Effective Carbon Rates on Energy Use in Latin America and the Caribbean: Estimates and Directions for Reform

Institutions for Development Sector

Fiscal Management Division

TECHNICAL NOTE Nº IDB-TN-2656

Hildegart Ahumada
Santos Espina Mairal
Fernando Navajas
Alejandro Rasteletti

March 2023

Effective Carbon Rates on Energy Use in Latin America and the Caribbean: Estimates and Directions for Reform

Hildegart Ahumada
Santos Espina Mairal
Fernando Navajas
Alejandro Rasteletti

March 2023

Cataloging-in-Publication data provided by the Inter-American Development Bank
Felipe Herrera Library

Effective carbon rates on energy use in Latin America and the Caribbean: estimates and directions of reform / Hildegart Ahumada, Santos Espina Mairal, Fernando Navajas, Alejandro Rasteletti.
p. cm. — (IDB Technical Note ; 2656)
Includes bibliographic references.
1. Carbon taxes-Latin America. 2. Carbon taxes-Caribbean Area. 3. Energy policy-Latin America. 4. Energy policy-Caribbean Area. 5. Carbon dioxide mitigation-Economic aspects-Latin America. 6. Carbon dioxide mitigation-Economic aspects-Caribbean Area. 7. Energy tax-Latin America. 8. Energy tax-Caribbean Area. I. Ahumada, Hildegart. II. Espina Mairal, Santos. III. Navajas, Fernando. IV. Rasteletti, Alejandro. V. Inter-American Development Bank. Fiscal Management Division. VI. Series.
IDB-TN-2656

http://www.iadb.org

Abstract*

This paper estimates effective carbon rates (ECRs) on carbon dioxide (CO_2) emissions from energy use for 18 Latin American and Caribbean (LAC) countries. We follow a methodology developed by the Organisation for Economic Co-operation and Development (OECD) as this allows us to compare ECR estimates for LAC countries with those for other countries in other regions. We also adapt the OECD methodology to assess the effect of energy subsidies on ECRs. The results obtained indicate that ECRs were low in LAC countries in 2018. On average, LAC countries priced carbon emissions from energy use at 24 euros per tonne of CO_2 equivalent (EUR/tCO_2e) emissions, while the average pricing in OECD countries was 41 EUR/tCO_2e. When considering energy subsidies, the average ECR in LAC falls to 17 EUR/tCO_2e. The difference in average carbon pricing observed between LAC and the OECD is, for the most part, explained by lower excise taxes in LAC and, to a lesser extent, to few LAC countries having carbon taxes and the lack of tradable carbon emission permit mechanisms. We also find a large heterogeneity of ECRs across LAC countries as well as across sectors within countries. ECRs are the highest in Costa Rica and the lowest in Ecuador. At the sector level, ECRs are on average the highest in the road transport sector and the lowest in the electricity sector and in the residential and commercial energy use sector. These differences stem mostly from the different taxation of the different energy products. The ECR estimates suggest that countries willing to introduce carbon pricing reforms must pay particular attention to reducing fuel energy subsidies and to increasing ECRs in sectors other than road transport, as these sectors constitute a large share of carbon emissions and are virtually untaxed.

Keywords: carbon pricing, effective carbon rates, energy taxation

JEL Codes: H23, Q54, Q58

* The authors thank Marco Buttazzoni for his comments during the final revision of this paper. Previous versions were presented at the 23rd Global Conference on Environmental Taxation (GCET), September 2022, University of Parma, Italy, and the 8th ELAEE/IAEE Energy Transition in Latin America meeting, November 2022, University TADEO, Bogota, Colombia. We are thankful for useful comments from Mikael Skou Andersen, Peter Hartley, Ricardo Rainieri, and participants in both meetings.

1. Introduction

The main objective of this paper is to assess the state of carbon pricing in Latin America and the Caribbean (LAC) by estimating effective carbon rates (ECRs) on carbon dioxide (CO_2) emissions from energy use in 2018. Carbon pricing policies are considered by some an essential climate change mitigation policy because they increase the price of carbon-based energy and create incentives to reducing carbon dioxide emissions. These reductions in emissions are achieved through different mechanisms, such as substitution with less carbon-intensive forms of energy, investments in cleaner energy, and development of low-emission goods and services. For these reasons, the Inter-American Development Bank (IDB), the Organisation for Economic Co-operation and Development (OECD), the International Monetary Fund (IMF), the European Commission, the World Bank, and the Inter-American Center of Tax Administrations (CIAT) have stated that while pricing CO_2 emissions alone may not be sufficient to address climate change, it is an essential part of the solution (International Tax Dialogue, 2015).

This paper calculates ECRs in 2018 for 18 LAC countries, thus is the most comprehensive study to date on this topic for the region. ECRs are usually defined as the total price that applies to carbon emissions as a result of market-based instruments, and they are considered a measure of carbon pricing. Measuring ECRs is not a straightforward task as tax rates on energy use vary substantially across energy products and the uses of those products. Therefore, a methodology is required to consistently analyze the different sources of emissions and their treatment by the different market-based instruments. The methodology used to calculate ECRs for LAC countries follows closely one developed by the OECD (see OECD, 2016, 2018, 2021a). The market-based instruments considered by this methodology are specific fuel taxes, carbon taxes, and carbon emission permit prices. ECRs are estimated at an economywide level as well as for different sectors of an economy.[1] Having sectoral ECRs allows one to identify different pricing treatments of carbon emissions across sectors and energy products, which is an important input for producing recommendations on carbon pricing reforms, another goal of this paper.

One issue with the original OECD methodology for calculating ECRs and which motivated this paper is that the original OECD methodology did not consider the

[1] The sectors considered by the OECD methodology are road transport, off-road transport, industry, agriculture and fishing, residential and commercial energy use, and electricity.

effect of energy subsidies while calculating carbon pricing. Energy subsidies operate as negative taxes on carbon emissions as they reduce effective prices of energy products. Therefore, not considering energy subsidies leads to an overestimation of ECRs, which might be important as fuel subsidies have remained significant on a global level (Coady et al, 2019; Parry et al, 2021). Furthermore, energy subsidies are larger in LAC countries when compared to OECD countries (FIEL, 2020). Conte Grand, Rasteletti, and Muñoz (2022) find that fuel subsidies reached an average of 1 percent of GDP in 2018 in LAC countries, while they reached 0.6 percent of GDP in OECD countries. FIEL (2020) finds energy subsidies were larger on electricity in LAC countries than in European countries. Thus, this paper presents LAC data for 18 countries and a methodology to include energy subsidies in the calculations of the economywide ECRs. Very recently, and after this paper was completed, the OECD (2022) started to include ECRs adjusted for subsidies for a sample of 71 countries, including 13 LAC countries. The OECD (2022) methodology uses criteria similar to the one adopted for this paper to incorporate fuel energy subsidies but is different regarding the treatment of electricity subsidies. Whereas this paper considers the fuel energy content of electricity generation for the adjustment of ECRs, the OECD (2022) data does not include this effect on adjusted ECRs and instead separates electricity subsidies per energy content (measured in gigajoules, or GJ). This paper follows the original OECD (2018, 2021a) methodology regarding the treatment of electricity taxes but departs in the treatment of fossil fuels used to generate electricity.

