TECHNICAL REPORT

ENERGY SUBSIDY REFORM IN ACTION

TOTAL CARBON PRICING FOR ENERGY CONSUMPTION

The Importance of Energy Taxes and Subsidies

THE WORLD BANK
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ESMAP
Energy Sector Management Assistance Program

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Paolo Agnolucci, Defne Gencer, and Dirk Heine

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ABOUT ESMAP

The Energy Sector Management Assistance Program (ESMAP) is a partnership between the World Bank and over 20 partners to help low- and middle-income countries reduce poverty and boost growth through sustainable energy solutions. ESMAP's analytical and advisory services are fully integrated within the World Bank's country financing and policy dialogue in the energy sector. Through the WB, ESMAP works to accelerate the energy transition required to achieve Sustainable Development Goal 7 (SDG7), which ensures access to affordable, reliable, sustainable, and modern energy for all. It helps shape WB strategies and programs to achieve the WB Climate Change Action Plan targets. Learn more at: https://www.esmap.org.

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ABOUT THIS SERIES

This report is part of the "Energy Subsidy Reform in Action" series produced by the ESMAP Energy Subsidy Reform Facility, with the objective of drawing insights from recent experiences and emerging approaches related to reform of energy subsidies in developing countries. The series includes issue-specific reports from various relevant domains such as energy sector reform, macroeconomic and fiscal policy, carbon pricing, poverty and distributional analysis, social protection, political economy, and communications.

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Abbreviations

bbl	barrel
CO_2	carbon dioxide
ECR	effective carbon rate
ETS	emissions trading system
EU	European Union
GHG	greenhouse gas
GJ	gigajoule
IEA	International Energy Agency
IMF	International Monetary Fund
LLMIC	low-income and lower middle-income countries
LPG	liquefied petroleum gas
MER	market exchange rates
OECD	Organisation for Economic Co-operation and Development
PPP	purchasing power parity
tCO_2	ton of carbon dioxide
TCP	total carbon price
TPS	tradable performance standards
UMHIC	upper middle-income and high-income countries
VAT	value added tax

All currency is in United States dollars (US$, USD), unless otherwise indicated.

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Executive Summary

Faced with the urgency of climate change mitigation, many governments around the world are considering and deploying different approaches to pricing greenhouse gas emissions. The efforts to put a price on carbon—aiming to reflect the social and environmental costs resulting from these emissions—have traditionally focused on carbon taxes and emissions trading systems.

Governments use a broader set of energy, climate, and fiscal policy instruments that affect the price signal on carbon emissions, even when sending such a signal is not stated as an explicit objective. In addition to decisions related to emissions trading or carbon taxes, governments take actions that influence the prices of the fuels that generate those emissions, whether by directly setting retail prices, providing energy consumption subsidies, or levying energy taxes.

Carbon price signals resulting from the combination of multiple policy instruments at one time are often unclear. Building on this observation, this report asks, How do different energy, climate, and fiscal policy instruments that affect the price of carbon interact? And what overall price signal do these direct and indirect ways of pricing carbon send to the economy?" To answer these questions, the report adopts the concept of the total carbon price (TCP), introduced in Agnolucci et al. (2023a; 2023b), to estimate the net carbon price signal resulting from the most commonly deployed energy, climate, and fiscal policy instruments that affect the price of carbon emissions. To show how the concept of TCP can be applied to understanding the interaction of these different policy instruments, this report carries out illustrative calculations using best-available multicountry data sets, with a special focus on energy subsidies.

Simply put, the TCP is calculated as an average of direct carbon prices (as determined via emissions trading systems and carbon taxes) and indirect carbon prices (energy subsidies and excise taxes), which are weighted based on the emissions covered by each instrument. The calculation of the TCP can be performed by fuel, sector, country, or a combination thereof. Data needs vary accordingly. In all cases, the data needed for calculating the TCP include nominal tax rates and consumption subsidies per unit of energy and the rate of direct carbon pricing per unit of emissions. For each instrument, the fuel consumption (or the carbon dioxide [CO_2] emissions equivalent) affected by that instrument, as well as the set of exemptions and discounts offered to specific sectors or fuels, are also required.

Illustrative calculations of the TCP using best-available global data sets render findings that will be worth exploring further in future work and validating through country-level data. The illustrative calculations, carried out to demonstrate how the TCP concept can be applied, use data from best-available multicountry data sets. Data used include those from the World Bank (direct carbon prices), the International Energy Agency (energy consumption), and the International Monetary Fund (fuel taxes and subsidies). These calculations can highlight the interaction of key climate policy tools and offer high-level insights and areas for future research.

The analysis based on illustrative TCP calculations shows that the level of price signals sent by energy subsidies, taxation, and direct carbon pricing instruments varies across fuels and sectors of the economy in different country groups. The main findings from the illustrative TCP calculations include the following:

- Carbon price signals vary greatly across countries, fuels, and sectors.
- A significant share of carbon price signals are currently delivered by indirect carbon pricing instruments, in particular taxation of fuels.
- Energy consumption subsidies substantially undermine the signals from direct carbon pricing and taxation.
- When energy subsidies, energy taxes, and direct carbon pricing are assessed together, multiple countries and sectors end up with negative aggregate carbon price signals.

Disaggregating TCP levels and their evolution by fuel and by sector reveals a considerable amount of heterogeneity in the patterns of the TCP and its components. The analysis shows that the TCP varies markedly by fuel and end-use sector. International oil prices affect the TCP, and the impact varies by fuel. According to illustrative calculations, the TCP for diesel and gasoline tends to rise along with international oil prices, whereas the TCP for liquefied petroleum gas (LPG), and to a lesser extent kerosene, has an inverse relationship with oil prices. The TCP for natural gas moves mostly in the same direction as that of oil prices, though there is some divergence from 2009 onward. The illustrative calculations do not indicate a strong relationship between oil prices and the TCP for coal.

When the TCP for energy-consuming sectors is explored, the transport sector faces the strongest carbon price signal by far. This is not surprising, given that the main fuels consumed by the sector, namely gasoline and diesel, are the fuels for which the TCP is strongest. Among the sectors included in this analysis, the power sector faces a much lower carbon price signal compared with others. On average, consumption of fuel by residential consumers receives the highest level of subsidies per ton of CO_2 emitted but also bears a relatively high level of taxation.

The analysis finds differences in the level of the TCP and its components across countries, by per capita income level,[1] and by fuel trading status. Because levels of the TCP and its components are influenced by country-specific structural and economic factors, such as income levels, patterns of fossil fuel trade, and fiscal debt levels, the analysis explores different groupings of countries to understand whether and how the TCP varies. In low-income countries exporting fossil fuels, energy subsidies are much larger than excise taxes, which makes the TCP consistently negative. On the other hand, the value of the TCP is positive, but relatively small, in low-income countries importing fossil fuels and high-income countries exporting fossil fuels.

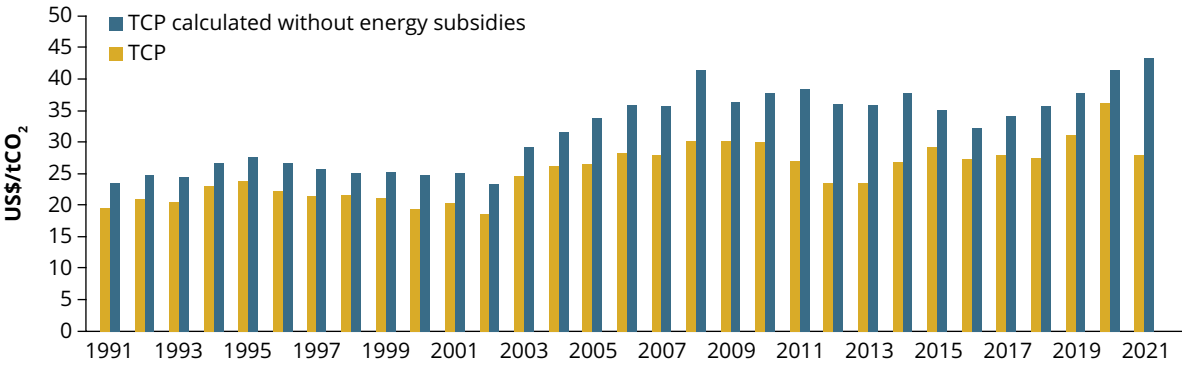
An important takeaway is that when energy consumption subsidies are considered alongside direct carbon prices, across countries, the resulting carbon price signal is much lower than the levels estimated to be needed for achieving the goals envisaged in the Paris Agreement. Illustrative calculations of the aggregate TCP at the global level demonstrate how energy subsidies counteract the positive pricing signals from other policy tools. Figure ES.1 plots the movement of TCP with and without energy subsidies; it is intended to show how energy subsidies dampen the carbon price signal from other instruments and weaken the economic incentives for reducing emissions. Of course, it is worth pointing out that although global aggregate estimates are useful for illustrating the critical role of indirect carbon pricing instruments, what primarily matters for any given country or jurisdiction are the signals sent by instruments that are in force within that jurisdiction.

The significant role that energy subsidies play in influencing the total carbon price highlights efforts to tackle energy subsidies as a core climate change mitigation action. In view of the gap between the current reality and global (and national) climate ambitions, it is imperative to recognize how energy consumption subsidies counteract and

1. Income classifications are based on World Bank Country and Lending Groups, accessed in May 2022 (World Bank 2022b).

FIGURE ES.1

Total Carbon Price with and without Energy Subsidies



Source: Authors' calculations using IEA, IMF, and World Bank data sets.
Note: TCP = total carbon price; US$/t$CO_2$ = US dollars per ton of carbon dioxide.

undermine direct and indirect carbon pricing efforts. An important related step will be to raise awareness and support policy makers in finding ways to make different energy, climate, and fiscal policy instruments work together rather than undermine each other. At this juncture, it is critical to emphasize the central role for energy subsidy reforms at the nexus of the energy, fiscal, and climate policy domains.

Although the analysis offers useful insights on high-level dynamics, it is important to remember that the results of the illustrative calculations are directly dependent on the underlying data sets used and assumptions made. Accordingly, any conclusions reached from that analysis will be highly dependent on the accuracy and completeness of the data from the underlying sources. Therefore, when attempting to apply the TCP concept for a specific country or set of countries, the higher the quality of the underlying data, the more reliable any conclusions drawn from the analysis will be. Investing in data quality and reliability can improve the relevance and usefulness of the analysis and conclusions from applications of the TCP.

The TCP does have a number of methodological limitations. First, the indicator is confined to greenhouse gas (GHG) emissions from the combustion of fossil fuels, including in power generation, but excluding emissions from agriculture and land-use change. Production subsidies and taxes are not taken into account, given data constraints. Moreover, the price-gap approach, which the TCP uses, cannot capture some forms of subsidies, such as conditional cash transfers, because not all subsidies result in net changes in end-user prices (Koplow 2009). In addition to limitations around sectoral emissions and policy instruments currently covered by total carbon pricing, select components of the TCP, namely net energy taxation or subsidy levels, had to be calculated rather than being based on observed data.

The TCP can be further strengthened and some of its limitations can be overcome through refinements in future applications and improved data availability. Some of the challenges, in particular those around reliable data, can be addressed through country-level work. Going forward, a critical area of focus should be to enhance the usefulness of the TCP for policy makers and practitioners, and to strengthen the quality of its application in specific countries using country-level data. Even with its current limitations, the application of the TCP can help strengthen the understanding of the full scale and impact of energy subsidies on carbon price signals, and recognizing their interaction with other energy, climate, and fiscal policy instruments will be important for policy makers and development practitioners.

ONE

Introduction

The genesis of this report is a recognition of the policy significance and climate change mitigation potential of direct and indirect carbon pricing instruments and an interest in better understanding the carbon price signals resulting from the combination of these instruments. To capture this dynamic, the total carbon price (TCP) indicator was developed to evaluate carbon price signals resulting from the combination of direct carbon pricing instruments with policy instruments serving as indirect carbon pricing, mainly through energy taxes and subsidies (Agnolucci et al. 2023b).[1]

The TCP indicator, developed as part of a wider analytical activity supported by the ESMAP Energy Subsidy Reform Facility, was introduced and elaborated in Agnolucci et al. (2023a, 2023b), which provide extensive detail on the underlying methodology and approach. The current report builds on the two companion reports and delves deeper into energy sector dimensions of the TCP. As part of the broader effort, this report focuses specifically on two key policy instruments affecting energy consumption—energy taxes and energy subsidies—which it explores in greater detail.

This chapter provides the context within which this report was conceived, discusses the objectives of the analysis, and introduces the key concepts.

1.1. Direct and Indirect Carbon Pricing: Key Policy Instruments

Over the past three decades, countries around the world have been deploying energy, climate, and fiscal policy instruments that directly or indirectly send price signals to economic actors using energy and contributing to carbon dioxide (CO_2) emissions, namely, direct carbon pricing, energy taxes, and energy subsidies. As elaborated in Agnolucci et al. (2023a) *direct carbon pricing* mechanisms are those that put a direct price on emissions, while *indirect carbon pricing* policies impose a cost on specific energy sources or carriers[2] producing carbon emissions by influencing the relative prices of products and services. Such indirect policies contribute to the net carbon price signal even when they are not fully aligned with the carbon content of the various fuels. A framework categorizing various instruments with carbon price signals, including pricing and nonpricing policies, and elaborating on their objectives is available in table A.1. These instruments have come to be increasingly used alongside one another, while being treated separately and evolving independently from each other for the most part, both in policy and in the academic literature.

1. The research and analytical work that informed this paper benefited from funding from ESMAP through its Energy Subsidy Reform Facility.
2. An energy carrier is defined as a "substance or phenomenon that can be used to produce mechanical work or heat or to operate chemical or physical processes" (ISO13600:1997). In the energy value chain, the carriers are the intermediate step between primary energy sources, such as crude oil and coal, and end-use applications, such as lighting, refrigeration, or heating. Examples of energy carriers include electricity; solid, liquid, or gaseous fuels; and heat.

It is important to recognize the policy significance and climate change mitigation potential of indirect carbon pricing instruments and to understand how direct and indirect carbon pricing instruments affect each other. In view of the coexistence of direct and indirect carbon pricing policy instruments in multiple jurisdictions, and the significant resources dedicated to each of them, it is important to understand the complementarity (and counteraction), similarity (or contradiction) of goals, impacts, co-benefits, and resource needs of these instruments. For example, when a country introduces a carbon pricing scheme affecting its cement industry but underprices or chooses not to tax key energy inputs for all industries, it is highly likely that any benefits from a modest carbon pricing scheme covering the largest enterprises in the cement sector will be undone by the energy subsidies that encourage inefficiency and waste elsewhere while also imposing significant fiscal burdens on government. A narrow perspective that focuses purely on direct carbon pricing instruments risks missing out on the significant climate change mitigation potential stemming from widely deployed fiscal and energy policy tools. These tools can be particularly helpful for developing countries to simultaneously achieve various macroeconomic, fiscal, sectoral, and climate change mitigation objectives. An integrated approach that takes into account the interaction of the various instruments that are part of the policy toolbox for developing-country governments is critical.

This report expands the concept of the TCP, presents illustrative calculations to demonstrate the application of the concept, and takes a closer look at the role of energy subsidies. Building on ESMAP-funded background research and analyses that informed the development of the TCP concept, and complementing the in-depth quantitative approach taken in the companion papers, this report considers how energy subsidies interact with direct carbon pricing to influence the ultimate carbon price signal. This report offers additional granularity on the main components of indirect carbon pricing, that is, energy subsidies and taxes, and emphasizes the central role of energy subsidies in influencing levels and movement of the TCP over time.

1.1.1. Direct Carbon Pricing

Direct carbon pricing comprises measures that levy a cost directly on emissions or in proportion to the carbon content of a product. Direct carbon pricing initiatives, typically introduced through carbon taxes and emissions trading systems (ETSs), aim to impose an explicit price on emissions, expressed as a monetary unit per ton of carbon dioxide (tCO_2).[3] Carbon taxes are aligned with the carbon content of different sources of CO_2 emissions, and as such, send a direct price signal on those emissions that is consistent across the economy. ETSs can be in the form of cap-and-trade schemes, tradable performance standards (TPSs), and select carbon crediting mechanisms. Table A.1 in appendix A presents a typology of pricing and nonpricing climate policy instruments along with details on the instruments included in direct carbon pricing.

3. The term CO_2 is used rather than CO_2e, which refers to CO_2 and other greenhouse gases, given that this paper considers only carbon dioxide.

Efforts to impose a direct price on carbon emissions have been growing worldwide. The number of direct carbon pricing instruments has been continuously increasing across countries at subnational, national, and international levels. According to *State and Trends of Carbon Pricing 2023* (World Bank 2023), 73 carbon pricing schemes were in place by April 2023, compared with 68 in 2022, 43 in 2017, and 23 in 2012, implying the introduction of about five new schemes every year over the past decade. The nominal price signal across schemes varies markedly—from US$0.08 per tCO_2 for the Polish carbon tax to US$137 for the Swedish carbon tax, with the median nominal carbon tax rate being US$20. Over the past two decades, direct carbon pricing has become an indispensable part of the policy toolbox used to mitigate climate change (Carbon Pricing Leadership Coalition 2017; OECD 2021c; UNDP 2021).

1.1.2. Indirect Carbon Pricing: Energy Taxes

Taxation of energy is a critical and widely deployed tool for raising revenue while also sending price signals and incentives related to the consumption of energy and therefore carbon emissions. One of the economic purposes of levying an energy tax is to correct for externality costs of the taxed good and thereby to alter the relative prices faced by consumers. The two main categories of taxation that provide indirect carbon price signals and are relevant for the current analysis are fuel excise taxes and value added taxes (VAT) to the extent that they deviate from standard VAT rates applicable to other goods and services across the economy.

Taxes can be levied on different energy sources or carriers at various levels of the value chain. Energy taxes can be levied on the production, processing, or consumption of specific fuels. It is common to distinguish between upstream and downstream taxes. Upstream taxes are imposed when energy first enters the economy through either extraction or imports, whereas downstream taxes are imposed when the actual energy consumption takes place, therefore allowing for different rates across different uses of the same fuel. Sometimes taxes are also imposed midstream, that is, when fuels are refined and transported. Energy taxes are generally not ad valorem, that is, a percentage of the commodity price. Instead, they are introduced based on a specific rate— a charge per physical unit of energy (e.g., per kilowatt-hour), volume (e.g., per liter), or mass (e.g., per ton). From an economic standpoint, it is preferable for energy taxes to be specific-rate taxes rather than depending on the price of the good given that energy taxes charge for an external cost accrued per physical unit of the good.

