	2015	✓	✓	✓	✓	73	19	0.99	Downstream	Environmental spending
Lithuania	2005	✓	✓			30	87	0.44	Downstream	General budget, environmental spending
Malta	2005	✓	✓			34	87	0.28	Downstream	General budget, environmental spending
New Zealand	2008	✓	✓	✓		49	53	0.20	Downstream	General budget, environmental spending
Romania	2005	✓	✓			33	87	0.89	Downstream	General budget, environmental spending
Slovakia	2005	✓	✓			50	87	0.64	Downstream	General budget, environmental spending
US	2009, 2012, 2018, 2021	✓	✓	✓	✓	7	24	0.05	Up & Midstream	General budget, direct transfers, environmental spending
Hybrid										
Canada	2019	✓	✓	✓	✓	67	38	0.16	Downstream	Tax cuts, environmental spending
Denmark	1992, 2005	✓	✓	✓	✓	62	52	0.29	Mid & Downstream	General budget
Estonia	2000, 2005	✓	✓			63	79	1.26	Mid & Downstream	General budget
Finland	1990, 2005	✓	✓	✓	✓	67	77	0.76	Mid & Downstream	General budget, tax cuts
France	2005, 2014	✓	✓	✓	✓	56	64	0.41	Mid & Downstream	General budget, environmental spending
Iceland	2005, 2010	✓	✓	✓	✓	93	56	0.62	Mid & Downstream	General budget
Ireland	2005, 2010	✓	✓	✓	✓	59	62	0.23	Mid & Downstream	General budget,direct transfers, environmental spending
Mexico	2014, 2020	✓	✓	✓	✓	61	4	0.02	Midstream	General budget
Japan	2010, 2011, 2012	✓	✓	✓	✓	77	2	0.05	Midstream	Environmental spending
Latvia	2004, 2005	✓	✓			25.4	79	0.39	Midstream	General budget
Liechtenstein	2005, 2008	✓	✓	✓	✓	81	130	0.60	Mid & Downstream	General budget
Luxembourg	2005, 2021	✓	✓	✓	✓	79	38	0.048	Mid & Downstream	General budget
Netherlands	2005, 2021	✓	✓			46	87	0.270	Mid & Downstream	General budget
Norway	1991, 2005	✓	✓	✓	✓	55	87	0.94	Mid & Downstream	General budget
Poland	1990, 2005	✓	✓	✓	✓	51	81	1.45	Mid & Downstream	Environmental spending
Portugal	2015, 2005	✓	✓	✓	✓	70	56	0.52	Mid & Downstream	General budget, environmental spending
Slovenia	1996, 2005	✓	✓	✓	✓	89	47	0.48	Mid & Downstream	General budget
Spain	2005, 2014	✓	✓		✓	37	82	0.25	Mid & Downstream	General budget, environmental spending
Sweden	1991, 2005	✓	✓	✓	✓	77	109	0.52	Mid & Downstream	General budget
UK	2013, 2021	✓	✓			49	67	0.42	Downstream	General budget, tax cuts
Switzerland	2008	✓	✓		✓	44	114	0.16	Midstream	Tax cuts, direct transfers, environmental spending

Sources: ICAP (2022); Marten and van Dender (2019); WBG (2019, 2022); Yunis and Aliakbari (2020); and government websites.
Note Revenue/rent excludes revenue loss from erosion of prior fuel tax bases. Values combine national, subnational and regional pricing. Mexico does not include subnational pricing schemes due to lack of coverage data.

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