Even though carbon pricing can be an effective tool to reduce carbon emissions,[2] to achieve reductions that are consistent with climate change objectives, carbon pricing instruments need to be applied on a large scale and at relatively high levels. There have been several discussions in the literature about what level of ECR should be appropriate. Traditionally, carbon prices were calculated related to the marginal damage produced by carbon emissions (Nordhaus, 2014). More recently, some studies have estimated the desired carbon prices based on the achievement of Paris Agreement goals (CPLC, 2019) or on reaching net-zero emissions (Kaufman et al, 2020). Several institutions have produced benchmark references. For instance, the High-Level Commission on

[2] Sen and Vollebergh (2018); Martin, Muûls, and Wagner (2016); and OECD (2021a) report evidence that higher ECRs reduce energy consumption and carbon emissions. Ahumada et al (2022) also find suggestive evidence that higher ECRs reduce carbon emissions. Their results imply that, at mean values, a country with an ECR 10 percent higher than others has 3.6 percent lower emissions.

Carbon Prices (CPLC, 2019) estimated that carbon prices between 40 and 80 euros per tonne of carbon dioxide equivalent (EUR/tCO_2e) were needed in 2020 for countries to achieve decarbonization goals that are in line with Paris Agreement goals. Meanwhile, the IMF recommended having carbon prices of 75 EUR/tCO_2e up to and including 2030 to support development of clean technology (IMF, 2019). However, rather than having a single ECR benchmark, the latest OECD report on ECRs (OECD, 2021a) references three benchmarks: 30 EUR/tCO_2e, 60 EUR/tCO_2e, and 120 EUR/tCO_2e. The 30 EUR/tCO_2e price is considered a low-end benchmark and one that could encourage agents to *start* abatement efforts. The 60 EUR/tCO_2e price is considered a mid-range benchmark of what carbon costs should be in 2020 and a low-end benchmark for the year 2030.[3] Finally, the 120 EUR/tCO_2e price is a more forward-looking estimate, presenting a conservative estimate of what carbon costs will be in 2030. This study uses these benchmarks produced by the OECD to assess carbon pricing gaps in LAC countries.

The ECR estimates presented in this document indicate that most LAC countries price carbon emissions at rates that are much lower than the benchmarks recommended by the OECD. The average ECR for the 18 LAC countries considered is 24 EUR/tCO_2e when the standard methodology is used. Once results are adjusted to consider energy subsidies, the average ECR drops to 17 EUR/tCO_2e. Only Costa Rica is an exception in the LAC region, with an ECR rate of 76 EUR/tCO_2e, more than three times the regional average. Besides Costa Rica, only two other countries (Jamaica and Uruguay) have ECRs above the low-end benchmark of 30 EUR/tCO_2e. In most LAC countries, excise taxes are the only market-based instrument increasing the price of carbon emissions, so differences in carbon pricing are, for the most part, explained by differences in excise taxes. In 2018, carbon taxes were present in four LAC countries,[4] and no country had a system of tradable permits for carbon emissions.[5]

The analysis of sector-level ECRs reveals a considerable heterogeneity of carbon prices across sectors. This is mostly resulting from the differential taxation of different energy products as well as from preferential tax treatments of some

[3] As carbon costs reflect the marginal damage caused by carbon emissions, benchmarks rise over time as more accumulation of carbon in the atmosphere increases the cost of new emissions.
[4] Uruguay introduced a carbon tax in 2022. This carbon tax is not considered in this paper as ECR estimations are for the year 2018.
[5] Mexico started operating a pilot emission trading system in 2020, which is intended to run for three years to test the system design. Chile and Colombia are currently studying introducing an emission trading system for the electricity sector.

sectors. Only the road transport sector faces carbon price signals, with emissions priced at 71 EUR/tCO_2e on average. This higher carbon pricing in this sector is mostly derived from the higher taxes on gasoline. In the remaining sectors considered, emissions are priced on average at 12 EUR/tCO_2e, despite being responsible for a larger share of emissions. Additionally, analysis of ECRs indicate that, on average, 58 percent of emissions of a given LAC country are entirely unpriced. These untaxed emissions usually originated in the electricity sector and the residential and commercial energy use sector. Also only 26 percent of emissions are priced above the 30 EUR/tCO_2e benchmark. Most of these emissions stem from the road transport sector.

The estimates obtained suggest several possible directions for reform that countries could follow if they are willing to increase the relevance of carbon pricing policies in their strategies to combat climate change. Reforming already existing policy instruments could significantly increase carbon pricing. For those countries with large energy subsidies, a priority should be defining strategies to reduce those subsidies in the short or medium term. This is more important in the case of fuel subsidies than in the case of electricity subsidies, as the latter do not imply more emissions except where fossil fuels are used to generate electricity. Also, most countries should prioritize increasing effective taxation on sectors other than the road transport sector. To achieve this goal, excise taxes could be reformed (i) to eliminate preferential treatments to some sectors, and (ii) to better align taxation of energy products with their carbon content and other externalities from their consumption. Reforming the taxation of biofuels is also important. The design of these reforms should consider (i) the structure of energy use in terms of products and consumption by sector, and the feasibility of substituting other energy products; (ii) the distributional effects of existing energy taxes and subsidies; and (iii) the economic and social impacts of sectoral preferential treatments. Countries could also start introducing new policy instruments (such as carbon taxes and tradable carbon emission permit systems), but the desirability of introducing these new instruments depends on the governments' institutional capacities as well as the countries' socioeconomic characteristics.

This paper has six sections, including this Introduction. Section 2 discusses the OECD methodology and the data used to implement it in the LAC countries considered. Section 3 presents the results obtained from using the OECD methodology and discusses the differences in ECRs across LAC countries as well as the heterogenous treatments of sectors and energy products. Section 4 extends the OECD methodology to consider energy subsidies and shows their effects on the economywide ECR estimates, thus adjusts ECRs for energy subsidies. Section 5 discusses directions for carbon pricing reform suggested by results obtained in previous sections. Finally, Section 6 presents the main conclusions of the document.