Energy taxes often have a broader set of objectives, which may include climate change mitigation but usually not as a primary goal. When energy taxes are set at the same rate across different energy carriers, the signal they deliver is not aligned to the CO_2 content of the fuels. Therefore, energy taxes offer a less direct and less potent carbon price signal compared with carbon taxes, which send marginal price signals aligned with the carbon content of different emission sources, and as such, are a more effective way of targeting emissions from these energy carriers.

1.1.3. Indirect Carbon Pricing: Energy Subsidies

Subsidies for the production and consumption of fossil fuels, electricity, and heating remain a persistent feature of the energy sectors in many countries. Energy subsidies can take many different forms and be delivered through various channels,[4] and a diverse set of methodologies are used to quantify subsidies.[5] Kojima (2017) defines fossil fuel subsidies as deliberate policy actions by government that specifically target electricity, fuels, or district heating and that result in a reduction in the net cost of energy purchased, a reduction in the cost of energy production or delivery, or an increase in the revenues retained by those engaged in energy production and delivery.[6] The World Trade Organization's (WTO's) work in this area is based on the Agreement on Subsidies and Countervailing Measures, in which the definition of a subsidy contains three basic elements: (1) a financial contribution (2) by a government or any public body within the territory of a Member (3) which confers a benefit. In this legal definition, all three elements must be satisfied to be a subsidy (WTO 1994).

1.1.4. Spotlight on Energy Subsidies: Negative Carbon Pricing with Multiple Downsides

Energy subsidies, in aggregate, cost billions of dollars of government and private funds each year. There are various approaches to quantification of energy subsidies applied by relevant multilateral agencies, such as the International Energy Agency (IEA), the Organisation for Economic Co-operation and Development (OECD), and the International Monetary Fund (IMF), and by think tanks. Most efforts to quantify energy subsidies focus on consumption subsidies and generate estimates of aggregate global figures using different methodologies.[7] There are two main approaches to quantifying energy subsidies: the price-gap approach and the inventory approach (Kojima 2017). The price-gap approach quantifies the gap between free-market reference prices and the prices charged to consumers, while the inventory approach estimates subsidies based on an inventory of government actions benefiting production and consumption of fossil fuels.[8] Recent estimates from the IEA, which uses the price-gap approach, described in greater detail in appendix A, show that explicit fossil fuel consumption subsidies exceeded US$1 trillion in 2022 (IEA 2023). These figures dwarf the spending levels needed to achieve Sustainable Development

4. As an example, more than 1,300 government budgetary transfers and tax expenditures encouraging the production or consumption of fossil fuels have been identified by the OECD in 50 countries (OECD 2021c). Subsidies can be grouped by instrument used to deliver them—direct transfers of funds, induced transfers, forgone government revenues, and transfer of risk (UNEP 2019). This taxonomy reflects the Agreement on Subsidies and Countervailing Measures under the World Trade Organization.
5. Various methodologies used to quantify subsidies are described in Clements et al. (2013).
6. Energy consumption is considered to be subsidized when end-user prices are below what they would be if they reflected all market costs and risks. Producer subsidies refer to preferential treatment for selected companies, sectors, or products when compared with other sectors or products, at home or abroad, with the overall aim of increasing the revenues retained by those engaged in energy production and delivery (GSI 2010; Kojima 2017).
7. As part of the broader Sustainable Development Goal tracking effort, fossil fuel subsidies are monitored by their own dedicated target, namely 12.c, measured by indicator 12.c.1 (OECD 2021c).
8. The inventory approach imposes a considerable data burden, especially at the global level and across time, and for this reason the price-gap approach has been adopted in this study.

Goal 7, target 7.1, on ensuring access to affordable, reliable, sustainable, and modern energy for all, for which yearly estimated funding needs are in the range of US$10 billion dollars.

The costs of energy subsidies for the economy, society, and the environment often outweigh their benefits. Commonly cited objectives for the provision of energy subsidies include keeping energy affordable for households, reducing the impacts of energy price volatility (and related inflationary pressures) on consumers, increasing the competitiveness of local firms, facilitating households' transition from traditional solid fuels with adverse health and environmental impacts, and encouraging the development of indigenous extraction and refining in countries with fossil fuel resources (Kojima 2016). Despite their stated objective of protecting the poor, a large part of the benefits of universal price subsidies accrue to wealthier households, which consume more energy than poorer households, and are therefore considered "regressive" (Coady, Flamini, and Sears 2015; del Granado, Coady, and Gillingham 2012; IMF 2013). Especially in low- and middle-income countries, universal energy price subsidies tend to disproportionately benefit higher-income households and can further entrench social and gender inequality by diverting resources away from progressive and inclusive social programs (Kuehl et al. 2021). Even when these subsidies confer some degree of benefit to poor and vulnerable households or promote industrial competitiveness, the positive impacts of energy subsidies are outweighed by the negative impacts, which are well documented.

Energy subsidies entail significant fiscal costs and create distortions across the economy. They divert fiscal resources from other spending priorities such as infrastructure or human development, aggravate fiscal imbalances (Flochel and Gooptu 2017), and promote capital- and energy-intensive economic development. Although energy subsidies decrease current inflation by dampening energy price increases, they only do so at the cost of future rises in inflation. In the energy sector, the persistence of underrecovery of costs and reliance on subsidies can affect the financial and operational performance of actors across the value chain and hamper the long-term financial viability of utilities when subsidies are not delivered in full or on time. They reduce incentives for investment in renewable energy and energy efficiency, cause stranding of extractive and power generation assets in the energy sector, and encourage fuel smuggling between neighboring countries.

Finally, and most important for the current analysis, energy subsidies serve as negative carbon pricing. By artificially lowering the cost of producing and consuming fossil fuels, energy subsidies encourage excessive consumption of energy and send wider signals that influence short-term behaviors and long-term investment choices. These subsidies encourage emission-intensive end uses, leading to higher local air pollutant and greenhouse gas emissions, and contribute to land degradation and biodiversity loss (Clements et al. 2013; OECD 2021b; World Bank 2019). In fact, the recent literature widely recognizes energy subsidies as negative carbon pricing (E3G PCT 2022; UNDP 2021; Wright et al. 2018). In reality, the estimated carbon price signal sent by aggregate global energy subsidies is well above the average global price signal from direct carbon pricing initiatives, as discussed in chapter 3.

1.2. Coexistence and Interaction of Direct and Indirect Carbon Pricing Instruments

Direct and indirect carbon pricing instruments have come to be increasingly used alongside one another, often being introduced by different authorities within the same jurisdiction—but without coordination or even explicit recognition of how they work together or against each other toward the achievement of various policy objectives. Direct and indirect carbon pricing instruments, that is, carbon taxes and ETSs on the one hand, and excise taxes and energy subsidies on the other, are closely linked. These instruments sometimes generate change in the same direction but in other instances in opposite directions, effectively working at cross-purposes. In principle, for price-responsive consumers, both direct and indirect carbon pricing can encourage greater energy conservation and efficiency when compared with conventional (rules- and standards-based) regulations. Direct and indirect carbon pricing can encourage the adoption and development of technological, management, or process changes with the aim of reducing marginal abatement costs across time,[9] given that lower marginal abatement costs imply a lower level of payments faced by the firms regulated by direct carbon pricing instruments. In the case of rules- and standards-based regulations, firms do not face any incentive to reduce emissions beyond a legal requirement or to reduce marginal abatement costs across time. In addition, carbon pricing delivers a host of economic benefits (Heine and Black 2019; PMR 2021a; Parry, Veung, and Heine 2015; West et al. 2013), including lower marginal costs of public funds (Schoder 2021), air quality improvement (Mayr and Rentschler 2023; Thompson et al. 2014), improved health (Watts et al. 2015), and reductions in transport-related social costs. These co-benefits are similar to those that can accrue from energy subsidy reforms, therefore reinforcing the complementarity between direct carbon pricing and energy subsidy reforms, as discussed in UNDP (2021). Other co-benefits from direct and indirect carbon pricing instruments include energy security, in the shape of reduced imports of fossil fuels, and industrial policy, in the shape of stimulating the development of green industrial sectors.

Despite their evident complementarity and interaction in the real world, direct and indirect carbon pricing have largely tended to be treated as two separate policy areas. The elimination of existing energy subsidies alongside the implementation of direct carbon pricing is sometimes considered a core principle of effective environmental policy making (UNDP 2021); nonetheless, this principle is not always operationalized. In reality, the complexity of political economy around subsidies in a given context may mean that, sometimes, introducing other policy instruments affecting carbon emissions more widely can be politically easier than removing existing subsidies for consumption or production of specific fuels or in specific sectors. Energy subsidies—even though they have come to be interpreted as negative energy and carbon pricing in the academic, advocacy, and

9. New operational and technology choices would be expected over time because the penalty for emitting CO_2 implied by direct and indirect carbon prices provides an ongoing incentive to reduce emissions at the lowest cost.

international organization spheres[10]—tended to receive disproportionately low attention in international environmental policy spheres until recently. For example, the United Nations Framework Convention on Climate Change, the Kyoto Protocol, and the Paris Agreement do not include any specific measures targeting the production or consumption of fossil fuels (Skovgaard and van Asselt 2018), although such measures can be listed as part of the nationally determined contributions in addition to a wide range of measures that are used to reduce CO_2 emissions at each country's own initiative. Academic literature features a similar divide. The literature on carbon pricing has mostly focused on direct carbon pricing instruments, mainly carbon taxes and ETSs (e.g., Khan and Johansson 2022; Stavins 2022). There has been relatively limited analytical effort to capture and assess the carbon price signal resulting from the simultaneous presence of energy subsidies, excise taxes, and carbon pricing.

Signs of convergence in the literature, and examples of work highlighting the interaction of these different policy instruments, have emerged in recent years. For example, World Bank (2023) states that energy subsidies act as a negative price on carbon by reducing the costs of using fossil fuels for businesses and individuals. UNDP (2021) argues that the effectiveness of carbon pricing instruments is optimal when combined with fossil fuel subsidy reform, given that these subsidies can hinder, cancel out, and in some cases reverse the impacts of carbon pricing on CO_2 emissions. A review by the European Court of Audits points out that energy taxation can be used not only for revenue mobilization but also to support climate objectives, so that price signals faced by users of different fuels are aligned with their environmental impacts (ECA 2022). Similar to this report, the European Court of Audits' analysis covers energy subsidies, excise taxes, and direct carbon pricing.[11] The fact that energy subsidies have not been phased out over the past decade, even in the European Union (EU), hinders an efficient energy transition. It is worth noting that a good degree of variation exists not only in the level of energy subsidies but also in taxes across fuels and sectors, including in deviations of VAT rates applied to energy relative to general consumption goods. As a noteworthy addition to the body of work in this space, OECD (2021c) assesses the net carbon price arising from energy and carbon taxes and energy subsidies for 59 countries, of which 15 are not OECD members.[12] OECD (2022) extends this computation to 71 economies between 2018 and 2021.

Recent changes also point to a possible convergence between direct and indirect carbon pricing, and between the broader spheres of energy subsidy reform and the climate policy agenda. The Glasgow Climate Pact contains the first negotiated reference to ending fossil fuel subsidies in the United Nations Framework Convention on Climate Change's 26-year history and is a clear sign of the need to frame subsidy reforms in the context of climate policy (UN Climate Change Conference UK 2021).

10. Examples can be found in Burke, Byrne, and Fankhauser (2019) and PMR (2021b).
11. Renewable energy subsidies are also covered by ECA (2022).
12. The full list of countries includes Costa Rica, Côte d'Ivoire, the Dominican Republic, Ecuador, the Arab Republic of Egypt, Ghana, Guatemala, Jamaica, Kenya, Morocco, Nigeria, the Philippines, Sri Lanka, Uganda, and Uruguay.

Going beyond direct carbon pricing and considering a broader view of policy instruments affecting energy consumption and carbon emissions is desirable when assessing any climate change mitigation policy. An exclusive, and narrow, focus on direct carbon prices as part of any process, including carbon border adjustment mechanisms, effectively penalizes low- and middle-income countries, which sometimes have a robust level of excise taxes but lack direct carbon pricing instruments.[13] Energy and fiscal policy instruments have an impact on fuel consumption and can facilitate substitution toward less-carbon-intensive fuels (if the rate is partially related to carbon content), even when they have not been introduced for environmental purposes. A consistent level of the overall carbon price could be actively pursued in multicountry initiatives to deliver a level playing field and fair recognition of country policies. Systematic assessment of direct and indirect carbon pricing policies is critical to understanding how the different policy instruments interact and how the resulting combined carbon price signal and fiscal burden are allocated across the economy.

1.3. Assessing Carbon Price Signals from Multiple Policy Instruments

In view of the coexistence of key energy, climate, and fiscal policy instruments that send price signals affecting energy production, consumption, and carbon emissions in multiple sectors, the TCP attempts to assess the pricing signals resulting from the combination of these instruments. This metric, introduced in Agnolucci et al. (2023a, 2023b) can be used to assess the carbon price signal sent by the combination of these instruments and to identify interactions and contradictions among policy tools. The TCP can be applied for an economy as a whole, a specific fuel or a specific sector, a single country, a group of countries, or globally.

This report applies the TCP concept to best-available global data sets, and delves deeper into the main components of indirect carbon pricing, that is, energy subsidies and taxes. Building on work done under the companion papers, this report offers further granularity on the main components of the TCP, and assesses how they vary across fuels, sectors, and fossil fuel trading positions, with a particular focus on energy subsidies. The review explores the central role of energy subsidies in influencing levels and movement of the TCP over time. By combining data on energy consumption from the IEA, on direct carbon prices from the World Bank, and on net excise taxes and subsidies from the IMF (Parry, Black, Vernon 2021), this report undertakes illustrative calculations of the TCP for more than 140 countries over the period 1991–2021 (see chapter 3).[14]

13. As a relevant example of existing policy making, adoption of the proposal for carbon border adjustment mechanisms by the EU, which considers only explicit carbon pricing instruments adopted by non-EU countries, has raised concerns in those countries with low carbon prices but high energy taxation (Tanabe 2022).
14. It is worth noting that the analysis includes price data up to 2021 but fuel consumption up to 2019, which is projected up to 2021 assuming consumption stays constant. As a consequence, reduced consumption during the pandemic is not considered in this study.

Illustrative calculations of the TCP can offer insights into the main components of this indicator for individual countries, sectors, or fuels as well as for groups of countries depending on their fossil fuel trading positions. The analysis presented in this report compares illustrative TCP figures for a country over time, as well as across countries. Although these findings are mostly consistent with the conclusions of key pieces of literature, such as IEA (2022a) and Parry, Black, Vernon (2021), they also highlight areas for further exploration.

The illustrative analysis in this report focuses on medium-term trends and does not include the impact of the most recent shocks and disruptions. The series of events that transpired in 2022, in particular the Russian invasion of Ukraine, subsequent supply constraints, and at times record-breaking commodity prices, with impacts that reverberated across energy sectors and economies around the world, and the series of government responses, including energy subsidies, are excluded from the analysis. Even without including 2021 data in the calculations, it is worth noting that in 2022 governments around the world introduced energy subsidies and tax breaks that will significantly alter total consumer subsidy levels for 2022. It is, however, not clear whether energy price and consumption influences on the TCP will go back to pre-pandemic levels or will follow a different trajectory in the long term.[15]

This report is organized into four chapters. Chapter 1 provides context on the evolution of and interaction of direct carbon pricing and indirect carbon pricing instruments. After summarizing the rationale and objectives for the TCP concept and indicator, chapter 2 discusses the principles underlying this indicator and the way in which it can be used. Chapter 3 presents the approach (which is further detailed in appendix A) and findings for the illustrative calculations based on best-available global data sets, exploring the variation of the TCP and its components across countries and by energy carrier and economic sector. Chapter 4 summarizes the main findings, attempts to draw insights and conclusions, and highlights areas for further research and analysis. Details on the underlying methodology and data sets and a comparison of different approaches are presented in the appendixes.

15. There are several channels through which the COVID-19 (coronavirus) pandemic appears to have affected energy supply and its carbon intensity, including through diversion of public funds (away from clean energy projects) or in some specific circumstances through a long-term impact on productivity (Olabi et al. 2022). In the case of energy demand, the pandemic had a fairly significant impact on transport fuel use (e.g., through reduced commuting) and changed the composition of demand between different sectors (e.g., changes in production patterns, remote work).

TWO

Context and Description of the Total Carbon Price

2.1. Background and Purpose

The need to assess the price signal from the combination of different policy instruments influencing the way in which carbon emissions are priced and paid for follows from the coexistence of energy subsidies, excise taxes, and direct carbon pricing in several countries. This is true for many countries around the world across low-, middle-, and high-income groups. For example, although Indonesia has introduced a carbon tax and is developing a wider emissions reduction framework that includes an emissions trading system (ETS) on the one hand, on the other it provides subsidies for diesel, kerosene, and liquefied petroleum gas (LPG) (Mafira 2021). Similarly, in Canada, federal fossil fuel subsidies amount to Can$600 million (Corkal, Levin, and Gass 2020) while emissions are also subject to direct carbon pricing through federal and state policy instruments.

A joint assessment of energy subsidies, energy taxes, and direct carbon pricing is important for understanding the combined pricing signal resulting from these policy instruments. Understanding these dimensions can be helpful to avoid policy inconsistencies and contradictions when taxing (directly or indirectly) carbon emissions. Such inconsistencies and contradictions between these three policy instruments could initially be addressed by phasing out energy subsidies that are the most environmentally harmful or those whose removal would have the least impact on the poorest households or on firms exposed to international competition.[16] The importance of assessing subsidies and taxes together has been recognized in recent relevant literature, where it has been shown that tax distortions are largely symmetric to those caused by subsidies (Kojima and Koplow 2015).

Assessments of combined price signals resulting from direct carbon pricing, excise taxes, and subsidies are also paramount for advancing the design and implementation of international climate agreements and mechanisms, such as minimum carbon price commitments and standardized rules for carbon border adjustment mechanisms. Progress in the adoption and implementation of these mechanisms is important not only to increase efficiency—which can be achieved by establishing similar marginal carbon price signals across countries, sectors, and fuels—but also to motivate action, given that uniform commitment to carbon pricing can lead to more ambitious cooperation (Schmidt and Ockenfels 2021).

By helping estimate the carbon price signal resulting from the combination of different policy instruments, the total carbon price (TCP) can inform policy making and choice of instruments that need to be combined, repurposed, or eliminated to achieve the government's objectives. In this context, the TCP can be used as a metric for helping policy makers understand the *interaction* of different policy tools that they deploy to address their climate change mitigation goals as well as fiscal and energy sector

16. As a relevant example of existing policy making, a proposal was adopted by the EU Commission to align taxation of energy products with EU energy and climate policies, to promote clean technologies and to remove outdated exemptions and reduced rates encouraging fossil fuel use (European Commission 2022).

objectives and determine the extent to which each instrument affects the ability of others to help or hinder progress toward these goals. The TCP, in its current form, focuses on *objectively measuring the carbon price signal*, rather than the more complicated endeavor of *assessing the decarbonization impacts* related to specific levels of the carbon price, which can be the focus of future work on measuring progress toward achievement of mitigation goals.