2. Methodology and Data

2.1. Methodology

This paper follows a methodology developed by the OECD (OECD, 2016, 2018, 2021a) to estimate ECRs on carbon emissions from energy use. The goal of this methodology is to measure the price that applies to carbon emissions because of market-based policy instruments. The ECR is simply defined as the sum of taxes and tradable carbon emission permits that effectively put a price on carbon emissions.[6] The methodology focuses *only* on carbon emissions from energy use, following a combustion approach to energy.[7] There are three market-based policy instruments considered by the OECD methodology, namely: specific taxes on energy use, carbon taxes, and tradable carbon emission permits.[8]

Measuring ECRs is not a straightforward task as tax rates on energy use vary substantially both across energy products and the uses of those products. Therefore, measuring ECRs requires a bottom-up approach, calculating the pricing

---

[6] The ECR estimation by the OECD draws upon its Taxing Energy Use (TEU) approach (OECD, 2019), which measures taxes per GJ in all energy forms including electricity. However, electricity taxes, and by extension subsidies, should not be included in the ECR estimates. This is what OECD (2022) actually does by separating electricity subsidies adjustments from the ECR estimates (expressed as EUR/tCO_2) and computing them in the metric of TEU (expressed in EUR/GJ). Our methodology departs from that of the OECD by considering the fuel content of electricity generation to estimate the effect of electricity subsidies on the economywide ECR (as fuels used in generation have a clear and quantifiable emission effect). The argument is that subsidies cause more electricity consumption and generation, and emissions arise whenever fuel energy is used in the process. We do not adjust for electricity taxes in a similar fashion because it is not as straightforward as the case of subsidies (where we have precise fiscal data on transfers) and because that would require a definition of excess taxation in electricity, which is more difficult to assess as in some countries the effect may interact with tax expenditures or reduced rates of value-added tax (VAT) that may compensate or give rise to an opposite effect. We prefer to leave this a topic for further research.

[7] The use of a combustion approach to energy implies that life cycle or "footprints" of emissions are not considered. Because of the importance of biofuels in emissions in LAC countries, these were always considered in our calculations and when referencing results from countries other than LAC included in OECD reports.

[8] The OECD methodology does not consider indirect taxes that, in principle, apply to all goods and services, such as sale taxes or the VAT. This approach is adequate in cases where the rate of these taxes does not vary across goods and services, as the uniformity of the tax rate does not affect relative prices. However, governments usually apply differentiated tax rates for certain goods and services, and in several countries, energy products benefit from lower VAT rates. These preferential treatments of energy products in the VAT act as a de facto specific subsidy, reducing ECRs. As the VAT is not included in the OECD methodology, these implicit subsidies are not captured in the ECRs.

of different combinations of energy products and users. In this paper, 66 different energy products are considered, and they are grouped in 8 energy categories, such as gasoline, natural gas, and biofuels.[9] Regarding individual users of the energy products, we consider 30 different types, which are grouped into 6 sectors: (i) road transport, (ii) other forms of transport (i.e., off-road transport), (iii) industry, (iv) agriculture and fishing, (v) residential and commercial use of energy, and (vi) electricity. Obtaining the pricing of all combinations of energy products and users requires a detailed review of the tax legislation to identify the types of emissions that are subject to taxation and the tax rates that apply to them. Reviewing tradable carbon emissions permit systems is not required in the case of LAC countries as these systems do not exist in the region.

Another difficulty that emerges when measuring ECRs is that taxes on energy products are usually not expressed in reference to carbon content of these products, which is directly related to carbon emissions from these products. Instead, tax rates are usually expressed in terms of physical units (e.g., liters, cubic meters), or in terms of energy content (e.g., kilowatt-hour, or terajoule, expressed as TJ). Therefore, converting tax rates from these units into units related to the carbon emissions is required. Fortunately, these conversions can be easily done, as there is a proportional relationship between the combustion of the energy products considered in this study and carbon emissions. This implies that specific conversion factors can be used to re-express tax rates for the different energy products in terms of rates for the equivalent of one tonne of carbon dioxide emissions (tCO_2e). Finally, as tax rates for a given country are expressed in local currency, the tax rates need to be converted into a single currency to be able to compare them across countries. We use euros (EUR) as the common currency to facilitate comparisons with the different OECD estimates for other countries of the world. Thus the ECRs are expressed as euros per tonne of CO_2 equivalent (EUR/tCO_2e) emissions.

Once the ECRs are calculated at the level of energy products and users with a common unit of measure, the results can be aggregated according to energy category or the sectors, as well as at the economywide level. These aggregations are done by calculating a weighted average of ECRs. The weights used are the shares of total emissions explained by the consumption of the different energy products and by the different users.

[9] The eight broad energy categories are: (i) coal and other solid fossil fuels, (ii) fuel oil, (iii) diesel, (iv) kerosene, (v) gasoline, (vi) liquefied petroleum gas or LPG, (vii) natural gas, and (viii) biofuels.

An important final remark on the methodology discussed above is that it disregards explicit subsidies on energy consumption, which leads to overestimating ECRs. This overestimation might be important if countries provide large subsidies on the consumption of energy products, which is the case in many LAC countries. To incorporate these subsidies while calculating ECRs, we propose an extension of the OECD methodology. We discuss this extension in Section 4 of the paper and present the details of the methodology in Appendix III.

2.2. Implementation of the Methodology

Implementing the methodology discussed above requires having information on: (i) tax rates on energy products, (ii) preferential tax treatments for certain users, (iii) consumption of energy products by consumer types, (iv) emission factors of the different energy products, and (v) exchange rates for local currencies. There is no need to collect information on the characteristics of tradable carbon emission permit systems as no such mechanism existed in a LAC country in the year used in the estimations.

To obtain all the relevant information related to taxes, tax codes that were in place in 2018 in all the different countries included in this study were analyzed. The focus on 2018 is because the data on energy consumption comes from that year. For excise taxes, the tax laws of the 18 LAC countries included in this study were analyzed, as all countries in the sample had this type of taxes on energy products. Regarding carbon taxes, these were reviewed for the four LAC countries that had a carbon tax in 2018 (Argentina, Chile, Colombia, and Mexico).[10] The tax information compiled for these reviews relates both to product-specific tax rates and sectoral preferential treatments.

Regarding consumption of the different energy products, the information used comes from the International Energy Agency (IEA, 2021), which produced an extensive database of energy balances known as Extended World Energy Balances. This database homogenizes the use of energy in common units (e.g., TJ) for different sectors.[11] For emission factors by fuel type, the information used comes

[10] The Mexican state of Zacatecas had a carbon tax in place in 2018. We do not consider this tax as the database on energy consumption does not allow us to analyze energy use at a regional level. This should not affect results significantly as Zacatecas is a relatively small state, and the carbon tax in place had a relatively low rate.