2.2. The Total Carbon Price: Main Elements and Calculation Approach

The main function of the TCP is to assess the carbon price signal resulting from the combination of energy consumption subsidies, energy taxes, and direct carbon pricing. In simple terms, the TCP is the average of the nominal rates of these instruments, converted to dollars per ton of carbon dioxide (tCO_2), and weighted by the share of emissions covered by each instrument. The direct carbon pricing instruments include carbon taxes and ETSs, with price signals that are directly levied on carbon emissions, whereas the indirect carbon pricing instruments incorporated in the TCP concept include fuel excise duties and subsidy instruments, normally levied on units of energy, which can be converted into carbon emissions.

The TCP indicator is formulated in a way that conveys the monetary cost per tCO_2 associated with a set of policy instruments. To this end, all data related to energy consumption covered by the instruments are initially expressed in energy terms and later converted into dollars per tCO_2 by using CO_2 conversion factors. Details of the TCP methodology and a description of the main elements, as well as instruments covered by the indicator, are available in appendix A.

The TCP concept is aligned with recent analytical approaches to assessing the impact of various climate policy tools, with some differences. The currently available set of approaches to measure, monitor, and assess carbon pricing measures, such as the World Carbon Pricing database (Dolphin and Xiahou 2022) and the effective carbon rate (ECR) (OECD 2021a), primarily entail producing an objective indicator to measure the carbon price signal. In contrast to the TCP, the ECR adopts a bottom-up (via statutory review) approach, which requires collecting, reviewing, and processing tax data from official documents. Given data availability considerations, the analysis carried out using this approach is focused on 44 OECD and G-20 countries for selected years (2018 and 2021). This topic is further explored in appendix A.

THREE

Application of the Total Carbon Price

Application of the total carbon price (TCP) concept to real-world data can enable analysts and policy makers to understand, in simple terms, how carbon price signals sent by consumption subsidies and indirect (energy taxes) and direct (carbon taxes and emissions trading systems [ETSs]) carbon pricing instruments compare to one another. This chapter summarizes the approach to the illustrative calculations that were undertaken to demonstrate application of the TCP concept and further explores its main components. Further detail on the methodology, data sets, and limitations are available in appendix A.

3.1. Approach to the Illustrative Total Carbon Price Calculations

3.1.1. Data Used and Estimation Approach for Total Carbon Price Components

TCP calculations draw on data from multiple sources. Calculating the TCP for a specific energy carrier requires observed data or estimations for the main components of the indicator. This means the necessary data include the nominal rates of excise taxes, subsidies, and direct carbon price instruments; their coverage in terms of fuel consumption; as well as exemptions and reduced rates. Because a single data set that combines all the elements necessary for the TCP calculation is not available for all countries around the world, the analysis used best-available existing data sets from the World Bank (direct carbon prices), the IEA (energy balances and consumption), and the IMF (prices, inferred fuel taxes, and subsidies). Simplified TCP formulas were developed to allow the use of the extensive data set made available by the IMF (Parry, Black, and Vernon 2021), as discussed in this section. The aggregated data set used in this study contains information on 142 countries, observed for a maximum of 31 years—from 1991 to 2021.

Illustrative TCP calculations were carried out for a select set of energy carriers, using best-available international data sets, and were adapted to data constraints. The choice of energy carriers and metrics was made based on methodological constraints and access to the available data sets, summarized in appendix A. The available data sets allow the calculation of the excise taxes and consumption subsidies for coal, diesel, gasoline, kerosene, liquefied petroleum gas (LPG), and natural gas. Consumption of electricity is excluded from the computation of the TCP, but consumption of energy fuels to produce electricity is included (see appendix A for further elaboration on exclusions and limitations).[17] Price and consumption data for the six fuels for several final users were

17. While introducing and discussing the general TCP methodology, the report refers to "energy carriers," given that the methodology can be applied to all energy carriers. On the other hand, because the current analysis does not include electricity, after the introduction of the general methodology, the expression "fuel" is used to refer to the energy carriers included in the analysis presented in this report.

aggregated according to end use, that is, into the industrial,[18] power, residential, public administration and services, and transport sectors.[19]

Although most elements are drawn from the available global data sets, some elements of the TCP were estimated. TCP components for which data and level of detail required for the indicator were not available for a given energy carrier, such as applicable rates of each direct and indirect pricing instrument, were computed drawing on available data. For example, where data on excise tax rates applicable for each fuel are not available for all countries, the analysis estimated the price gap attributable to indirect taxes net of energy consumption subsidies. This approach is summarized in appendix A and explored in greater detail in Agnolucci et al. (2023a, 2023b).

3.1.2. Focus on Net Price Signals

The analysis presents "net" computed values to reflect the price signal resulting from the TCP estimations. A positive price gap estimated for a particular energy carrier at a specific time and jurisdiction is labeled a "net energy tax." In this case, retail price net of value added taxes (VAT) is higher than the sum of supply costs and direct upstream carbon prices. On the other hand, a negative calculated price gap for energy carriers is labeled a "net energy subsidy." In this case, the retail price net of VAT is lower than the sum of supply costs and direct upstream carbon prices. These net variables show the difference between applicable fuel excise taxes and subsidies, and are computed for all sector-fuel combinations in the data sets.

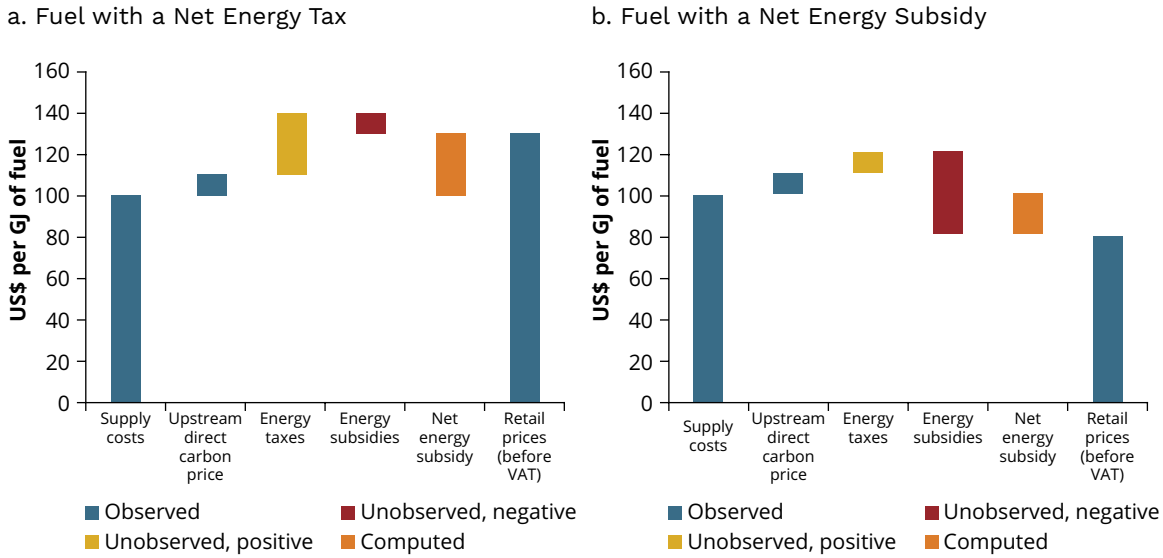
It should be noted that the components labeled "net energy taxes" and "net energy subsidies" are used as proxies for the value of energy taxes and energy subsidies. Because the data sets used in this study do not contain measured taxes and subsidies, a proxy for these components of the indirect carbon price is computed drawing on available data on retail prices, supply costs, and VAT rates. When illustrative TCP calculations using best-available data sets are discussed in the section "Observations from illustrative TCP calculations," energy taxes and subsidies are used as a shorthand for net energy taxes and subsidies, which are defined based on the approach summarized above and detailed in appendix A.

The price gap estimated for a fuel used in a specific sector and country is either positive or negative in any given year, but the sign can change over time as the underlying variables change. This also means that the value calculated for a given country-fuel-sector combination can be included in the estimated global aggregate figure for

18. The industrial sector includes subsectors related to cement, construction, food and forestry, iron and steel, machinery, mining and chemicals, nonenergy use, nonferrous metals, other industrial uses, and other manufacturing sectors. It excludes consumption related to energy transformation in the Climate Policy Assessment Tool, which encompasses the following IEA flows: transformation processes; transfers, including pipelines; energy industry own use; distributional losses; and a statistical difference (World Bank 2022c).
19. The transport sector includes three subsectors: domestic shipping, railways, and road. Each category includes consumption related to both freight and passenger traffic.

FIGURE 3.1

Illustration of Cost, Price, Tax, and Subsidy Scenarios



Source: Authors' illustration using IEA, IMF, and World Bank data sets.
Note: This figure illustrates the relationship between supply costs, direct upstream carbon prices, energy taxes, energy consumption subsidies, net energy tax or net energy subsidy, and the retail price before value added taxes (VAT) under two different hypothetical scenarios. All variables are expressed in terms of US$ per gigajoule (GJ) of fuel.

net energy taxes in one year and net energy subsidies in another. This occurs because the focus of the analysis is on the calculated aggregate figures, like those presented in figure 3.1, rather than on the individual components. The way in which the combination of upstream direct carbon pricing (i.e., levied before the fuel reaches the final consumer), energy taxation, and consumption subsidies generates net energy taxes and subsidies is shown in figure 3.1. Panel a of figure 3.1 illustrates the cases in which retail prices (before VAT) are higher than supply costs, implying that the sum of energy taxes and upstream direct carbon pricing is larger than energy subsidies. Panel b of figure 3.1 shows the opposite situation, for cases in which retail prices (before VAT) are lower than supply costs, which implies that energy subsidies are higher than the sum of taxes and upstream direct carbon pricing. As an example, panel a illustrates a case in which the supply cost is US$100/GJ, while upstream direct carbon pricing and fuel taxes add up to US$40/GJ. Because energy subsidies equal US$10/GJ, estimated net energy taxes would be US$30/GJ, implying that the retail price before VAT (supply cost plus estimated net energy tax) would be equal to US$130/GJ. Conversely, in panel b, upstream direct carbon pricing and energy taxes add up to US$20/GJ, which is about half the level of energy subsidies, at US$40/GJ, a situation in which a net energy subsidy would arise.

3.1.3. Limitations of the Methodology

As noted, the first limitation that should be recognized is related to the need to compute select components of the TCP, given that data were not consistently available for all the countries and fuels covered. When applying the TCP concept to a single country, it may be possible to gather data at the level of detail required, such as actual excise rates by fuel, rather than estimating them, which can enable a more reliable analysis. When built using good-quality data, the application of the concept has the potential to help inform assessments and policy design choices that recognize tradeoffs between policy instruments and focus on efficient use of limited fiscal resources.

While these calculations are made to illustrate the implications of the combination of different policy instruments, it is important to keep in mind that they are subject to the limitations commonly associated with price-gap approach for quantifying energy subsidies and avoid overinterpreting them. Kojima and Koplow (2015) point out that calculating adjusted reference prices (essentially the supply cost illustrated in figure 3.1) may require dedicated studies taking into account diversity within a country, especially in large countries such as Brazil or China, in terms of location-specific costs of transportation, storage, distribution, and retail, but also exemptions and thresholds that can be granted to specific users or uses of a certain fuel. In addition, price-gap analysis cannot capture some forms of subsidies, for example, conditional cash transfers, because not all subsidies result in net changes in end-user prices (Koplow 2009). It is also true that policies boosting domestic prices, such as market price supports, may end up being interpreted as a tax on energy if they lead to an increase in the retail price (Kojima and Koplow 2015). Furthermore, retail prices of fossil fuels are affected by competition in the market, and concentrated, oligopolistic markets, with limited existing and potential competition, will tend to have higher prices without influencing the reference price (for this report, the supply costs). When using the price-gap methodology, there is a risk that such situations of limited competition with higher prices may be misinterpreted as a higher TCP, even though the higher retail price is not due to any climate or fiscal policy instrument. Recognizing methodological limitations and data constraints, it is important to keep in mind that the illustrative TCP calculations presented in this report should be seen as the initial step in a process that can be improved by collecting more comprehensive and precise information on supply costs. Other limitations of the methodology and approach are discussed appendix A.

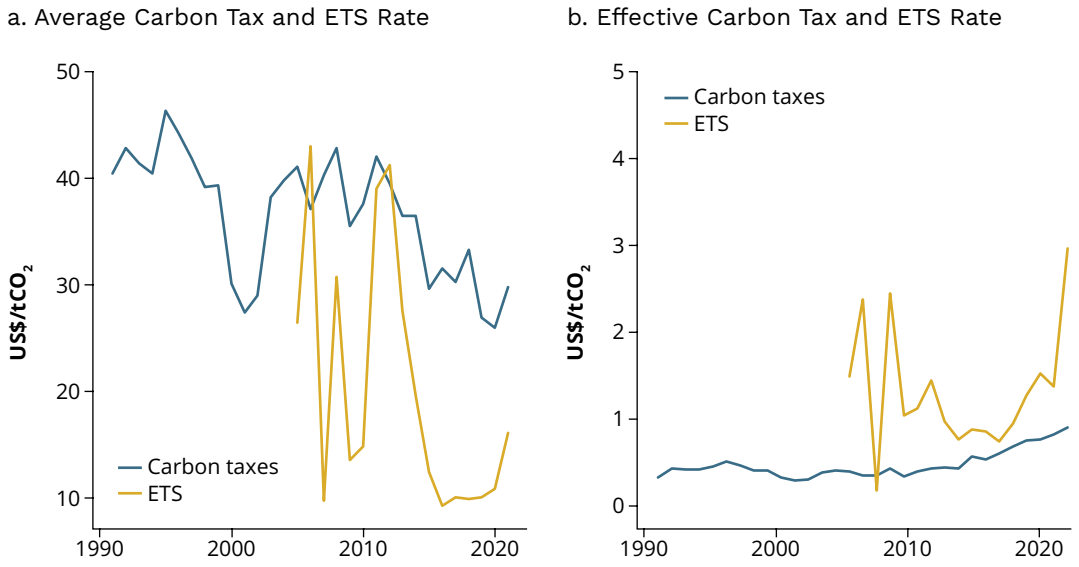
3.2. Observations from Illustrative Total Carbon Price Calculations

Findings of the analysis using the available data sets offer some observations and insights. Illustrative calculations were carried out to estimate total carbon price signals resulting from the combination of key policy instruments considered in this report, namely, energy subsidies, energy taxes, and direct carbon pricing, as measured by the TCP, across 142 countries.

The global average of the nominal rates of direct carbon pricing instruments imply relatively high carbon prices (panel a of figure 3.2); however, effective rates, that is, the nominal rates weighted by the shares of global emissions the instruments cover, appear to be much lower (panel b). Panel a of figure 3.2, replicated from Agnolucci et al. (2023a), shows that at about US$30 per ton of carbon dioxide (tCO_2), the global arithmetic average of carbon taxes is reasonably high, despite the reduction of the average caused by the introduction of taxes with lower rates compared with the relatively high levels

FIGURE 3.2

Global Nominal and Weighted Rate of Direct Carbon Pricing Instruments

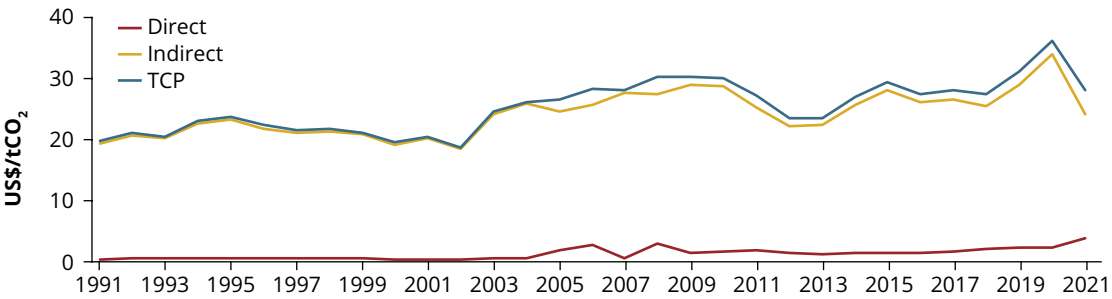


Source: Agnolucci et al. 2023a.
Note: Nominal rates (panel a) are calculated by taking the arithmetic average of rates from each instrument across countries, while effective rates (panel b) are calculated by weighting nominal rates from each instrument across countries by the share of global emissions the instrument covers. ETS = emissions trading system; US$/$tCO_2$ = US dollars per ton of carbon dioxide.

introduced in several Nordic countries in the 1990s.[20] It is important to point out that the average in panel a of figure 3.2 takes into consideration only the rate of implemented carbon taxes or ETSs without any weights. The nominal ETS rates show much more variability, initially because of the relatively small number of such instruments (up to 2013), which increased over time. The spike in 2021 can be explained by the introduction of new ETSs with relatively high carbon prices, such as those in Canada (Saskatchewan) and Germany. As shown in panel b of figure 3.2, aggregated effective direct carbon prices, weighted by emissions coverage, are relatively low for ETS and carbon taxes. The increase in the ETS effective rate observed in 2021 reflects the higher price in existing carbon markets (e.g., the EU ETS), the introduction of new instruments such as the German ETS, several schemes in Canada, and in particular the national ETS in China.[21] The difference between the two panels in figure 3.2 can be explained by the limited coverage of the direct carbon pricing instruments introduced so far compared to the total level of emissions.[22] Although there has been considerable progress in recent years, as documented in World Bank (2023), effective carbon price levels averaged on a global level still send a carbon price signal that is assessed to be inadequate to deliver, on its own, the CO_2 emission reductions required by the Paris Agreement.[23]

FIGURE 3.3

Aggregate Total Carbon Price, Direct and Indirect Carbon Pricing



Source: Authors' reproduction based on Agnolucci et al. (2023a).
Note: TCP = total carbon price; US$/t$CO_2$ = US dollars per ton of carbon dioxide.

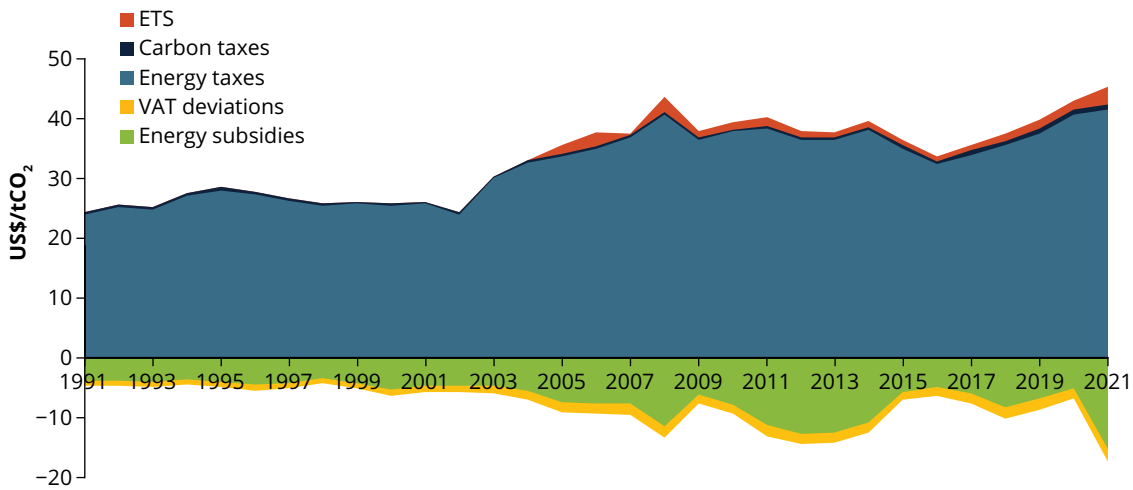
20. In the case of the global arithmetic average, only countries with a carbon tax or an ETS are included in the computation with no weights assigned to the rates of the countries with either a tax or an ETS to compute the values in panel a of figure 3.2.
21. Because price data on China's national ETS are not available for 2020 from World Bank (2021a), a price of US$7 per allowance was sourced from ICAP (2022).
22. This is because the nominal revenues from the schemes, that is, nominal rates multiplied by the amount of covered emissions, are divided by the total amount of covered emissions in panel a of figure 3.2 and by the total amount of emissions, regardless of whether they are covered by the schemes, in panel b.
23. The High-Level Commission on Carbon Prices concluded that the explicit carbon price level consistent with achieving the Paris temperature target is at least US$40–US$80/tCO_2 by 2020 and US$50–US$100/tCO_2 by 2030, provided a supportive policy environment is in place (Carbon Pricing Leadership Coalition 2017).

The carbon price signal resulting from the TCP, which combines direct and indirect carbon pricing instruments, diverges substantially from direct carbon pricing instruments alone. Figure 3.3 plots the global average TCP, calculated using the data sets and approach discussed above and further detailed in appendix A, along with the two main groups of carbon pricing instruments—direct and indirect. Figure 3.4 brings in further granularity, and focuses on the individual components of the TCP—ETSs, carbon taxes, energy taxes, and subsidies—and illustrates relative shares.

Illustrative TCP calculations indicate that a significant share of carbon price signals worldwide is currently delivered by indirect instruments, in particular through the taxation of energy. Moreover, as figure 3.3 shows, the global aggregate for the TCP indicator closely tracks the pattern of energy taxes and subsidies, which leads to an interesting insight: a considerable portion of carbon price signals at the global level appear to be delivered by policies that were not introduced with climate objectives in mind, but that nonetheless have a large role in reining in (or exacerbating, in the case of fossil fuel subsidies) global CO_2 emissions.

FIGURE 3.4

Evolution of Total Carbon Price Components

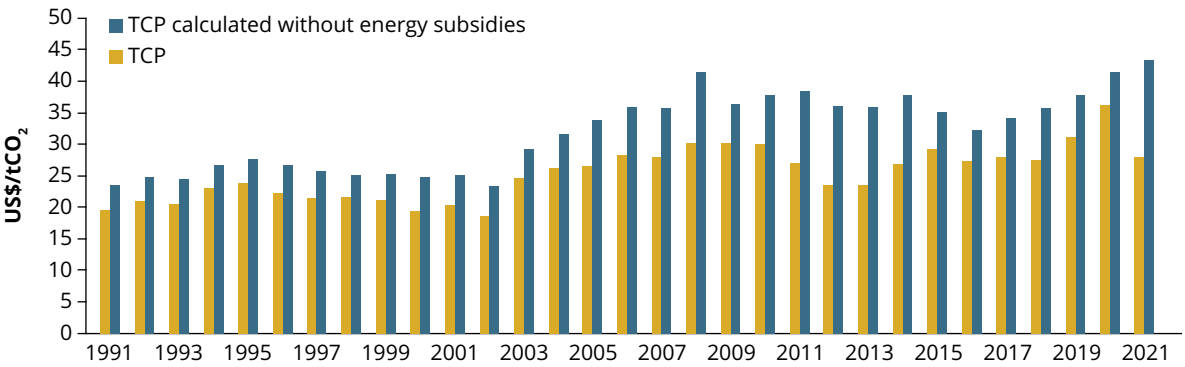


Source: Authors' reproduction based on Agnolucci et al. (2023a).
Note: The figure shows net energy taxes, carbon taxes, emissions trading systems (ETS), value added tax (VAT) deviations, and net energy (consumption) subsidies,. The way in which net energy taxes and subsidies are computed is discussed in appendix A. TCP = total carbon price; US$/t$CO_2$ = US dollars per ton of carbon dioxide.

The analysis shows that, in aggregate, energy subsidies counteract the positive pricing signals from other policy tools. The TCP estimations indicate that, at the global level, the aggregate pricing signal sent by energy subsidies is significantly higher than the signals sent by carbon taxes and ETSs as direct carbon pricing instruments, though the difference may vary at the country level. As such, energy subsidies weaken the positive price signals from direct carbon pricing instruments, and serve as negative carbon pricing (see figure 3.4). For example, according to indicative TCP estimates, in 2021, the global aggregate signal from direct carbon pricing (ETSs and carbon taxes) was about US$4/t$CO_2$ (see figure 3.3) while the indirect (and negative) carbon price signal rendered by energy subsidies amounted to about US$10/t$CO_2$ (see figure 3.4). Figure 3.5 plots the movement of the estimated TCP with and without energy subsidies. In simple terms, this figure can give a sense of how much higher the carbon price signals could be without energy subsidies. As such, it illustrates how energy subsidies dampen the carbon price signal from other instruments—not only direct carbon pricing, but also indirect signals, in particular energy taxes—and how they weaken the economic incentives for reducing emissions. This finding is consistent with insights from Parry, Black, and Vernon (2021).

FIGURE 3.5

Total Carbon Price with and without Energy Subsidies



Source: Authors' calculations using IEA, IMF, and World Bank data sets.
Note: TCP = total carbon price; US$/t$CO_2$ = US dollars per ton of carbon dioxide.

Although global aggregate estimates are useful for illustrating the critical role of indirect carbon pricing instruments, what primarily matters for any given country or jurisdiction would naturally be the signals sent by instruments that are in force within that jurisdiction. For instance, in a country or subnational jurisdiction where an ETS or carbon tax scheme sends strong signals and subsidies are limited, the economic incentives to reduce emissions would still be in place, even with subsidies working against them. Still, the global data sets indicate that pricing signals, and hence economic

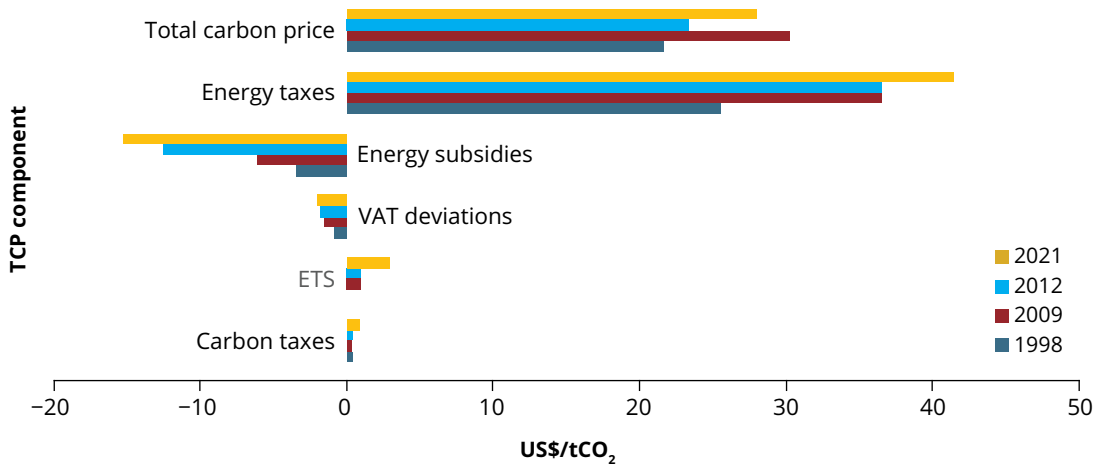
incentives, from energy subsidies can be significant even in jurisdictions where relatively substantial (in nominal terms) direct carbon pricing instruments have been introduced. This is particularly notable for some countries where the coverage of the direct carbon pricing schemes is relatively limited, and hence effective carbon tax and ETS rates, when weighted by their coverage, are relatively small and can be easily undermined by energy subsidies.

The gradual increase in the average TCP observed at the global level over the course of the early 2000s tapered off when energy subsidies grew significantly. According to available data, energy subsidies showed a rising trend from 2000 to 2008. After that, the time pattern of energy subsidies became more uncertain, with increases followed by declines. The reduction in energy subsidies (which was primarily driven by the decline in international oil prices associated with the slowdown in global economic activity due to the COVID-19 pandemic) translated into the highest global TCP estimate in 2020, but these figures changed with the sharp fall in 2021.

Exploration of the composition of the TCP in select sample years further illustrates the role of energy subsidies in influencing price signals. Figure 3.6 depicts TCP estimates for a select set of years with low, mid-range, and high energy subsidies to illustrate the variation in the TCP in line with energy subsidy and taxation levels. The significant role energy subsidies play in undermining pricing signals overall, and in particular the strong signals from energy taxes, underscores their cost not only from a fiscal perspective, but also from a climate change mitigation perspective.

FIGURE 3.6

Total Carbon Price Components in Select Years



Source: Authors' calculations based on IMF, IEA, and World Bank data sets.
Note: ETS = emissions trading system; TCP = total carbon price; US$/t$CO_2$ = US dollars per ton of carbon dioxide; VAT = value added tax.

Disaggregating TCP levels and their evolution by fuel and by sector reveals a considerable amount of heterogeneity in the patterns of the TCP and its components. The analysis shows that the TCP varies considerably by fuel and end-use sector. Figures 3.7 and 3.8 show the evolution of the TCP by fuel, and figure 3.9 presents the illustrative TCP calculations by end use. Figure 3.8 shows that fuels used mostly in the transport sector tend to face the highest carbon price signal.[24]

The analysis finds considerable differences in the level of consumption subsidies and taxation across countries by per capita income level[25] and fuel trading status. In low-income countries that export fossil fuels, energy subsidies are much larger than excise taxes, which makes the TCP consistently negative. On the other hand, the value of the TCP is positive but relatively small in low-income countries that import fossil fuels and high-income countries that export fossil fuels.

3.2.1. Observations by Fuel

International oil prices affect the TCP, and the impact varies by fuel. Figure 3.7 charts the evolution of the TCP for different fuels together with the evolution of the Brent crude oil price over the same period. As figure 3.7 illustrates, the TCP for different fuels varies as oil prices change, and the direction of movement depends on the channels of impact for that particular fuel. There are different potential channels through which oil prices affect different TCP components, and the degree of this impact varies by fuel, mainly through the price of the commodity and energy subsidies. For instance, for imported liquid fuels, rising oil prices would be reflected in higher import or supply costs if no changes in refining margins are assumed; and if domestic retail prices are not allowed to increase at the same rate, these higher costs could translate into higher net energy subsidies and in a decline in the TCP. Figure 3.7, drawing on the data sets used in this study, indicates that the TCP for diesel and gasoline tends to rise along with international oil prices, while the TCP of LPG, and to a lesser extent kerosene, has an inverse relationship with oil prices. The TCP for natural gas moves mostly in the same direction as oil prices, though there is some divergence from 2009 onward. Figure 3.7 does not indicate a strong relationship between the TCP for coal and oil prices.

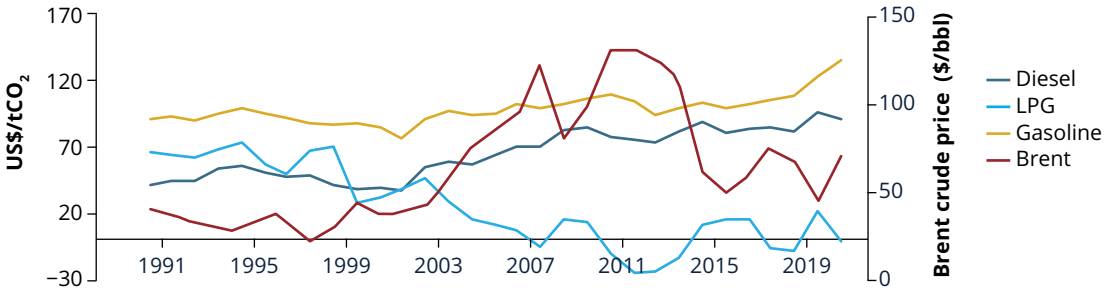
Among the fuels included in this analysis, in aggregate, gasoline stands out as the fuel for which the carbon price signal is the highest, driven by taxation. Gasoline is followed by diesel, another transport fuel. Figure 3.8 shows that the levels of the TCP, delivered primarily through fuel taxes, appear to have steadily strengthened for both gasoline and diesel over time. The trend is particularly noticeable since 2002 for diesel, although the rate of increase has slowed in the more recent years. The observation that the TCPs for gasoline and diesel were high well before the international community's attention to climate change began to rise suggests, again, that the total pricing of carbon is often not driven by climate considerations.

24. Note that different grades of fuel (expressed by octane level) tend to receive different subsidies, although these variations cannot be reflected in this report given that the database used provides only average prices for each country.
25. Income classifications based on World Bank (2022b).

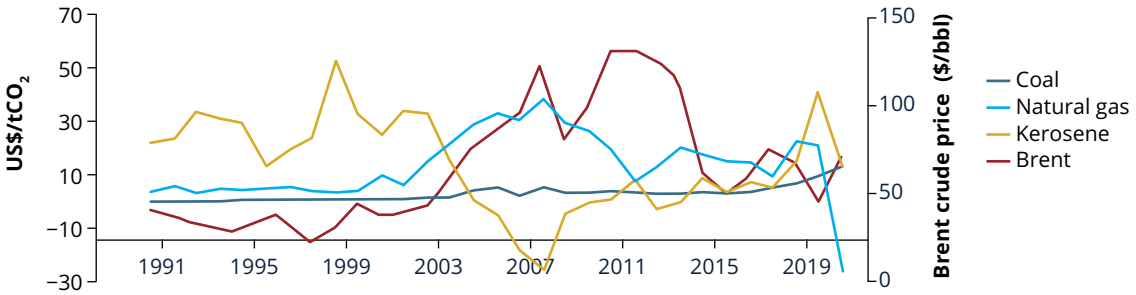
FIGURE 3.7

Evolution of Crude Oil Prices and Total Carbon Price

a. TCP for Diesel, LPG, and Gasoline, Plotted with Brent Crude Prices



b. TCP for Coal, Kerosene, and Natural Gas, Plotted with Brent Crude Prices

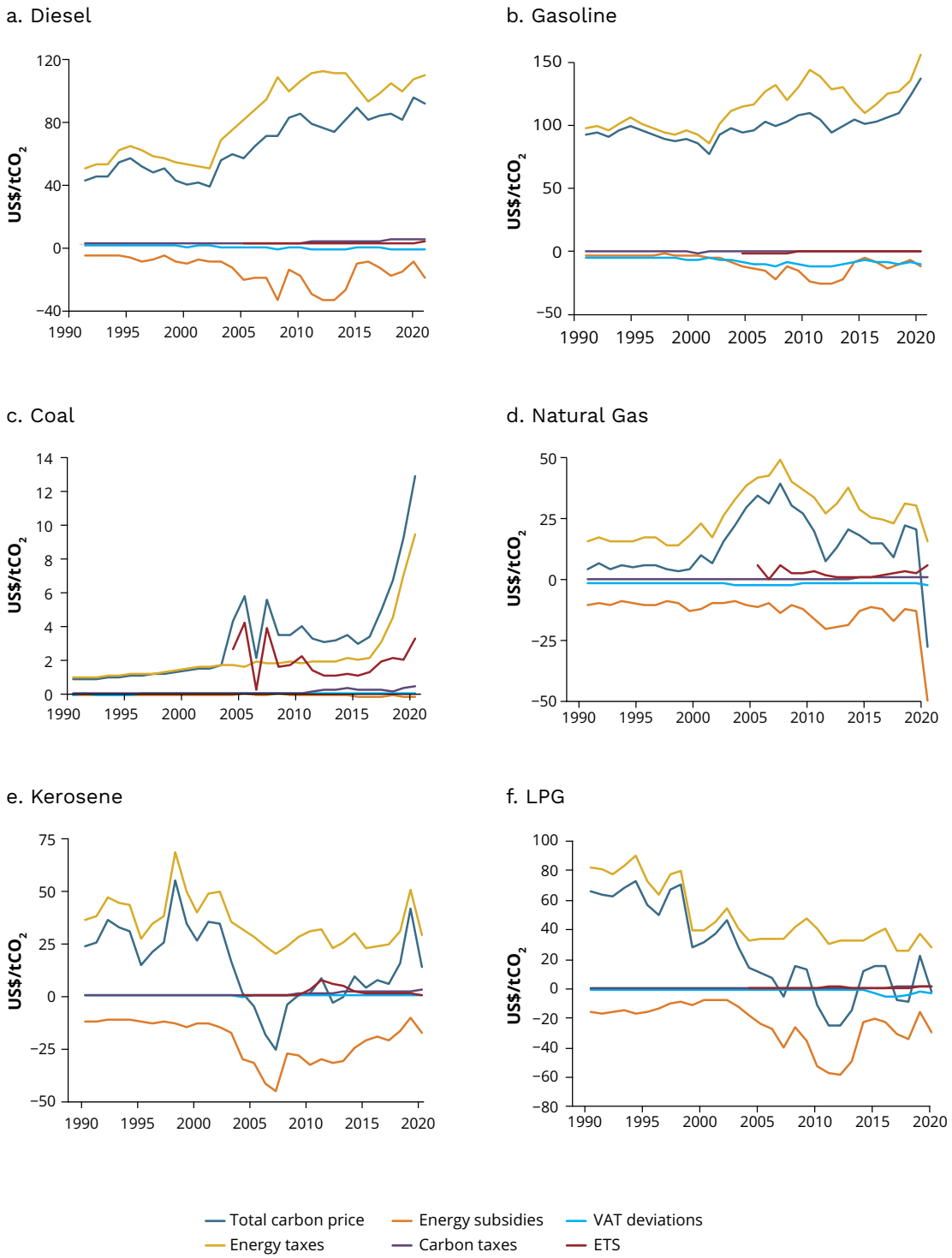


Source: Authors' calculations based on IMF, IEA, and World Bank data sets.
Note: Panel a plots the total carbon price (TCP) for select liquid fuels, namely, diesel, liquefied petroleum gas (LPG), and gasoline alongside Brent crude prices; panel b presents the TCP for coal, kerosene, and natural gas using the underlying data sets. Brent crude prices are from IEA (2024). Note the difference in scale for TCP between the two panels. The oil price (right-hand) axis is the same, while the TCP axis (left-hand) was adjusted to reflect the value of the series being plotted. $/tCO$_2$ = US dollars per ton of carbon dioxide.