[11] Following the OECD (2019b) methodology, the electricity sector was defined as where the primary energy use occurs in electricity generation (e.g., including transformation and distribution losses). Non-energy use of fuels was not considered. Energy use not assigned to a particular sector (e.g., non-

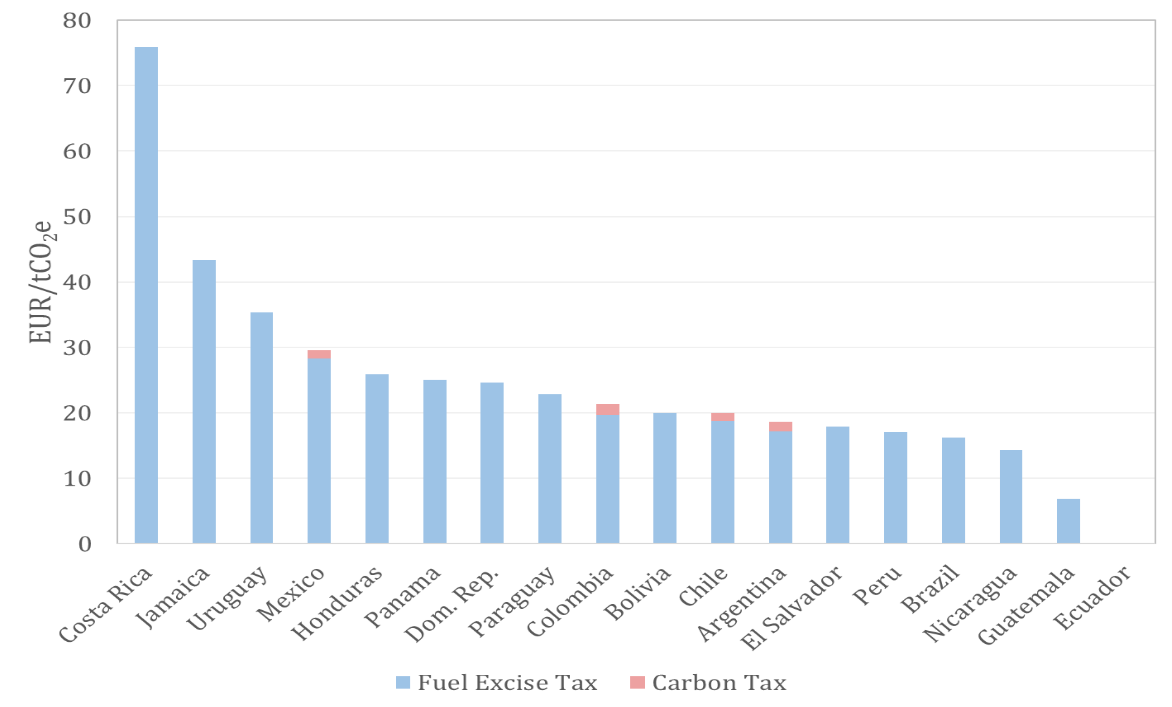
from the United States Environmental Protection Agency (EPA, 2018). Missing data was completed with information from the United States Energy Information Administration (EIA) and the Intergovernmental Panel on Climate Change Emission Factor Database (IPCC). These emission factors were used to convert energy consumption into carbon emissions. Finally, to convert tax rates into a common currency (euros), 2018 exchange rates from the World Bank were used (World Bank).

3. Effective Carbon Rates in Latin America and the Caribbean: Levels, Structures, Stylized Facts

At an aggregate level, ECR estimates indicate that most LAC countries have low ECRs on energy use (see Figure 1). In 2018, the regional average for ECRs was 24.17 EUR/tCO_2e, which is low compared to the 41.03 EUR/tCO_2e average in OECD countries. Most LAC countries had an ECR below the threshold of 30 EUR/tCO_2e, which is the low-end benchmark used by the OECD. Costa Rica appears as an outlier in the region, with an ECR of almost 76 EUR/tCO_2e, ranking only second to Luxembourg when also considering the ECRs of countries studied by the OECD (see Figure A1 in Appendix 1). Another outlier, but on the opposite end, is Ecuador. It has a zero ECR according to the OECD methodology, as it places neither excises nor carbon taxes on fossil fuels.

specified use in the Extended World Energy Balances or EWEB database) was not included, with the exception of the electricity sector, where energy is assigned on a primary-use criteria. The industry sector includes electricity generated in auto producer plants.

Figure 1: Effective Carbon Rates in Latin America and the Caribbean, 2018

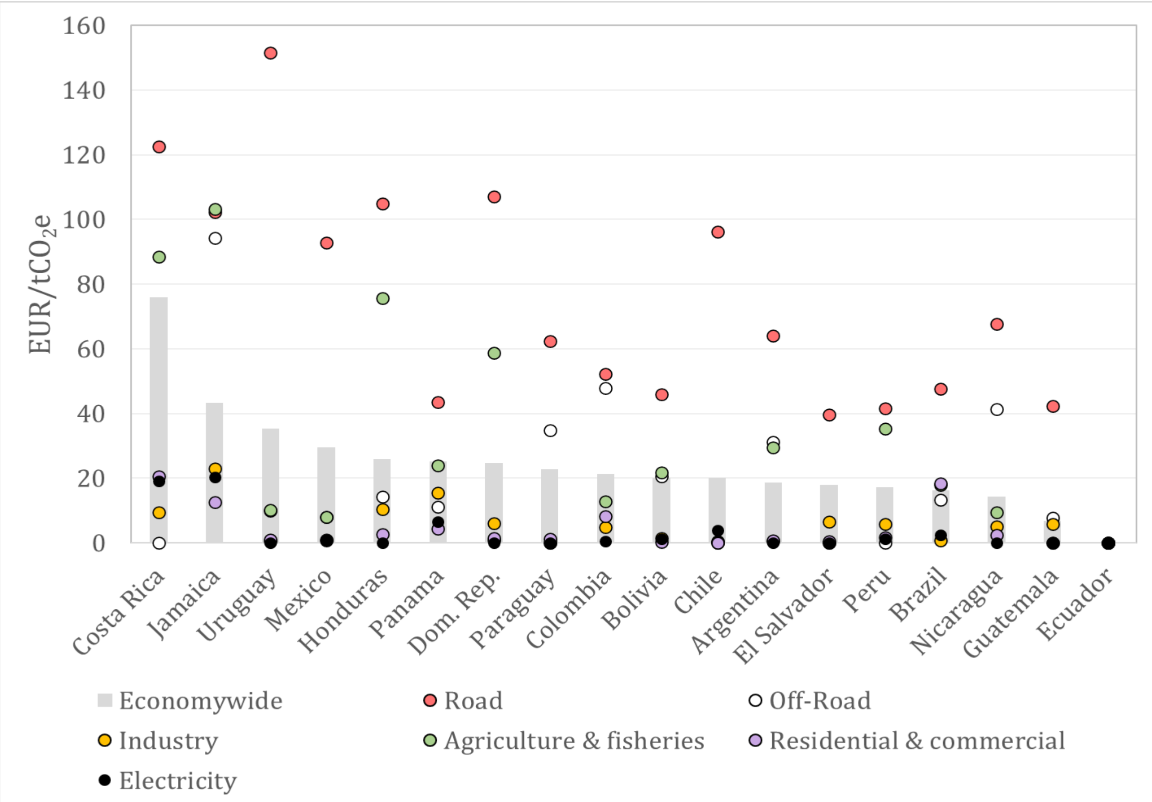


Source: Authors' estimations.