Coal emerges as the fuel with the lowest carbon price signal. Tax rates on coal are low although they have increased since 2015, and VAT deviations and consumption subsidies are almost zero. Coal tends to be used in the industrial and power sectors, for which VAT payments (and therefore deviations) do not apply. It is important to point out that, in addition to the consumption subsidies explored in this analysis, the production of coal receives substantial subsidies, estimated to be about US$10 billion in OECD member countries (OECD 2021b). As such, the carbon price signal for coal could be even lower. Although there is limited evidence on consumption subsidies to coal, it should be noted that coal is priced in a way that does not reflect its carbon content. Given the variation of carbon content across fuels, this hints at an opportunity to explore fuel pricing aligned with carbon content to move toward carbon cost alignment.

FIGURE 3.8

Global Trends Across Fuels in the Total Carbon Price and Its Components

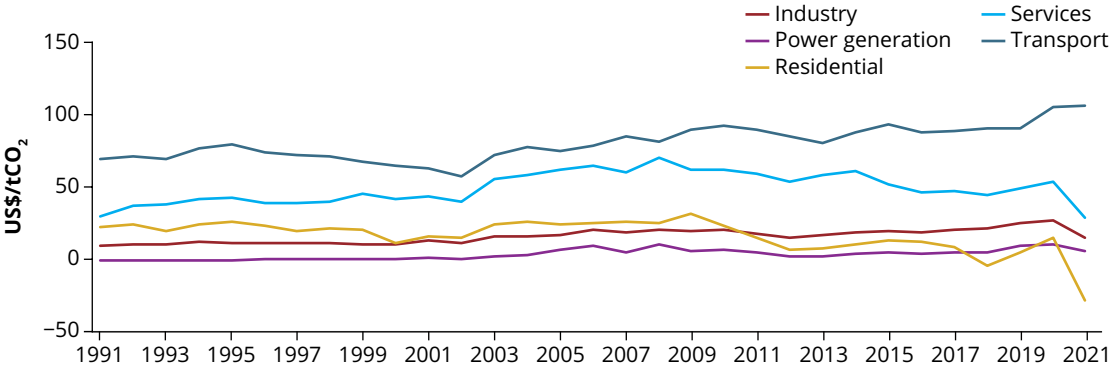


Source: Authors' calculations based on IMF, IEA, and World Bank data sets.

Note: The total carbon price (TCP) for each fuel was estimated based on net excise taxes, emissions trading systems (ETSs), value added tax (VAT) deviations, carbon taxes, and net energy (consumption) subsidies, based on underlying data sets. The way in which net energy taxes and subsidies are computed is discussed in appendix A. The range of the y-axis of each subplot depends on the time series being plotted, and therefore the difference in scale should be kept in mind while navigating different graphs. LPG = liquefied petroleum gas; US$/t$CO_2$ = US dollars per ton of carbon dioxide.

FIGURE 3.9

Total Carbon Price Estimates by End-Use Sector



Source: Authors' calculations based on IMF, IEA, and World Bank data sets.
Note: TCP = total carbon price; US$/t$CO_2$ = US dollars per ton of carbon dioxide.

According to the available data, aggregate TCP levels for LPG and kerosene appear relatively low. Based on the dataset in Parry, Black, and Vernon (2021), these fuels have received subsidies while being subject to relatively modest tax rates. As a consequence, the TCP calculations for these two fuels appear to be mainly driven by the levels of the energy subsidies accruing to them. The TCPs for kerosene and LPG have been very close to zero for about half of the years covered in this analysis. The global average level of subsidies for the two fuels appears to be approximately equal, and kerosene and LPG are typically not covered by direct carbon pricing instruments such as ETS or carbon taxes. Given that kerosene is the fuel commonly used by less affluent households for lighting, subsidies for it are not as regressive as other subsidies, but as argued in Kojima (2016), many subsidies did not prove cost-effective for achieving policy objectives, including equity. In both cases, the relatively high oil prices observed beginning in the mid-2000s contributed to increases in energy subsidies compared with rises in energy taxes, thereby reducing the carbon price signal measured by the TCP.

The data set used in this study indicates that TCP levels on natural gas increased for several years before declining in 2021. The global average of consumption subsidies on natural gas, has been relatively stable over the past 30 years, except in 2021. Although natural gas has recently been subject to some degree of direct carbon pricing (as can be seen in figure 3.8), in 2021 its global TCP level became negative for the first time since 1991. This decline may be due to a divergence between international oil prices and domestic retail prices. The drivers of this divergence are context dependent and can be affected by whether countries import or export natural gas; whether they use crude oil–based pricing formulas or regional gas hub–based pricing, which has become common in recent years; or whether specific government policy or regulatory actions are in place to keep prices of natural gas lower than alternatives.[26]

26. More details on the pricing of natural gas are available in Kojima (2016).

3.2.2. Observations by Energy-Consuming Sector

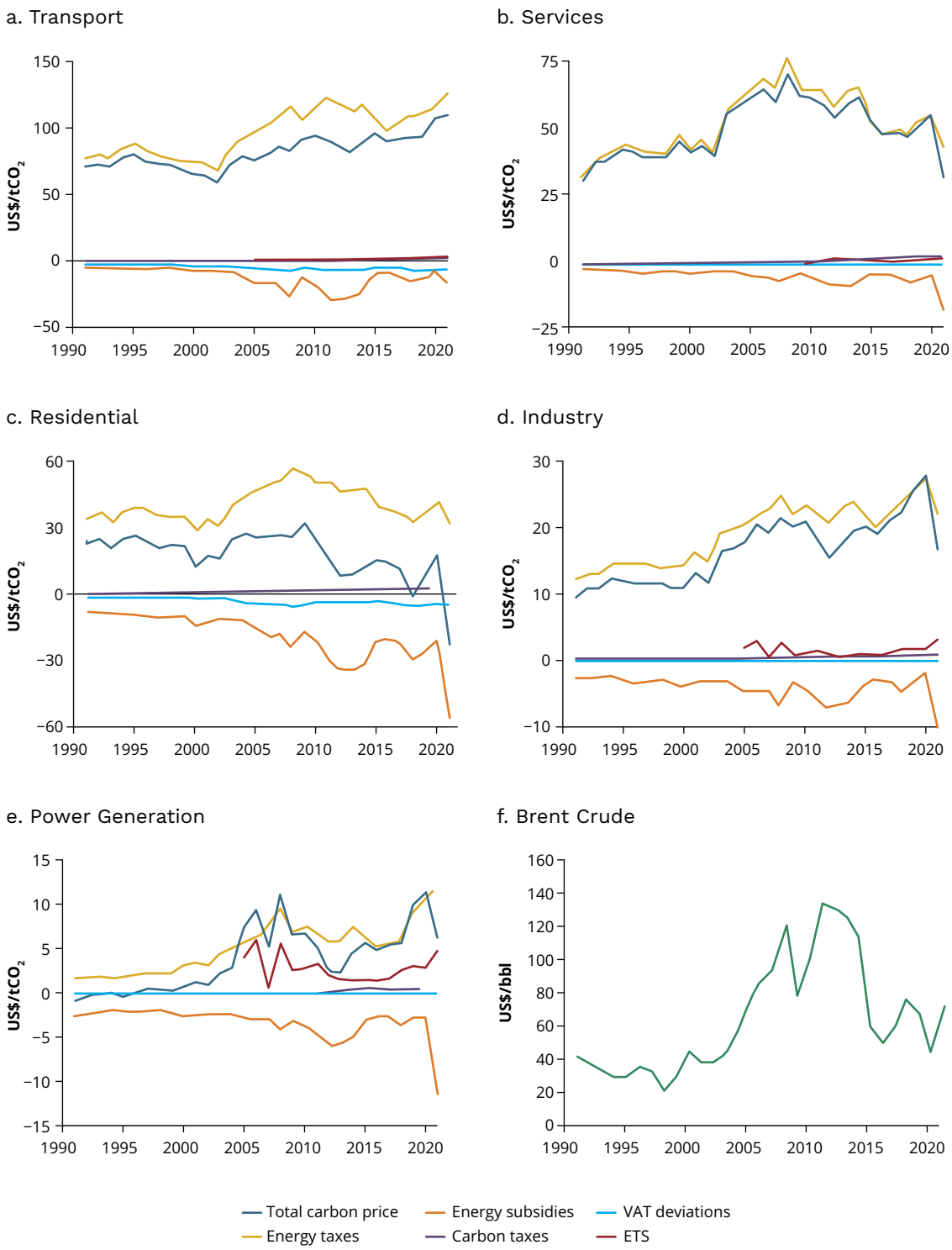
When the TCP faced by energy-consuming sectors is explored, transport faces the strongest carbon price signal by far. This outcome is not surprising given the main fuels used in the sector, namely gasoline and diesel, are those for which the TCP is strongest, as shown in figures 3.9 and 3.10. These findings are consistent with results in OECD (2022). Note, however, that there is variation across countries and across transport fuels, with fuels being heavily taxed in some countries while perhaps lightly subsidized in others. Therefore, some of the general observations made here will not be applicable in every country context.

Among the sectors included in this analysis, the power sector faces a much lower carbon price signal. This is consistent with results in OECD (2022). On the other hand, the power sector is one of the sectors most affected by the direct carbon price as shown in figure 3.10, which provides a breakdown of TCP components by sector. On average, residential energy consumption receives the highest level of subsidies per ton of CO_2 emitted but also bears a relatively high level of taxation.

On the other hand, the services sector has faced a higher TCP than the industrial sector in the period covered by the analysis. This outcome can be explained by the lower energy subsidies provided to the services sector and the higher level of excise taxes to which it is subject, which could be due to the services sector's lower exposure to international competition (and hence demands for subsidies in the name of competitiveness). Lower exposure to international competition arises from the fact that trade in services is considerably lower than trade in goods. In the last part of the period covered by this analysis, the TCP for the residential sector becomes lower than that for the industrial sector.

FIGURE 3.10

Global Trends Across Sectors in the Total Carbon Price and Its Components, Plotted Alongside Brent Crude Prices



Source: Authors' calculations based on IMF, IEA, and World Bank data sets.

Note: The figure shows the aggregate total carbon price (TCP) for each sector based on net excise taxes, emissions trading systems (ETSs), value added tax (VAT) deviations, carbon taxes, and net energy (consumption) subsidies. The way in which net energy taxes and subsidies are computed is discussed in appendix A. The range of the y-axis of each subplot depends on the time series being plotted. Brent price is measured in 2021 US dollars per barrel ($/bbl). US$/tCO_2 = US dollars per ton of carbon dioxide.

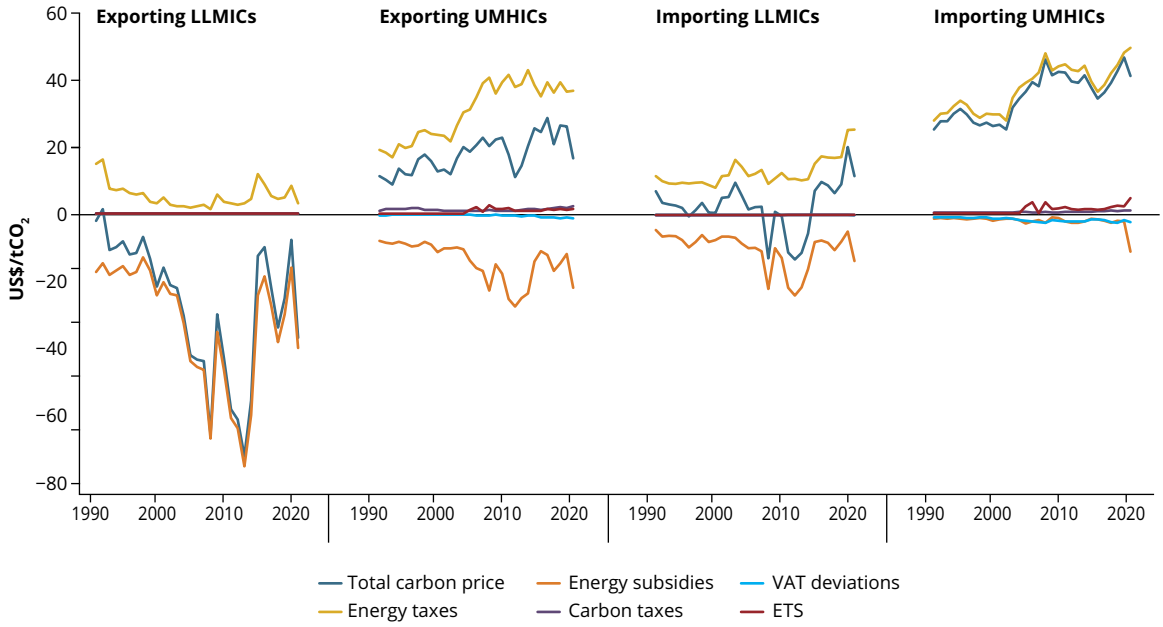
3.2.3. Observations by Country Grouping

Because levels of the TCP and its components are influenced by country-specific, structural, and economic factors such as income level, pattern of fossil fuel trade, and level of the fiscal debt, the analysis explores different groupings of countries to understand whether and how the TCP varies. Following Vagliasindi (2013), the analysis breaks the results down to those for low-income and lower middle-income countries (as per World Bank 2022b) denoted as "LLMICs"[27]; and upper middle-income and high-income countries, or "UMHICs." The analysis also splits the sample based on countries' fossil fuel commodity trading position, with one group including countries that have been mainly net exporters of fossil fuels and the other containing countries that have been mainly net importers.[28] The countries are organized into four groups according to these factors: (1) mainly net exporting LLMICs, (2) mainly net importing LLMICs, (3) mainly net exporting UMHICs, and (4) mainly net importing UMHICs. As shown in figure 3.11, the difference between the four groups is striking, confirming that fossil fuel pricing policies are strongly country-specific (Kojima 2016), but some common patterns emerge among countries with similar circumstances.

27. Ideally, the analysis would have been conducted for low-income, lower middle-income, upper middle-income, and high-income countries separately. However, the sample would have to have been split into eight subsamples (four groups related to economic development times two groups related to fossil fuel trading status) with concerns related to the reliability of the results caused by the limited number of countries in each subsample.
28. Whether a country has been mainly a net oil exporter or net importer is determined by whether the sum of the net exports across the sample used in this study is positive or negative.

FIGURE 3.11

Global Trends in the Total Carbon Price and Its Components by Country Grouping



Source: Authors' calculations based on IMF, IEA, and World Bank data sets.
Note: Total carbon price (TCP) is estimated using net excise taxes, emissions trading systems (ETS), and value added tax (VAT) deviations, carbon taxes, and net energy (consumption) subsidies, by level of per capita income and importing or exporting countries. The way in which net energy taxes and subsidies are computed is discussed in appendix A. A country is allocated to the net importers or exporters grouping based on its cumulative trade in crude oil and natural gas liquids. LLMICs = low-income countries and lower middle-income countries; UMHICs = upper middle-income countries and high-income countries; US$/t$CO_2$ = US dollars per ton of carbon dioxide.

Illustrative TCP calculations using the available data sets show that the TCP and its components follow different patterns across fuels, depending on country income and trade groupings, as shown in figure 3.11. The TCP in figure 3.11 is negative and closely tracks the level of subsidies in exporting LLMICs across all fuels, except coal. This finding is consistent with the discussion in Kojima (2016), according to which price subsidies persist among current or former hydrocarbon exporters and only a select few major oil exporters subsidize every fuel. The same level of homogeneity can be found at the opposite end of the spectrum: in importing UMHICs, TCP closely follows energy taxes across fuels.

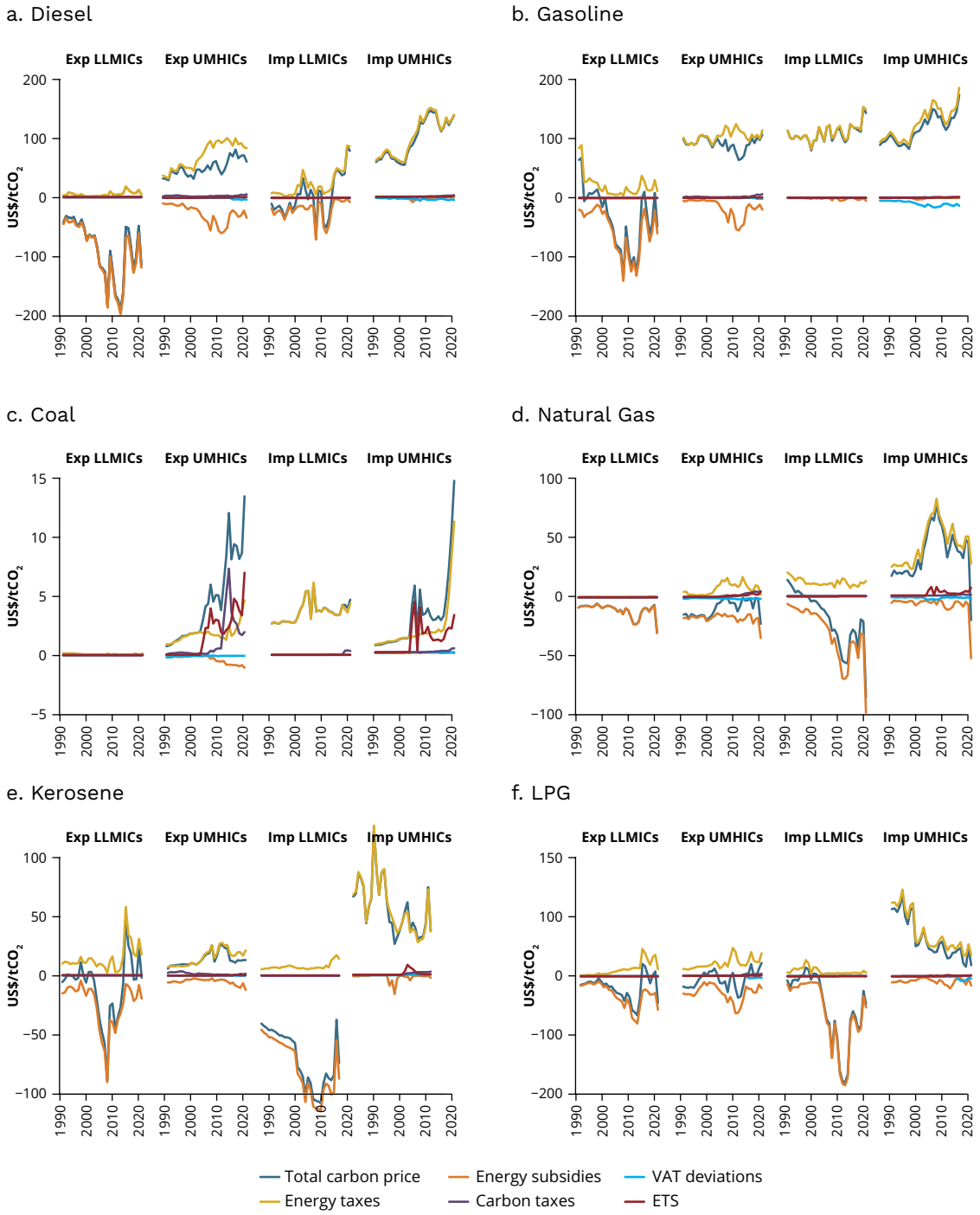
These illustrative calculations show that net fossil fuel exporting LLMICs have been consistently sending negative total carbon price signals. This is consistent with results from IEA (2022a), according to which energy subsidies are mostly concentrated in the Middle East and North Africa region and the Commonwealth of Independent States. Given that energy taxation levels in exporting LLMICs tend to be low, the pattern and the level of the TCP closely follow those of consumption subsidies, resulting in a negative TCP, and hence, negative carbon price signals.