In LAC countries almost all ECRs are explained by excise taxes (Figure 1). On average, excise taxes account for 98 percent of the ECR of a given LAC country, while carbon taxes account for the remaining 2 percent. This proportion contrasts with that of OECD countries, where excise taxes accounted for 84 percent on average, tradable carbon emission permit systems accounted for 9 percent, and carbon taxes accounted for 7 percent of ECR (OECD, 2022). The minimal proportion of carbon taxes in ECRs in LAC is not only due to the fact that four countries had a carbon tax in place, but also due to the low pricing they impose. The average carbon tax rate in the four LAC countries was only 2 EUR/tCO_2e in 2018.

At the sectoral level, analysis of ECRs demonstrates an important heterogeneity in the way carbon emissions are taxed across sectors. Figure 2 presents the ECRs across the economies of LAC countries and for the six sectors considered. Emissions from the road transport sector are priced at a much higher rate than those from the other sectors. While the average ECR in the road sector is 71 EUR/tCO_2e, it is only 28 EUR/tCO_2 in the agriculture and fisheries sector, the second-highest average sectoral ECR (see Figure 3). The two sectors facing the lowest average sectoral ECRs are the residential and commercial energy use sector, and the electricity sector, which have average ECRs of 4 EUR/tCO_2e and 3 EUR/tCO_2e, respectively. Residential and commercial use is untaxed in 2 countries of the sample of 18 LAC countries, while electricity is untaxed in 7 countries. On average, 58 percent of emissions of a given LAC country are entirely untaxed. The asymmetry in the taxation across sectors is not exclusive to the LAC region, as it is also observed in OECD (see Figure A2 in Appendix 1). However, OECD countries tend to tax non-road sectors at higher rates, which results in a lower intersectoral dispersion of ECRs in the OECD compared with in LAC.

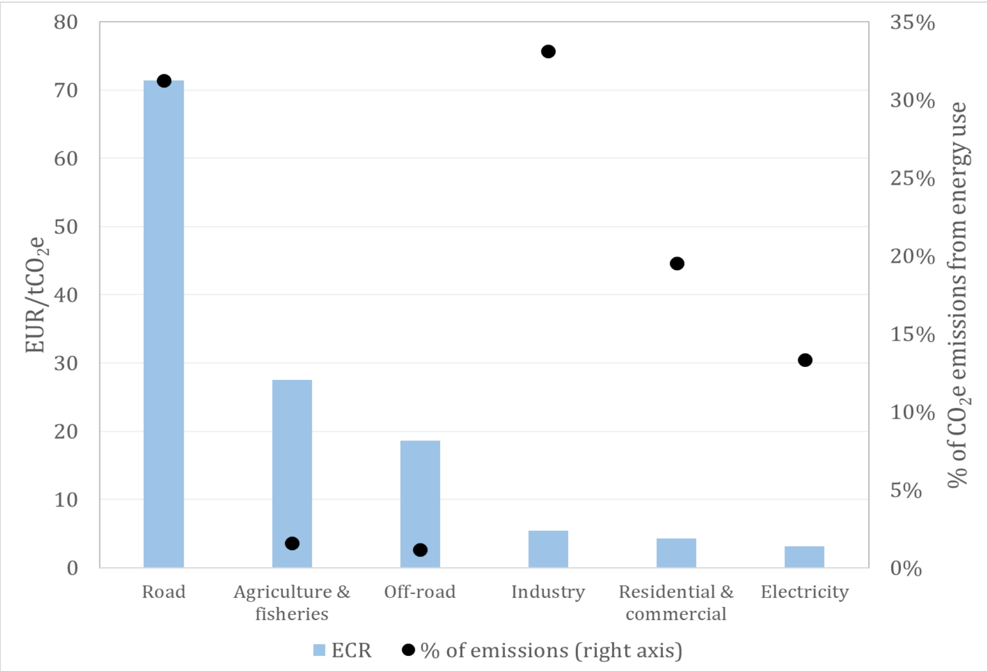
Figure 2: Effective Carbon Rates in Latin America and the Caribbean, by Country and Sector, 2018



Source: Authors' estimations.

Another important finding is that most sectors present ECRs below the low-end OECD benchmark of 30 EUR/tCO_2e despite those sectors accounting for large shares of emissions (see Figure 3). In fact, only 26 percent of emissions from energy use are priced above the 30 EUR/tCO_2e benchmark (see Figure A3 in Appendix I for country detail). This contrasts with what is observed in the road transport sector, where most countries have an ECR above the mid-range benchmark of 60 EUR/tCO_2e, with Uruguay and Costa Rica even surpassing the 120 EUR/tCO_2e benchmark. The fact that the road transport sector is taxed much more heavily than other sectors is mostly explained by the fact that excise taxes had origins quite different from environmental objectives. Taxation of fuels used in transport played a major role in providing fiscal revenues and financing sources of transport infrastructure, as discussed in Ahumada et al. (2022).

Figure 3: Average Effective Carbon Rates in Latin America and the Caribbean, and Contribution to Emissions from Energy Use, by Sector, 2018

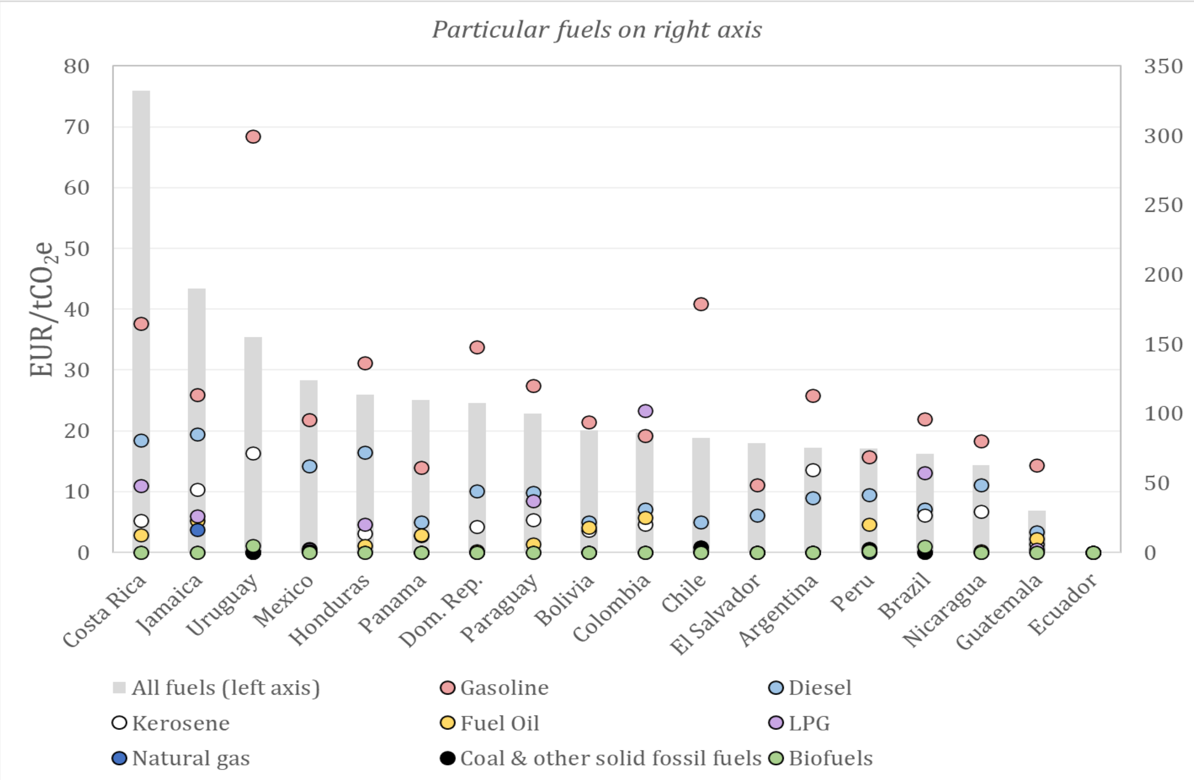


Source: Authors' estimatations.

Interestingly, most of the intersectoral heterogeneity regarding carbon pricing does not seem to be mostly a consequence of sector-specific special tax treatments, such as exemptions, rebates, or refunds, as discussed in Appendix II (see Figure A5). On average, these preferential treatments reduce ECR by merely 2 EUR/tCO_2e for a given country. Instead, dispersion of ECRs across sectors is best explained by examining the fuels used more (or less) in different sectors and their ECRs. Differences in ECRs across fuels translate into differences in ECRs across sectors. Figure 4 shows that gasoline and diesel have comparatively high ECRs in comparison with other fossil fuels. These higher ECRs by fuel then translate into a high ECR for the road transport sector (see Figure 3).

ECRs on kerosene, fuel oil, and LPG vary substantially by country but tend to rank after gasoline and diesel. On the other hand, coal and other solid fossil fuels in general, as well as biofuels and natural gas, tend to be almost untaxed. At the level of policy instruments (thus considering three instruments previously noted: excise taxes, carbon taxes, and emission trading systems) the dispersion of ECRs across fuels is mostly due to excise taxes, which represent the large majority of ECRs. However, it is worth mentioning that carbon taxes present in the region demonstrate heterogeneous treatments of fuels, as countries exempt different fuels from the carbon tax (see Figure A4 in Appendix I). For instance, Chile is unique in placing a carbon tax uniquely on natural gas and coal, while Argentina places its carbon tax on gasoline, diesel, and kerosene.

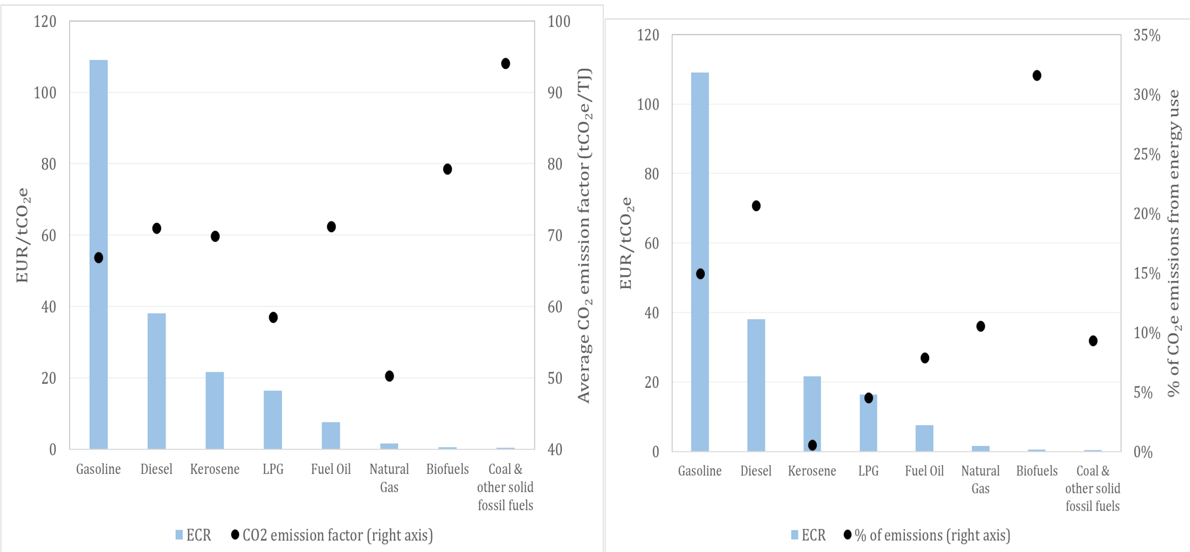
Figure 4: Effective Carbon Rates in Latin America and the Caribbean, by Country and Fuel



Source: Authors' estimations.

Another important finding worth highlighting is that the ECRs for the LAC region applied to the different fuels does not reflect the order of fuels in terms carbon content, and nor does it reflect the fuels' contributions to carbon emissions of the country. Fuels with larger carbon content than gasoline, such as coal or diesel, have lower ECRs, showing a misalignment from an environmental perspective.[12] Similarly, fossil fuels other than gasoline and diesel that result in significant shares of carbon emissions are virtually untaxed, implying that tax rates have not prioritized taxing based on emission levels.

Figure 5: Effective Carbon Rates in Latin America and the Caribbean, Emission Factors, and Contribution to Emissions by Fuels