Energy subsidies display a similar pattern and size in exporting UMHICs and importing LLMICs. Levels of taxation are, however, much higher in exporting UMHICs, which renders a positive TCP, as shown in figure 3.11. For importing LLMICs, levels of taxation are lower, rendering TCPs near zero in the first half of the timespan covered by this study, followed by negative TCPs caused by higher consumption subsidies, and positive and increasing TCPs in the 2010s as subsidies fall and taxes increase. The lower level of excise taxes in LLMICs may be due to limitations in the tax base as well as institutional capacity constraints for tax administration and enforcement (including the ability to minimize tax evasion) rather than being a deliberate policy choice. Finally, for importing UMHICs, the data set in Parry, Black, and Vernon (2021) indicates that subsidies are modest. Consequently, the level and pattern of the TCP in importing UMHICs is closely associated with excise taxes throughout the sample included in this study.

For exporting UMHICs and importing LLMICs, TCP levels and patterns, and hence carbon price signals, tend to vary across fuels, reflecting that pricing policies tend to be strongly fuel-specific. This is consistent with Kojima (2016). Figure 3.12 presents the TCP by fuel and country grouping. For gasoline, the data set does not indicate any significant difference across the two groups of countries, given that gasoline is highly taxed and only lightly subsidized in both exporting UMHICs and importing LLMICs. A similar observation is possible for LPG in the two groups of countries, where the TCP closely follows subsidies, although the level of consumption subsidies per ton of CO_2 for LPG is much smaller in exporting UMHICs than in importing LLMICs. For other fuels, significant differences are observed across the two groups of countries. The level of carbon pricing on diesel in importing LLMICs, as measured by the TCP, became positive only in the last few years of the sample whereas it has been positive throughout in exporting UMHICs. Natural gas experienced the opposite pattern in importing LLMICs, from positive values of the TCP in the first part of the sample to negative values. The value of the TCP is also negative, although small, in exporting UMHICs. The value of the TCP has been consistently negative for kerosene used in importing LLMICs, but positive in exporting UMHICs. Consistent with the results in figure 3.10, subsidies and taxes on the consumption of coal are low, but the strength of the direct carbon price signal has increased considerably in UMHICs with the recent introduction of ETSs. On the other hand, the range of TCP variation for coal across time in the four groups of countries used in the analysis is narrow compared with the ranges observed for other fuels.

FIGURE 3.12

Observations on Fuels, by Per Capita Income and Trading Status



Source: Authors' calculations based on IMF, IEA, and World Bank data sets.

Note: The way in which net energy taxes and subsidies are computed is discussed in appendix A. A country is allocated to the net importers or exporters grouping based on its cumulative net trading position in crude oil and natural gas liquids. The range of the y-axis of each subplot depends on the time series being plotted. ETS = emissions trading system; Exp = exporting; Imp = importing; LLMICs = low-income countries and lower middle-income countries; LPG = liquefied petroleum gas; UMHICs = upper middle-income countries and high-income countries; US$/t$CO_2$ = US dollars per ton of carbon dioxide; VAT = value added taxes.

FOUR

Conclusions and Next Steps

4.1. Findings, Conclusions, and Takeaways

While there has been encouraging progress in efforts toward carbon pricing, their interaction with energy taxes and subsidies— which are, in fact, responsible for a significant share of the ultimate carbon price signal—has received limited attention. Initiatives and policies to price carbon in the energy and climate domains have evolved in parallel, and often without coordination. Over the past few years, several countries around the world have introduced carbon pricing instruments while at the same time they and others have introduced or increased fossil fuel subsidies. In view of these dynamics, it is important to understand the interaction of different energy, climate, and fiscal policy instruments and to assess the resulting carbon price signal sent by the combination of these policies and instruments.

This report highlights the interactions of key climate policy tools by adopting the concept of the total carbon price (TCP), undertaking illustrative calculations, and drawing high-level insights on policy interactions. The TCP can be applied for an economy as a whole, for a specific fuel or a specific sector, and for a single country, a group of countries, or globally. This report uses the TCP to estimate carbon price signals resulting from the combination of direct carbon pricing instruments and indirect carbon pricing instruments, mainly subsidies and taxes on energy consumption. The report presents illustrative calculations of the TCP indicator for 142 countries, from 1991 to 2021, and was carried out by using best-available data sets from credible international sources. The data sets contain information on coal, diesel, gasoline, kerosene, liquefied petroleum gas (LPG), and natural gas, and cover energy consumption in the industrial, power, residential, public administration, services, and transport sectors.

The focus of this analysis is on providing an understanding of how energy subsidies affect carbon price signals from climate and fiscal policy instruments. The illustrative calculations of the TCP using best-available data sets show that a significant share of carbon price signals are currently delivered by energy taxation. An important finding from the analysis is that efforts to levy and enforce direct carbon prices risk being substantially undermined by energy subsidies, and that energy subsidies act as a negative carbon price.

Illustrative calculations of the TCP for the group of countries for which data were available suggest that levels of energy subsidies, taxation, and direct carbon prices vary considerably across countries, fuels, and sectors of the economy. Across countries, the TCP level is highest in the transport sector, mainly because gasoline and diesel tend to be heavily taxed, as indicated by the levels of net energy taxes. On the other hand, consumption of energy in the residential sector has faced relatively low TCP signals, while the power, industrial, and services sectors fall somewhere in between these two extremes.

The illustrative TCP calculations also indicate differences between countries based on levels of per capita income and fossil fuel trading position, rendering observations that are consistent with the recent literature on energy subsidies and taxation. In low-income and lower middle-income countries (LLMICs) that predominantly export fossil fuels (exporting LLMICs), consumption subsidies tend to be high, energy taxes low, and the resulting total carbon price signal strongly negative. The opposite is observed in importing upper middle-income and high-income countries (UMHICs), where energy taxes tend to be high and energy subsidies low, rendering a strongly positive total carbon price. Exporting UMHICs and importing LLMICs fall somewhere in the middle. Because low levels of energy taxes in LLMICs might reflect the ability of the central government to raise tax revenue rather than being a deliberate policy choice, it is important to explore further how energy subsidy reform efforts can complement wider initiatives aimed at strengthening governments' fiscal capacity, including the ability to raise revenues.

The illustrative TCP calculations point to variations across countries and fuels over time, based on income and fuel trading position. Countries with high levels of subsidies (exporting LLMICs) or excise taxes (importing UMHICs) appear to apply taxes or subsidies consistently across fuels with only minor exceptions, such as coal in exporting LLMICs. The other two groupings of countries— importing LLMICs and exporting UMHICs—show much more diversity with regard to pricing carbon emissions. On the one hand, consumption of kerosene and LPG in these countries tends be subsidized, while on the other hand, consumption of gasoline seems to be heavily taxed. In addition, a transition from prevalent subsidies to prevalent taxation has occurred for diesel in importing LLMICs, an encouraging sign for the reform of energy subsidies.

4.2. Policy Implications

The application of the TCP highlights the importance of coordination between energy, climate, and wider fiscal policy. Significant benefits can be found from carrying out energy subsidy reforms in conjunction with direct carbon pricing instruments and assessing the implications of fuel taxation and value added tax (VAT) rates in detail. From a broader perspective, given that the achievement of international climate goals will require an integrated approach to managing carbon emissions, the exploration of interactions and synergies between energy, climate, and fiscal policy instruments affecting energy consumption and carbon dioxide (CO_2) emissions will be critical. It is therefore important that quantification of any instrument type not be carried out in isolation. The TCP indicator can be useful in illustrating these dynamics.

The variation in TCP levels across fuels observed in the indicative calculations has several implications for energy and climate policy. It is important to recognize that even when all fuels face positive TCPs, the existence of variation in TCPs across fuels—or, to put it simply, of different carbon price signals—within a country is often the result of

non-climate-related policy drivers. Because these policies can encourage consumption, along with operational, technology, and investment choices within jurisdictions, they can have direct and significant consequences for greenhouse gas (GHG) emissions in the short and medium term, underscoring the importance of the climate community's engagement with other policy spheres that significantly shape the pricing of carbon, and generally the need to convey to policy makers which nonclimate considerations support raising carbon pricing.[29]

This analytical exercise calls attention to the important role that energy subsidy reforms can play in the context of climate policy. This conclusion holds regardless of the exact estimated figure for a global TCP, which, as noted earlier, is dependent on the underlying databases. Even though they may set out to achieve different sectoral objectives, carbon pricing and subsidy reform are largely aligned and reinforce each other's impacts and cobenefits. In addition to freeing up critical fiscal resources for climate and clean energy priorities, energy subsidy reforms can correct the negative carbon price signal resulting from energy subsidies, which work against energy taxes and direct carbon pricing. Estimates made using existing data sets, along with available country data, indicate that the average direct carbon price from the energy, climate, and fiscal policy instruments introduced so far, taking into account emissions coverage, could be as low as US\$3/tCO_2. This is consistent with findings in OECD (2022) and indicates that direct carbon price signals are much too low to achieve the international goals and milestones reflected in the Paris Agreement.[30]

Understanding the full scale and impact of energy subsidies and their interaction with other energy, climate, and fiscal policy instruments will be important for policy makers and development practitioners. It is imperative that policy makers expending substantial effort to introduce carbon pricing initiatives are aware of the extent to which energy subsidies undermine these initiatives, in addition to worsening fiscal pressures. This analysis demonstrates the climate urgency of emphasizing and prioritizing energy subsidy reforms in addition to introducing direct carbon pricing instruments.

A key takeaway for climate policy is that global carbon pricing is mostly driven by policy instruments that do not have explicit climate objectives. Efforts to raise overall carbon prices therefore must reach outside of the climate community. To achieve the goals and targets of the Paris Agreement, the aggregate pricing signal needs to rise, and this is precisely what the TCP indicator is attempting to measure. Direct carbon prices account for only a small (although rising) share in the TCP. The policy instruments that hold greater sway for total carbon prices are pursued for nonclimate reasons, such as fiscal and energy policy purposes. Therefore, to move forward on global carbon pricing, it is essential for the climate, fiscal, and energy policy communities and practitioners to come together. The TCP has the potential to help as a joint indicator of progress in these individual domains. If a large share of the TCP is driven by instruments that are pursued for nonclimate motivations, unlocking progress on carbon pricing may require the creation of much greater

29. See Heine and Black (2019) and Parry, Veung, and Heine (2015) for a summary of these nonclimate benefits of carbon pricing.
30. According to the Carbon Pricing Leadership Coalition (2017), achievement of GHG reductions needed to meet the Paris climate goal would necessitate prices of at least US\$40–US\$80/tCO_2 by 2020 and US\$50–US\$100/tCO_2 by 2030.

awareness of the nonclimate benefits of raising carbon pricing. Those benefits can be pervasive (e.g., Heine and Black 2019) but may not be well known. The sheer size of indirect carbon pricing relative to direct pricing shows how important those nonclimate benefits may be to making progress in overall carbon pricing.

4.3. Next Steps and Future Work

It is important to recognize that, despite the novelty of the analytical exercise, the TCP methodology and data set still have limitations that will need to be tackled in future work. Several limitations stem from constraints with the underlying data, along with the assumptions and approximations necessary to get to the key components of the TCP metric. Various areas for further strengthening the TCP methodology are discussed in Agnolucci et al. (2023a) and appendix A, including extension of the concept to non-CO_2 GHG emissions, emissions from land use change and forestry, and carbon embodied in trade. This section complements that discussion and focuses on areas for improvement particularly related to energy subsidies and taxation.

An analysis is only as good as the underlying data. While the illustrative calculations of the TCP using best-available data sets help demonstrate the importance of policy interactions and the value of an aggregate indicator capturing carbon price signals from direct and indirect instruments, it is critical to recognize data limitations and focus on data quality and reliability. For an analysis to render relevant, useful, and trustworthy conclusions, the importance of having accurate, good quality data that is periodically updated and validated in-country cannot be overemphasized. As such, the approach used in this report, of estimating TCP using best-available data sets, should be seen as a first step in a process that can be improved by collecting more precise data, as pointed out in Kojima and Koplow (2015).

4.3.1. Strengthening the Methodology and Data Sets

In the future, including electricity consumption subsidies in the scope of the TCP can be considered. As discussed in chapter 2 and appendix A, the current iteration of the TCP excludes electricity consumption subsidies because of data limitations and challenges in the price-gap approach, given the complexity related to policy and regulatory interventions in the sector. Future work could explore the possibility of incorporating electricity subsidies, provided data are available and reliable estimation of subsidies using the price-gap methodology is feasible after taking into account the impact of other policy interventions and market power on electricity prices.

The inclusion of production taxes and subsidies in the TCP could be more challenging, but could still be explored. Including such taxes and subsidies would require data and analysis on the extent to which they affect retail prices, which is itself dependent on whether the fuel is internationally traded, on the market share of the country in the context of global markets, and on the extent to which taxes and subsidies are passed through to retail prices. This would be a significant departure from the current application of the TCP, given that the assessment of these issues entails economic modelling to, for example, determine the effect of any national policy on international commodity prices rather than the simple arithmetic computations currently involved in TCP estimations. A more straightforward step could be to include production tax deviations, that is, reduced rates for specific firms or industries. If it is assumed that the pass-through rates of the production tax deviation are equal to the pass-through of production taxes, the inclusion of this component in the TCP would not present significant methodological challenges, but putting together an adequate data set on production tax deviations, especially covering a significant number of countries across time, might be resource intensive. A further area for focus could be to address the limitation in the TCP's likelihood of capturing compliance effects unless the impact of a lower level of compliance is incorporated in the retail price. Because compliance tends to be weaker in low- and lower middle-income countries compared with upper-middle- and high-income countries, this consideration would affect international comparisons of the effective TCP across countries.

Some of the limitations of the approach can be overcome by improving underlying data. One area worth highlighting is the limited data related to statutory rates of energy taxes and subsidies for the set of countries considered. In the current analysis, the lack of comprehensive data on statutory rates of energy taxes and subsidies was addressed by using two proxies, which have been labeled net energy taxes and net energy subsidies, respectively. In view of this limitation, it is important to keep in mind that all conclusions in this report on the levels of energy taxes and subsidies are based on the computed levels of these two proxies, rather than on actual data. It is clear that the collection of actual, granular data for individual countries would strengthen the quality and relevance of the analysis, allowing meaningful conclusions to be drawn for policy making. Another area for improvement is the treatment of VAT thresholds or informality, which are currently excluded from the analysis because of lack of data on these two dimensions. Given that both of these factors reduce the effective VAT rate overall, and in particular on lower income deciles, the TCP likely overestimates the carbon price related to fuels, such as kerosene, affected by VAT thresholds or consumed by lower-income deciles.

4.3.2. Country-Level Application and Further Analysis

Going forward, a critical area will be to enhance the usefulness of the TCP for policy makers and practitioners and to strengthen its quality through its application in specific countries using country-level data collected from the bottom up. As noted earlier, in-country applications will be a natural next step. Moreover, in-country applications of the TCP would enable access to much more reliable data that can be validated and improved over time. Having better data can enhance the usefulness of the analysis and help facilitate the development of meaningful policy advice. In addition, in-country applications can generate practical insights into the methodology itself, which can enable further refinements. In fact, the TCP was recently piloted as part of technical assistance engagements with a select set of World Bank client countries. These applications, in particular those in Paraguay and Uruguay, have already rendered highly valuable design and implementation insights for the TCP.[31] Another related idea worth considering would be to calculate the TCP over time for countries that have implemented carbon taxation and other measures included in the TCP, after calculation of earlier sector-specific measures. From a practical perspective, these case studies would be helpful for policy makers considering the adoption of measures included in the definition of the TCP to understand the potential tradeoffs involved.

Although aggregate global comparisons of carbon price signals from direct and indirect carbon pricing instruments are helpful in illustrating the interaction of different instruments at a high level, the real relevance and usefulness of the TCP as a metric would be in-country application. For a given country, the primary focus would be the carbon price signal from the combination of direct and indirect carbon pricing instruments in place in that jurisdiction. Therefore, the main value of the TCP indicator

31. An activity where the TCP could potentially be piloted may be World Bank public finance reviews.

would come from in-country applications. When reliable data are available, and TCP components are calculated using consistent approaches, the strength of carbon price signals can be compared across countries.

Future analyses could explore the relationship between the TCP and various factors describing the economic development and the institutions of specific countries. Drawing on insights from relevant energy subsidy reform literature (e.g., Vagliasindi 2013, IMF 2014), this report explores variation in the value of the TCP based on factors such as countries' income levels and trading status (as net exporters or importers of fossil fuels covered by the TCP). The approach could be further improved by using these factors to group countries or to conduct a more robust econometric analysis. In such an analysis, the TCP calculations can be grouped and broken down in different ways to render different insights. As an example, countries that are net energy exporters receive substantial rents from their exports, decreasing the need for other sources of government revenues, such as energy taxes, until there is a crash in commodities prices. Similarly, the high TCP rate observed in upper middle-income and high-income countries might be related to their citizens' willingness to pay to avoid emissions or to more developed tax institutions. Insights from the literature exploring the reasons influencing a country's decision to tax or subsidize fossil fuels, such as Mahdavi, Martinez-Alvarez, and Ross (2022), would be a natural starting point for this analysis.