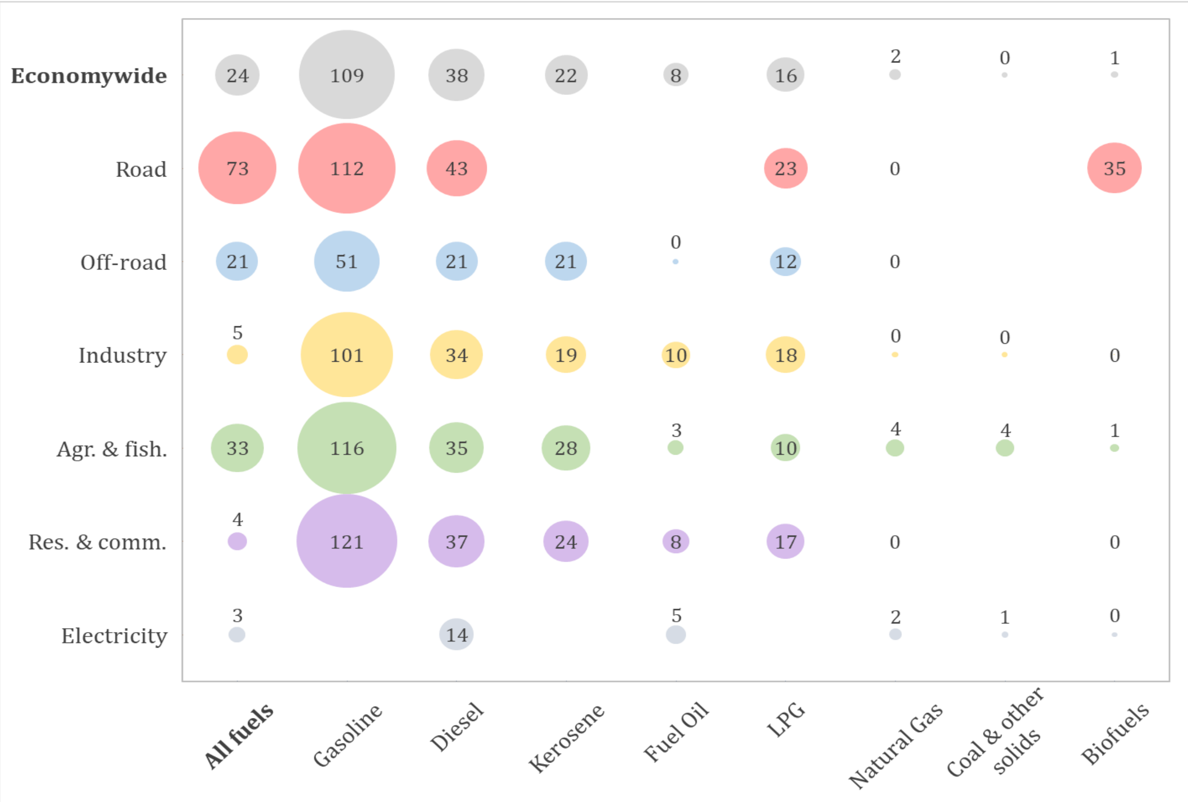
Source: Authors' estimations.

Finally, as ECRs on energy products vary across sectors due to preferential treatments by sector, the analysis above can be extended by computing ECRs that are specific to the different combinations of sectors and energy products. The results obtained from computing ECRs by specific product and sector ECR show that there is a large heterogeneity of carbon pricing across sectors for the same fuel (see Figure 6). Two sectors that appear to benefit the most from preferential

[12] Optimal taxation of fuels implies that tax rates on fuel should not be uniquely linked to their carbon content because other externalities beyond climate change exist, as well as other economic distortions. For instance, different fuels can cause different local externalities, they can have different complementary or substitutability with untaxed goods, and their taxation can have different distributional effects. For a recent review of factors determining the optimal taxation of fuels, see Conte Grand, Rasteletti, and Muñoz (2022). For a broad review of energy taxes within green tax reforms, see Gago, Labandeira, and López-Otero (2014). For a quantitative application of a quasi-optimal tax framework to tax reform exercises related to energy and the environment in Argentina, Bolivia, and Uruguay, see Navajas, Panadeiros, and Natale (2012).

treatments in the region are off-road transport and the electricity sector. The off-road transport sector tends to have fuel-specific ECRs that are about half of those of the road transport sector for their most relevant fuel. Meanwhile, the electricity sector has low tax rates for every fuel category relative to other sectors.

Figure 6: Effective Carbon Rates in Latin America and the Caribbean, by Regional Average, Sector, and Fuel



Source: Authors' estimations.
Notes: ECRs are shown in EUR/tCO_2 e, with regional averages, by sector-fuel combinations. Where ECRs are not shown, this reflects the fact that some fuels are not used in specific sectors.

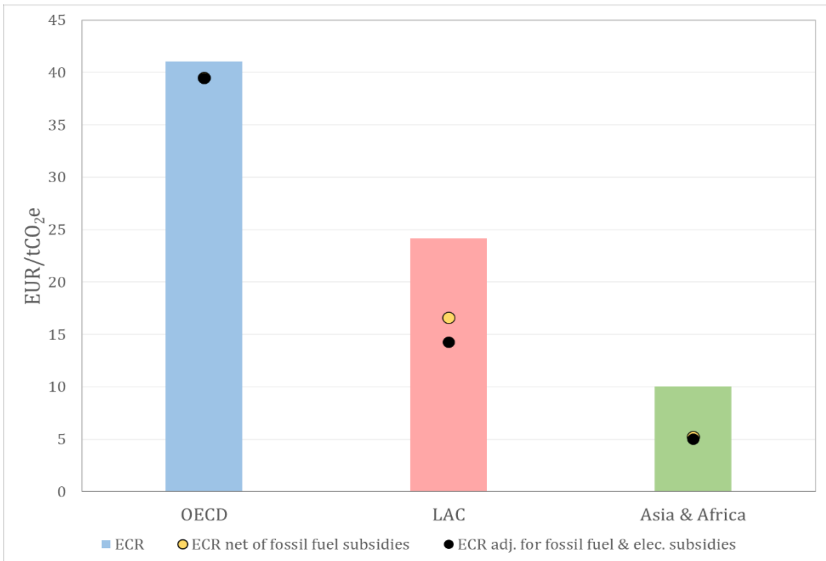
4. Energy Subsidies and Adjusted Effective Carbon Rates

The results presented in Section 3 were based on the original OECD (2016, 2018, 2021a) methodology, which ignores the effects of energy subsidies in ECRs. This might be problematic in the case of LAC countries, where energy subsidies are large, which leads to an overestimation of ECRs. Including subsidies in the calculation of ECRs following the same bottom-up approach as in the baseline methodology is difficult, as this requires having information about subsidies on the pricing of energy products at a sectoral level. Very recently OECD (2022) started implementing such an approach; see also Parry, Black, and Vernon (2021). However, as this information was not available for LAC countries for 2018, the same bottom-up approach based on the subsidy wedge contained in the sectoral pricing of energy could not be followed. To overcome not having information on subsidies at the sectoral level, this paper presents an approach that adjusts the economywide ECRs obtained using the OECD methodology for the likely effect of energy subsidies on the ECR estimates. The adjustment proposed considers fuel and electricity subsidies separately. In the case of fuels, the steps required to include them in the estimates were relatively straightforward. In the case of electricity subsidies, some difficulties appear, as the effects of subsidies on emissions depend on the structure of electricity generation, as it affects resulting emissions. Appendix III describes in detail the methodology and data uses for adjusting the baseline ECRs to consider fuel and electricity subsidies.

The results obtained from adjusting ECRs for fossil fuel subsidies and electricity subsidies show that these adjustments have the largest impact in LAC as compared with other regions of the world (see Figure 7). In LAC countries, the adjustments reduce the economywide ECR by almost 10 EUR/tCO_2e, but in Asian and African countries studied by the OECD (2021a and 2021b), the adjustments reduce the ECR by about 5 EUR/tCO_2e, and in OECD countries, the adjustments reduce the ECR by less than 2 EUR/tCO_2e. Most of the reduction in the adjusted ECRs in LAC is due to fuel subsidies.[13] Despite the fact that electricity subsidies have a smaller impact on ECR than fuel subsidies, their effects on ECR in LAC is still much larger than that observed in other regions.