When comparing the TCP across countries, it is important to keep in mind what VAT deviations measure and how they vary. The concept of VAT deviation included in the TCP focuses on the difference between economywide VAT rates and the rate charged on energy commodities. Although including VAT deviations within a country (between energy and other commodities) in TCP estimations can offer insights into indirect carbon price signals within that country, caution should be exercised when attempting to use the TCP for cross-country comparisons. Countries can have different standard VAT rates, which means a comparison of nominal VAT and deviations from it across countries can be misleading. Therefore, in practical cross-country applications of the TCP, it should be recognized that the presence of different VAT baselines affects the rate of VAT deviation. The exclusion of VAT deviations, on the other hand, can significantly alter the results, both at the country level and in cross-country comparisons. Therefore, it is advisable for analysts to keep this limitation in mind and to explore pragmatic solutions to it when attempting cross-country comparisons, including estimating the TCP with and without VAT differentials and supporting the analysis with qualitative discussions. A related question concerns the extent to which VAT deviations should be included when analyzing the TCP for sectors other than households if adequate information on the extent to which firms are able to recover VAT paid is not available.

While the TCP focuses on producing an objective measure of the carbon price, future work could explore how effectively emissions are abated by various direct and indirect carbon pricing tools. It is clear that the way in which carbon pricing is done and the way in which revenues from carbon pricing are used will affect the scale of emissions

avoidance per unit of pricing.[32] It is worth noting that the impact of combinations of policy tools (some of which may not be related to climate change or environmental purposes) does not necessarily correspond to the sum of the impacts of the individual instruments. The impact will depend on various other factors, including sector structure, the accompanying policy framework, and market failures. Therefore, it is worth keeping in mind that, although the TCP calculations illustrate the direction and strength of carbon price signals from different sets of instruments (such as carbon pricing and fossil fuel subsidies), the impact of these measures on the ground may not simply be the sum of the two. Moreover, as discussed in the literature, carbon price signals alone would not be capable of delivering sufficient emissions reductions unless supported by complementary policy measures to enable the energy transition. These measures include government support for technology development and investment, renewable energy support mechanisms, energy efficiency standards, financing and aggregation mechanisms, and other measures to address market failures and barriers to clean energy scale-up.

32. Some abatement actions originate directly from the introduction of carbon pricing and the choice faced by any emitter to abate or pay the carbon price. Other abatement actions, however, can indirectly originate from the way in which revenues from carbon pricing are used, for example, by earmarking revenues to fund abatement actions.

Appendix A. Methodology, Coverage, Exclusions, and Data Sets

This technical appendix presents the main elements of the total carbon price (TCP) methodology, explains its coverage and exclusions, and discusses the underlying data. It is intended to provide greater detail on the methodological aspects of the analysis presented in the report, and builds on the work in the companion papers to this report, in particular, Agnolucci et al. (2023a, 2023b).

A.1. Total Carbon Price Methodology

The TCP calculates an average of the nominal levels of the policy instruments affecting direct and indirect carbon prices, weighted by the volume of emissions affected by each instrument. Direct carbon pricing instruments include carbon taxes and emissions trading systems (ETSs), where a price signal is directly levied on carbon emissions. Indirect carbon pricing instruments include fuel excise taxes and subsidies, normally levied on units of energy that can be converted into carbon emissions.

The main components of the TCP are defined as follows:

- The **retail price** (*rp*) is an average end-user price paid by final users in a particular sector (e.g., power generation, industry, residential) or for the whole economy, incorporating all applicable taxes and subsidies, including value added taxes (VAT). This would be the average price "at the pump" in the case of gasoline.
- The **supply cost** (*sp*) is an average cost including all production, transformation, transportation, and distribution costs and profits but excluding taxes.
- **VAT rates** include the standard VAT rate in each country and the reduced rates granted to specific fuels for a limited set of end uses.[33] Because the data set used in this study does not incorporate information on exemption thresholds and alternative regimes for specific fuels, these factors have not been included in the current computation of the TCP.

The TCP can be calculated for a specific fuel, sector, or country, or for a collection of fuels, sectors, and countries. In its most general application, calculating the value of the TCP for multiple countries requires data for all countries covered (index *c* in equation (A.1)), sectors (index *s*), and fuels (index *f*):

$$TCP_t = \sum_{c=1}^{C}\sum_{s=1}^{S}\left[\sum_{f=1}^{F}\left[\frac{\sum_{j=1}^{J} T_{csfjt}FC_{csfjt} - \sum_{k=1}^{K} S_{csfkt}FC_{csfkt}}{\sum_c \sum_s \sum_f CO_{2_{csft}}} + \sum_{l=1}^{L} \frac{CP_{csflt} \times CO_{2_{csflt}}}{\sum_c \sum_s \sum_f CO_{2_{csft}}}\right]\right] \quad \text{(A.1)},$$

33. The VAT rate is assumed to be zero for businesses given that these fuel users reclaim paid VAT (as is standard practice in VAT systems).

In equation (A.1), *T* indicates nominal tax rates per unit of energy; *S* the level of nominal fuel subsidies, also expressed per unit of energy; and *CP* the rate of direct carbon pricing per unit of emissions. The subscripts of the variables indicate the country *c*, sector *s*, fuel *f*, and time *t* related to the specific value of the variable. Nominal rates of excise taxes and subsidies are expressed per unit of energy and multiplied by the fuel consumption affected by a specific instrument, that is, FC_{csfjt}, which is the amount of fuel *f* consumed in sector *s* and country *c* at time *t* and affected by energy tax *j*.[34] Each set of policy instruments is allowed to contain several measures with different objectives, hence the need for subscript *j* in the case of energy taxes, *k* for energy subsidies, and *l* for direct carbon pricing instruments. Financial variables related to the policy instrument in the numerator of equation (A.1) are divided by the total levels of emissions from combustion, obtained by using standard conversion factors for energy fuels, yielding a monetary figure per unit of emissions. Equation (A.1) simplifies when calculating the TCP for a specific fuel or for a specific sector or a specific country because some of the sums can be left out. As an example, for the TCP for fuel *f* at time *t*, the sums across fuels in equation (A.1) can be left out because the TCP is computed for a specific fuel; similarly, for the TCP for a specific country, the sum across countries is not required.

A.2. Total Carbon Price Coverage

Within the three types of policy instruments mentioned above, the *Carbon Pricing* group, CP_{cslt}, includes direct carbon pricing instruments such as carbon taxes and ETS, which are fairly straightforward because the price signal is directly levied on carbon emissions. In theory, other direct carbon pricing instruments could be added, although they were not included in the first round of analysis of the TCP because of data availability constraints. Additional carbon pricing instruments that could be included as part of future TCP calculations and subsequent analyses include carbon crediting instruments, TPS, and feebates.

- **Carbon crediting instruments.** The impact of carbon crediting instruments on the average carbon price depends on their design. When allowances from these instruments are used to meet targets as part of existing mandatory instruments, such as the EU ETS, an indicator that includes both the price signal arising from the crediting and that from the mandatory instruments would result in double-counting of emissions. On the other hand, price signals arising from voluntary offsets that cannot be used as part of mandatory instruments may indeed be included in the TCP.
- **Tradable performance standards (TPS).** The credit generation mechanism is the key factor in determining whether this type of instrument would generate any price signal. TPS policies that target emission intensity, such as the low-carbon fuel standards in California and Oregon, generate an explicit carbon price,[35] while volumetric mandates like the zero-emission vehicle program in California do not influence the carbon price because credits are gained when vehicles are sold, regardless of their actual use.

34. Note that exchange rate fluctuations may affect the evolution of these elements of the TCP.
35. This is reported to have varied between US$25 and US$200 for the low-carbon fuel standard in California (Yeh et al. 2021). Indeed, several TPSs are recognized in the World Bank's State and Trends of Carbon Pricing Reports as ETSs.

- **Feebates.** Similar to TPS policies, the generation of any price signal from feebates[36] depends on the design of the policy.[37] Introducing feebates on firms with emission rates above or below the industry average emission rate, as advocated in Parry (2021), is an example of direct carbon pricing. On the other hand, the feebate introduced in France in 2008 on the sales of light duty vehicles (German and Meszler 2010) does not generate any marginal carbon price signal.

Indirect carbon pricing instruments incorporated in the TCP include taxation, T_{csfjt}, and subsidy instruments, S_{csfkt}.

- **Excise taxes.** Given that the rate of these instruments—a monetary amount per physical unit of the good (e.g., US$/liter)—can be translated into a carbon rate in a straightforward way, by using carbon dioxide (CO_2) emission factors, they can easily be included in the TCP.
- **Energy consumption subsidies.** By reducing the cost of consuming energy, these instruments result in negative carbon pricing, and hence are included in the TCP calculations. The incorporation of these instruments into the TCP requires tackling quantification-related challenges. In the price-gap approach (Coady et al. 2019; Kosmo 1987; Larsen and Shah 1992), consumption subsidies are defined as the difference between the end-use (retail) price set by the government, or charged by the seller, and a reference price corresponding to the price prevailing in the competitive market.[38] This approach implies that the size of subsidies varies in conjunction with changes in the reference price,[39] and no subsidy is recorded until the retail price falls below the reference price.
- **VAT deviations.** Although VATs aim at "fiscal neutrality," many governments levy lower VAT rates for consumption of specific fuels in select sectors. When doing so, a subsidy is granted to end users affected by the reduced VAT rate, with the subsidy equal to the difference between the standard VAT rate (VAT_{ALL} and the reduced rate (equation (A.2)).

$$VAT_{FUEL} = VAT_{ALL} - VAT_{RED} \tag{A.2}$$

  Because such deviations change the relative prices of fuels, consumers' choices are affected by fiscal consequences, in terms of forgone revenues, and environmental consequences, in terms of additional CO_2 emissions. VAT regimes incorporate threshold exemptions for specific fuels, so the calculation in equation (A.2) should be adjusted to take account of the impact of these thresholds on the average rate.

Further details on the different carbon pricing instruments discussed above are available in Agnolucci et al. (2023a), and table A.1 is replicated from that paper for reference.

36. According to the Oxford Languages English Dictionary, feebates are a system of charges and rebates whereby energy-efficient or environmentally friendly practices are rewarded while failure to adhere to such practices is penalized.
37. This depends on the measurement metric of the reference point separating the rebate function from the fee function.
38. More information on methodologies and approaches for quantification of subsidies is available in Kojima (2017). Corresponding terminology used by IMF publications is "pre-tax subsidies" in Coady et al. (2019) and "explicit subsidies" in Parry, Black, and Vernon (2021).
39. As an example, subsidies quantified by IEA (2022a) for a pool of countries in 2020 totaled about US$181 billion (in 2020 US$), down about 40 percent from the previous year, a change reflective of a 30 percent drop in the oil price, and bounced back in 2021 to US$440 billion—very close to the 2018 levels—as the cost of energy in international markets increased and energy consumption approached prepandemic levels.

TABLE A.1

Taxonomy of Pricing and Nonpricing Climate Instruments

Climate policies	Policy type		Type of market failure	Policy instrument	Estimating the total carbon price	Estimating Embodied Carbon Price (ECP)
Pricing Policies	Carbon pricing	Direct carbon pricing	Unpriced carbon externalities	Carbon taxes	Straightforward but depends on coverage	Requires consideration of exemptions and reduced rates
				Emission Trading Systems		
				Carbon crediting mechanisms	Design-dependent, baseline considerations	Design-dependent; often a subsidy to abatement rather than a tax on emissions
				Tradeable Performance Standards	Straightforward if trading price data is transparent; depends on coverage	Reduced by benchmark free allocation of credits
		Indirect carbon pricing		Fuel (excise) taxes	Depends on alignment between car-bon content and tax rates across fuels	Requires consideration of exemptions
				Fuel subsidies (consumption)		
				VAT deviations: VAT differential on fuels		
				Fuel subsidies (production)	Unclear to what extent the removal affects national prices. Data limita-tions.	As per contribution the total carbon price
	Technology and production incentives	Renewable support	Technology market failures	Feed-in tariffs, technology deployment subsidies	Improve relative costs of renewables but no marginal emissions reduction or fuel-switching incentive	Combining a subsidy with (sometimes) implicit tax to recover cost, design-specific
		Other taxes and tradable standards	Technology market failures & Information, behavioral and financial barriers	Clean energy standards, tradable renewable portfolio standards, energy efficiency tax credits, VAT differential on machinery, vehicle taxes	Correcting relative costs across mul-tiple sources, but no marginal emissions reduction incentive	
Non pricing policies	Standards (non-tradable) and other regulations			Technology mandates, air pollution standards, fertilizer regulations, fuel efficiency, energy efficiency building codes.	Estimation difficult, unlikely to influence price*, but design dependent	
	Public investment			Public transportation infrastructure, other infrastructure for innovation.	Estimation difficult, unlikely to influence price*	
	Information policies		Information, behavioral and financial barriers	Certification, product labeling and rating, information disclosure policies		
	Other policies			Other EV policies		

Source: Agnolucci et al. 2023a.
Note: EV = electric vehicle; VAT = value added taxes.

A.3. Total Carbon Price Exclusions, Limitations, and Data Constraints

The TCP methodology excludes several elements and is subject to a series of limitations, as summarized below. The way in which these and other limitations could be addressed in future work is discussed in the concluding chapter of the main report.

- The TCP concept is currently confined to emissions from the combustion of fossil fuels, including in power generation, thereby excluding GHG emissions from agriculture and land-use change. Calculating the indirect carbon pricing emerging from pricing incentives applied to deforestation-driving commodities by extending the coverage of the TCP to GHG emissions from agriculture and land-use change could be a crucial extension of the TCP, especially in some emerging market and developing economies where agriculture accounts for a considerable share of national emissions. Moreover, by focusing on fossil fuel combustion, the analysis leaves out non-CO_2 emissions or industrial process emissions (e.g., from cement, aluminum, and other manufacturing industries).
- Electricity and biofuels are not included because the calculation of corresponding carbon price metrics proved to be conceptually more challenging, given that no direct emissions are generated when consuming electricity. In addition, in the case of electricity, interventions motivated by nonenvironmental reasons are fairly widespread, including economic regulation, supply security requirements, and contractual mechanisms, along with constraints arising from sector structure and the variety of market design and competitive arrangements, thereby limiting the feasibility of applying a price-gap methodology to the computation of the TCP. Calculation of reference prices for electricity is also challenging because of differences in the way electricity is generated, transported, consumed, traded, and priced across borders, as well as the nuances in tariff setting, market dynamics, and positive externalities arising from access to electricity. Price data for biofuels are also very limited.
- Production subsidies and taxes are not taken into account in the TCP analysis in this report in view of the challenges associated with incorporating them. The challenges arise from, first, the uncertainty about their impact on the price, and second, the limitations on availability of data on the amount of production subsidies and taxes and the way in which these two instruments interact with market characteristics. In particular, the impact of production subsidies and taxes on carbon prices depends crucially on (1) whether the fuel is internationally traded, (2) the market share of the country in the context of global markets, and (3) the extent to which taxes or subsidies are passed through to retail prices. Production subsidies and taxes on locally traded fuels may have an impact on the domestic marginal price of the fuel, its consumption, and resulting emissions, depending on the level of cost pass-through. For internationally traded fuels, the extent to which production subsidies and taxes affect international prices depends on the market share of that country in the international market. A price-taker country producing a globally traded fuel may alter its own production level in response to the price, yet have no impact on international prices, total consumption, and resulting

emissions because other countries can adjust their own production shares in response. Production subsidies and taxes are excluded because of the limitations on the availability of adequate and systematic data on these two elements, although they could be introduced when data become available.

- Moreover, price-gap analysis cannot capture some forms of subsidies or government support, for example, conditional cash transfers, because not all subsidies result in net changes in end-user prices (Koplow 2009).

Some of these limitations can be overcome in future applications of the concept, with stronger data and additional resources.

A.4. Data Sets, Sources, and Scope

The data sets used for the illustrative calculations combine data on direct and indirect carbon prices, energy consumption and emissions, and trade of fossil fuels.

- Data for direct carbon prices are originally from World Bank (2021a) and the associated Carbon Pricing Dashboard (World Bank 2022a), including nominal rates and coverage for each carbon tax and ETS, and degree of overlap across policies. Because no information is available on the extent of free allocation of allowances in ETSs and exemptions in carbon taxes, the computed direct carbon price presented here should be seen as an upper bound for the price faced by energy consumers.
- Data on fuel consumption and emissions are originally from the energy balances published in IEA (2022b), while CO_2 emission factors and standard energy conversion factors are obtained from World Bank and IMF (2024).
- Data for imports and exports of crude oil and natural gas liquids are from IEA (2022b), and were used to group countries covered in this study into net importers or exporters of energy.[40] A more detailed discussion of the data sources used here to compute net energy taxation and subsidies can be found in Parry, Black, and Vernon (2021); greater detail on how data used for this analysis have been combined is available in Agnolucci et al. (2023a).
- Retail prices in Parry, Black, and Vernon (2021) are taken from IMF and World Bank country-specific data sets or computed as averages across various third-party sources when not available from IMF and World Bank country-specific departments. When data are not available for power generation, Parry, Black, and Vernon (2021) use prices in the industrial sector, and vice versa. In those cases where both were unavailable, the retail price was assumed to be equal to the supply cost plus any known taxes, including import duties (weighted by the share of the imported fuel) and preretail taxes (such as an upstream carbon tax).
- Supply costs in Parry, Black, and Vernon (2021) consist of port (or hub) prices from IEA (2021) in the case of finished petroleum products, and national prices in the case of

40. Countries were allocated to the importer or exporter grouping based on whether their net trade in crude oil and natural gas liquids since 1991 onward has been positive (exporters) or negative (importers). Positive net trade indicates that the sum of exports over time was larger than the sum of imports.

large natural gas markets (e.g., most European and South and East Asian countries).[41] Liquefied petroleum gas (LPG) is assumed to be priced at a 30 percent discount to gasoline, taking as a reference the difference between gasoline and pretax prices for LPG for unsubsidized European markets, although the price difference might in reality be different across markets, especially in those subsidizing LPG (Kojima 2021). Retail prices and supply costs for coal and natural gas are disaggregated by end-user category—industrial, residential, and power generation—while only an average for the whole economy is provided for the other fuels. More detailed discussion of these data sources can be found in Agnolucci et al. (2023a) and Parry, Black, and Vernon (2021).

Table A.2 summarizes data sources and estimation approaches used for each TCP component.

TABLE A.2

Data for Total Carbon Price Components, Sources, and Approach

Category	Included elements	Data source and approach
Direct carbon pricing instruments	Carbon taxes, emissions trading systems	World Bank, Carbon Pricing Dashboard
Indirect carbon pricing instruments	Energy (fuel) taxes, energy consumption subsidies, VAT deviations	IMF (Parry, Black, and Vernon 2021) Note that energy taxes and energy consumption subsidies have been computed based on variable supply costs and retail prices in the database. Note that VAT deviations have been computed from the economywide and the fuel-specific VAT rates.
Fuels	Coal, diesel, gasoline, kerosene, LPG, and natural gas	IEA 2022b
Sectors	Industrial, power, residential, public administration and services, transport	Energy data set from IEA 2022b
Geography and time period of the total carbon price	142 countries, with observations of between 10 and 32 years per jurisdiction	*Collated by* matching the databases from the World Bank Carbon Pricing Dashboard; Parry, Black, and Vernon (2021); and IEA (2022b)

Source: Original table for this publication.
Note: LPG = liquefied petroleum gas; VAT = value added tax.

The best-available international data sets used for the analysis incorporate a number of simplifications required to abstract from the underlying complexity of local energy markets. The data sets do not include spatially specific price and cost data for any of the fuels analyzed in this study, thus do not accurately reflect variations in the price of the same fuel across administrative units and locations of a country. As an example, LPG prices are known to vary considerably within a country because of variations in the size of the

41. Countries for which domestic prices were not available were mapped to a specific regional hub price (either the Henry Hub in the United States, the Netherlands Title Transfer Facility, or Northeast Asian LNG). In the case of liquefied natural gas exporters without well-functioning domestic natural gas markets, a country-specific liquefaction and shipping fee was deducted to net-back prices from delivery abroad (Parry, Black, and Vernon 2021).

cylinders, local market conditions, and local delivery arrangements (Kojima 2021).[42] Similarly, no spatially specific VAT rates are taken into account, given data constraints and in order to keep the multicountry analysis simplified, even though in reality the same fuel can be subject to different rates across administrative units and locations within a country. This is particularly relevant for countries with federal structures where VAT rates can vary considerably across constituent units, and it is advisable for any analysis focusing on a specific country to use spatially specific VAT data, where available, to properly assess intracountry variations. Transport, shipping, and distribution costs are included in the data sets, but only as fixed mark-ups, in the range of US$0.15–US$0.22 per liter, based on the average of unsubsidized OECD countries, with an additional US$0.10 per liter added to landlocked and small-island developing countries. Mark-ups are allowed to be higher for residential users than for industrial power generation (following US EIA [2021] and European Commission [2018]) but do not take into account factors such as market concentration.

A.5. Estimation of Select Total Carbon Price Components

Most elements of the TCP are drawn from global data sets, but others were estimated. As noted earlier, the data set used in this report contains information on 142 countries, observed for a maximum of 31 years, from 1991 to 2021. For the energy subsidy figures used in the TCP estimation, because information on rates of each excise tax, T_{csfjt}, each subsidy, S_{csfkt}, and their coverage, f_{cfjt} and f_{csfkt}, respectively, was not available, for each specific fuel-sector combination, Agnolucci et al. (2023a) and Parry, Black, and Vernon (2021) compute the price gap attributable to indirect taxes net of energy consumption subsidies. This calculation includes upstream carbon pricing instruments applied to fuels, which are reflected in the retail price, and any type of taxation, such as excise taxes, except VAT payments. Following the price-gap approach (Coady et al. 2019; Kosmo 1987; Larsen and Shah 1992), the price-gap is computed as follows:

$$\textit{price gap} = \textit{retail price} - \textit{VAT payment} - \textit{supply cost} - \textit{direct upstream carbon price} \quad \text{(A.3)}$$

A.6. Focus on Net Energy Taxes and Subsidies

To understand the price signal from the combination of instruments, a distinction can be made between sector-fuel combinations with a positive price gap, indicated as net energy taxes, and those with a negative price gap, that is, net energy subsidies. These are net variables given that they are defined as the computed difference between the terms in the right hand side of equation (A.3), which in practice describes the difference between

42. Kojima (2021) notes that selling LPG in small quantities can render the fuel more affordable, in terms of expenditure per purchase, but is costlier for each kilogram sold. That analysis finds that markets with no price controls have settled on cylinders larger than 10 kilograms as the size that strikes the balance between affordability and supply cost.

applicable fuel excise taxes and subsidies; taxes and subsidies are not observed separately, only their combination is contained in the data set used in this study. The term net energy taxes indicate those cases where the retail price net of VAT is higher than the sum of supply costs and direct upstream carbon prices, while the term net energy subsidies indicates the opposite case.

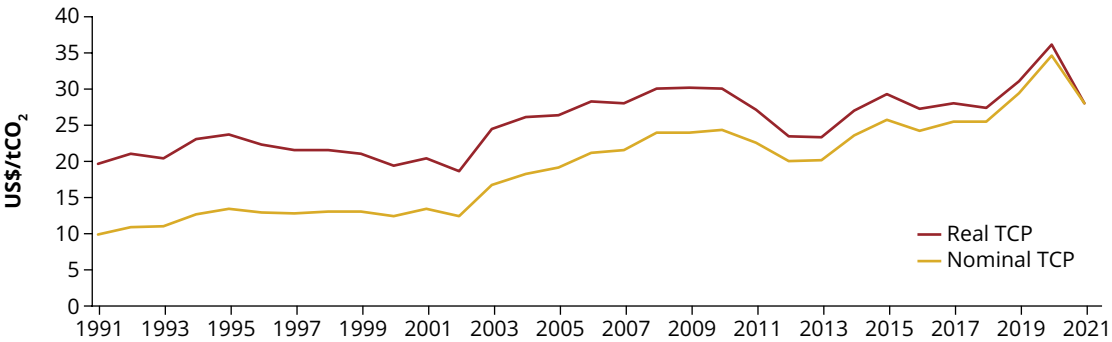
Because rates of the policy instruments incorporated in the TCP are not available at the global level, indirect carbon prices are computed drawing on available data on retail price, supply cost, and VAT rates. The data set in Parry, Black, and Vernon (2021) contains nominal rates for these three variables expressed in US$ obtained using market exchange rates (MER), which have been transformed into real terms by using standard deflators. The impact of the conversion factor (purchasing power parity [PPP] or MER) on the TCP is ambiguous given that both energy taxes and subsidies are affected. In the case of the data set presented in this report, the TCP calculated via PPPs renders lower carbon price signals than the one calculated using MER because PPP amplifies not only carbon prices but also fuel subsidies. More details can be found in section 6 of Agnolucci et al. (2023a).

Appendix B.
Supplemental Analyses and Figures

Figure B.1 charts nominal and real total carbon price (TCP) in purchasing power parity terms, showing the impact of inflation on the value of the TCP across time. When assessing the value of the TCP in real terms it becomes clear that half of the increase of the nominal TCP has simply reflected the increase in the general level of prices.

FIGURE B.1

Nominal versus Real Total Carbon Price

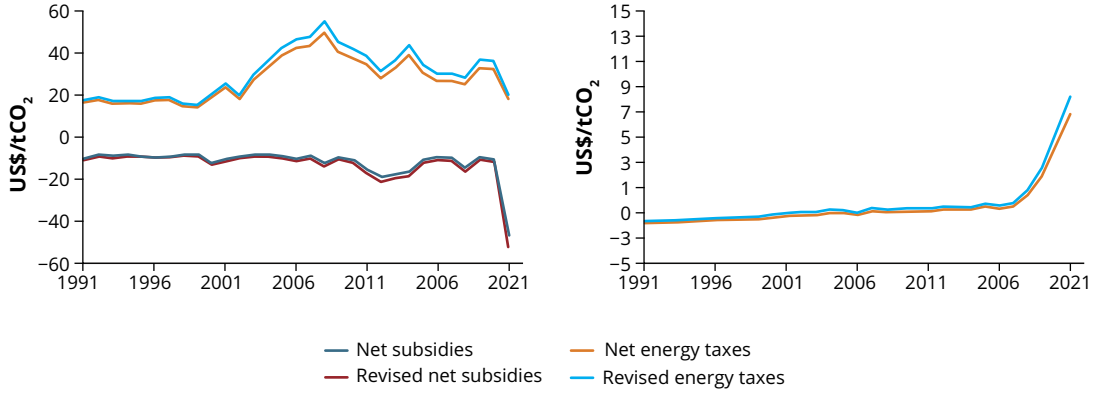


Source: Authors' calculations based on IMF, IEA, and World Bank data sets.
Note: TCP = total carbon price; US$/t$CO_2$ = US dollars per ton of carbon dioxide.

Figure B.2 shows estimates of net energy taxes and subsidies for natural gas and coal, eliminating the data points for which there was uncertainty about subsidy and tax data. For example, this exercise was undertaken for cases in which the subsidy or tax values appeared as zero over multiple years in the data set, and the authors could not verify whether this was due to lack of data or because taxes or subsidies were actually zero. Therefore, the TCP estimates for these two fuels were recalculated by excluding series for which multiple years were "zero." The exclusion of those series does not appear to make a significant difference to overall TCP levels.

FIGURE B.2

Total Carbon Price Estimates for Natural Gas and Coal, Excluding Years with Data Uncertainty

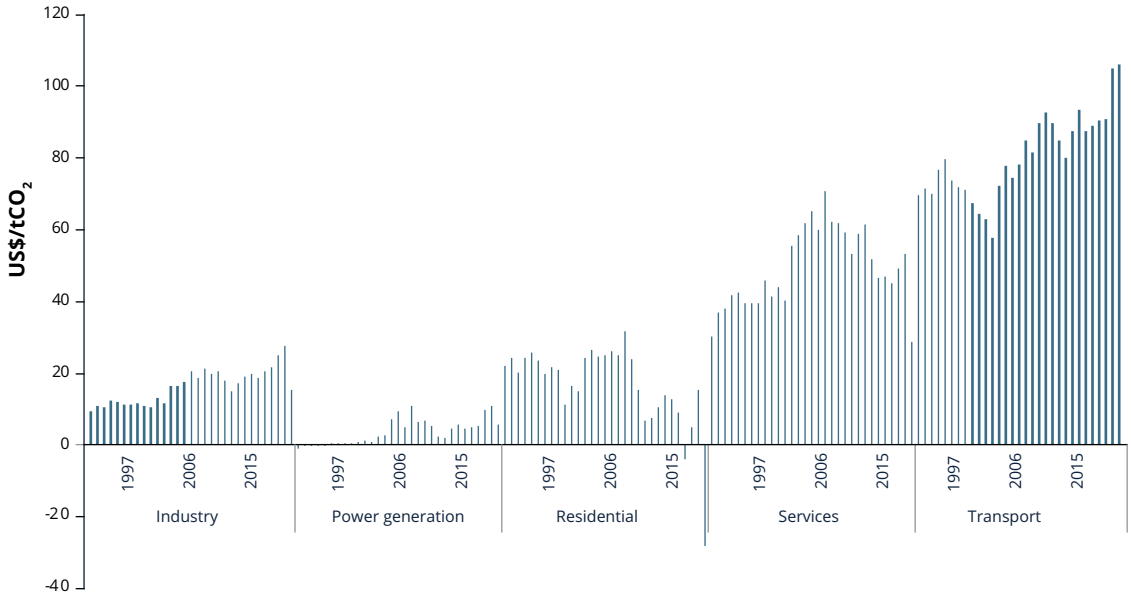


Source: Authors' calculations based on IMF, IEA, and World Bank data sets.
Note: TCP = total carbon price.

Figure B.3 shows the evolution of the estimated TCP by end-use sector over the years.

FIGURE B.3

Evolution of Total Carbon Price across Sectors and Years

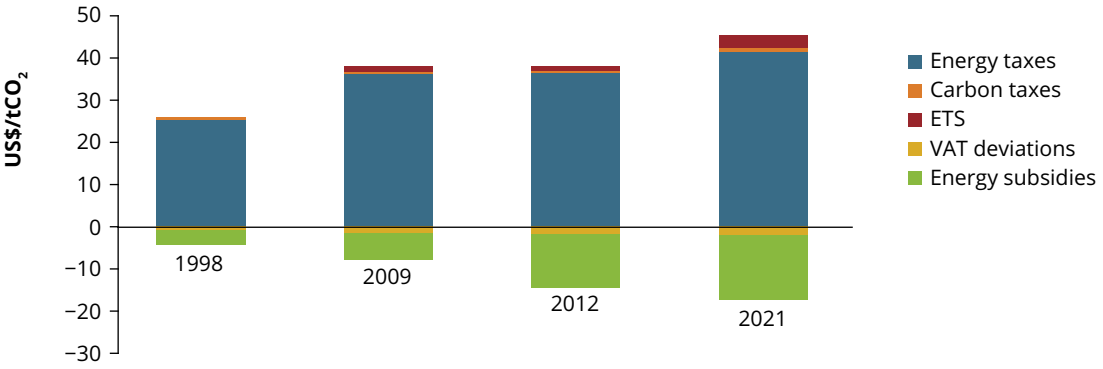


Source: Authors' calculations based on IMF, IEA, and World Bank data sets.
Note: TCP = total carbon price; US$/t$CO_2$ = US dollars per ton of carbon dioxide.

Figure B.4 illustrates the makeup of the TCP in select years with low, moderate, and high energy subsidy estimates.

FIGURE B.4

Total Carbon Price Composition, Select Years



Source: Authors' calculations based on IMF, IEA, and World Bank data sets.
Note: ETS = emissions trading system; TCP = total carbon price; US$/t$CO_2$ = US dollars per ton of carbon dioxide; VAT = value added tax.

Appendix C.
Comparison of Policies, Quantification Approaches, and Metrics

This appendix presents the most common approaches for estimating energy subsidies and compares total carbon price (TCP) results using the price-gap methodology with the OECD (2022) ECR methodology.

C.1. Main Approaches for Quantifying Subsidies

Box C.1 presents the three main approaches applied by key entities for quantification of energy subsidies. Each approach comes with different methodological constraints as well as data and analytical requirements.

BOX C.1

APPROACHES FOR QUANTIFYING ENERGY SUBSIDIES

The most commonly used methods for quantifying subsidies are the price-gap approach and the inventory approach. Kojima and Koplow (2015) argue that these methods are complementary rather than substitutes and should be used together.

Price-Gap Approach. The price-gap approach is the most commonly used methodology for quantifying consumption subsidies and the easiest to implement. It compares average end-user prices to reference prices conveying the full cost of supply, that is, prices that would have prevailed in a competitive market. The subsidy is quantified as the amount by which the end-user price falls short of the reference price. [Subsidy = (Reference price − End-user price) × Units consumed] These calculations are sensitive to reference prices, which are based on international prices, or when not available (e.g., in the case of electricity), they are derived from average-cost pricing. Only subsidies affecting end-user prices are included in this methodology. This approach is used by the IEA for estimation of consumption subsidies.

Inventory Approach. The inventory approach used by the OECD is a bottom-up method of estimating government support to fossil fuels by identifying and quantifying individual policy measures. This approach measures fossil fuel support as well as direct budgetary transfers and tax expenditures that provide a benefit or preference for fossil fuel production or consumption. This approach follows the subsidy definition in the Agreement on Subsidies and Countervailing Measures under the World Trade Organization. The OECD's broad definition of support, as opposed to subsidy, was adopted in 2019 to track and measure Sustainable Development Goal 12.c.1 on fossil fuel subsidies.

Another approach is the **Pre- and Post-Tax Approach**, which is applied by the IMF. Pretax subsidies, estimated primarily based on the price-gap approach, occur when end users pay prices—either an international price or the local supply price—that are below the costs incurred to supply energy. On the other hand, tax subsidies exist when energy is taxed below the expected level, that is, differently from any other consumer products (e.g., reduced VAT rate) or if the retail prices do not reflect externalities arising from energy consumption and production. Posttax subsidies are calculated as the sum of pretax and tax subsidies.

C.2. Comparison of TCP and OECD ECR Methodology

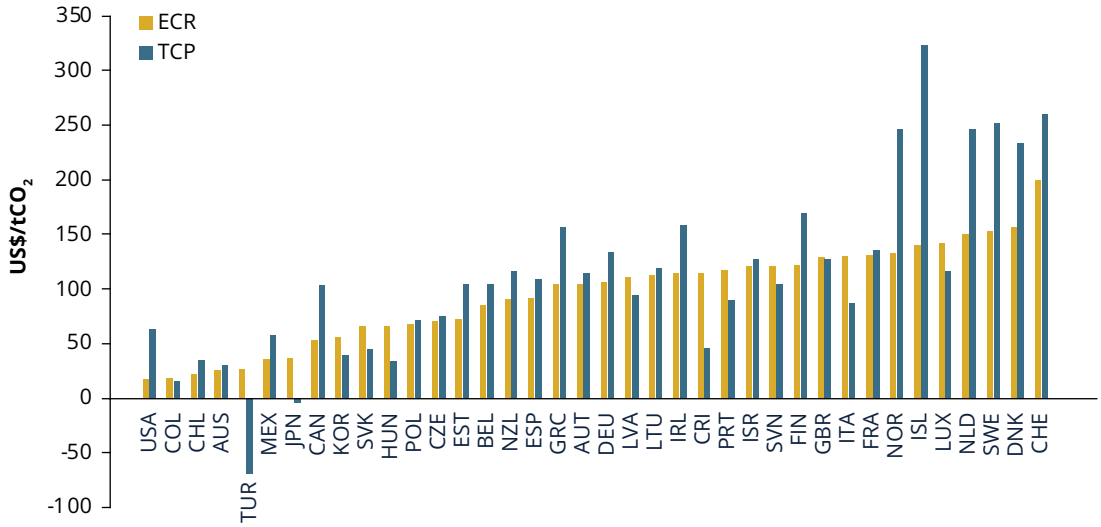
This section provides a brief comparison of the TCP approach with the ECR approach, as elaborated in OECD (2022).

Although the concepts are consistent in their underlying recognition of the importance of understanding the interaction of different climate policy instruments, the ECR and TCP concepts have slight differences. The OECD's ECR study covers a narrower set of countries, given that it relies on resource-intensive desk reviews of fuel excise taxes and consumption subsidies. The results of the two methodologies seem generally well aligned for OECD countries (figure C.1). In some cases, the TCP seems to overstate the contribution of indirect carbon pricing relative to the values obtained in OECD (2022). On the other hand, the TCP estimates are well below the ECR in some countries—especially those that are in lower income levels. For non-OECD countries, the signs of the TCP and the ECR tend to be the same, but the levels are highly variable. A concerted and coordinated data-collection effort using comparable methodologies would be valuable for consistent comparisons across a wide range of countries and for improving the calibration and use of price-gap methods.

FIGURE C.1.

Comparison of the Net Effective Carbon Rate and the Total Carbon Price

a. OECD Countries



b. Non-OECD Countries

Source: Agnolucci et al. 2023.
Note: ECR = effective carbon rate; OECD = Organisation for Economic Co-operation and Development; TCP = total carbon price; US$/t$CO_2$ = US dollars per ton of carbon dioxide.

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