[13] OECD (2022) produces estimates of net ECR for 2021. The paper arrives at similar results to those in this paper concerning the role of fuel subsidies in net ECRs but also provides a perspective on the sectoral drivers of results. With great heterogeneity across countries, Europe faces the highest net-carbon prices, where very low or even negative ECRs from fossil fuel subsidies are most common in the agriculture and fisheries sectors, followed by road transport and the building sector. The highest net ECRs tend to result from high fuel taxes in the road transport sector. Finally, where emissions from industry and electricity are priced, this is usually through emissions trading schemes or carbon taxes. The bottom-line conclusion is that subsidies impair the effectiveness of carbon pricing as net ECRs reach on average only 40 percent of total emissions from energy use, up from 32 percent observed in 2018, thanks to the introduction of carbon pricing in several countries.

Figure 7: Effective Carbon Rates by Region and Adjusted for Subsidies



Source: Authors' estimatations. ECR figures without adjustment for OECD and Asia and Africa countries come from OECD (2021a) and OECD (2021b).

When analyzing country-specific results, important heterogeneities emerge (see Figure 8). In about half the countries analyzed, subsidies for fossil fuels and electricity do not affect ECRs considerably. In the remaining countries, the effects are relatively large, even causing ECRs to be negative in three countries (Bolivia, Argentina, and Ecuador). In most countries where the effects are large, subsidies for fuels tend to have a larger effect on ECRs than subsidies for electricity. Ecuador is an outlier in this group, with the ECR dropping by more than 70 EUR/tCO_2e as a consequence of fuel subsidies. In other countries, like Mexico and the Dominican Republic, electricity subsidies are more important due to the high share of thermal generation. Meanwhile, Argentina and Bolivia have large subsidies on both fossil fuel and electricity.

Figure 8: Effective Carbon Rates and Subsidies in Latin America and the Caribbean, by Country

Source: Authors' estimatations.
Notes: Bolivia provides negative excise rates on imported diesel, thus a subsidy These account for transfers of about 1.2 percent of GDP, which is consistent with the 1.1 percent budgetary estimates from FIEL (2020).

5. Suggested Directions for Reform

The ECR estimates obtained for the different sectors and fuels suggest directions for reform that could be followed by LAC countries willing to increase the use of carbon pricing as a policy instrument to combat climate change. Table 1 shows by LAC country and for the LAC region, and for the OECD average, the carbon pricing gaps with respect to a benchmark of 120 EUR/tCO_2e, the benchmark that corresponds to the OECD conservative estimate of what carbon costs will be in 2030. At an economywide level, LAC countries show a significant gap in carbon pricing, with the LAC average for ECR (24.17 EUR/tCO_2e) only 20 percent of the 120 EUR/tCO_2e benchmark. The gap for the LAC average is much smaller for the road transport sector, at 59 percent of the benchmark. In the remaining (non-road) sectors, the gap for the LAC average is very large, as the ECR is only 4 percent of the referred benchmark. Considering that non-road sectors account for 69 percent of energy related emissions in LAC, countries willing to increase the use of carbon pricing policies should focus on extending and increasing ECRs in non-road sectors.[14,15]

Table 1: Effective Carbon Rate Gaps in Latin America and the Caribbean, by Country and Region (in percent)

	ECR as a % of 120 EUR/tCO_2e benchmark			**Fuel type responsible for majority of carbon emissions from energy use from the non-road sectors**
Country	Economywide	Road sector	Non-road sectors	
Argentina	16	53	3	Natural gas
Bolivia	17	38	2	Natural gas
Brazil	14	40	3	Biofuels
Chile	17	80	0	Biofuels
Colombia	18	44	4	Biofuels
Costa Rica	63	>100	12	Biofuels
Dominican Republic	21	89	2	Oil products
Ecuador	0	0	0	Oil products
El Salvador	15	33	3	Oil products
Guatemala	6	35	0	Biofuels
Honduras	22	87	4	Biofuels
Jamaica	36	85	18	Oil products
Mexico	25	77	0	Natural gas
Nicaragua	12	56	3	Biofuels
Panama	21	36	9	Oil products
Paraguay	19	52	1	Biofuels
Peru	14	35	3	Biofuels
Uruguay	29	>100	1	Biofuels
LAC average	20	59	4	
OECD average	34	93	19*	

Source: Authors' estimations.
*The OECD average for non-road sectors is an unweighted mean for all sectors other than the road transport sector. In contrast, the LAC average contemplates the share of each sector in terms of emissions and taxation.

[14] The focus on sectors other than road transport does not imply that no attention should be given to the road transport sector in LAC countries, where there are important opportunities for reforms in several countries.

[15] The strategy of increasing carbon pricing can become more appealing to LAC countries if carbon tariffs start being implemented by developed countries. Recently, the European Union approved a Carbon Border Adjustment Mechanism (CBAM), which is a carbon tariff placed on carbon-intensive products imported by the European Union that are taxed at low rates in their countries of origin. The CBAM will take effect in 2026, with reporting starting in 2023 (see Barreix and Bès, 2023).

The choice of policy instruments used to increase carbon pricing depends on the socioeconomic context of each country and the country's institutional capacities. Tax reforms (e.g., increasing excise taxes or introducing a carbon tax) and the reduction or elimination of subsidies have the advantage of simple administration, but the political economy of implementing these approaches can be complicated. Tradable carbon emission permit systems can be an effective option for increasing ECRs in certain sectors (e.g., electricity generation or industry), but they can require higher institutional capacities and important investment in monitoring technologies.

For those countries willing to embark on tax reforms, the focus should be on eliminating existing exemptions regarding excise taxes and on defining a path for increasing rates on newly taxed sectors. Excise tax reforms should also aim at reducing differences in carbon pricing across fuels that are not explained by externalities or other economic considerations. Two areas of excise tax reform seem of particular importance. First, gas and coal should be taxed more heavily, particularly for power generation, given their high carbon content and emissions. Second, biofuels are currently virtually untaxed in many countries. Even though the combustion of biofuel for road use does not generate significant emissions, its life cycle can generate large emissions, particularly if biofuels require changes in land use and/or consumption of fertilizers. In this context, taxing biofuels can be an indirect way of taxing an activity contributing to climate change (e.g., a change in land use leading to the nonabsorption of carbon by plants or production of fertilizer). Countries willing to embark on tax reforms could also introduce carbon taxes, which are a natural path toward reducing existing distortions and having more uniform carbon pricing across energy products and sectors. If the decision to introduce a carbon tax is taken, policymakers should ensure that tax rates are sufficiently high to effectively foster emission reductions.[16] In contrast, several countries that introduced carbon taxes imposed negligible tax rates or

[16] Carbon taxes can be effective in reducing emissions if tax rates are sufficiently high. For instance, Andersson (2019) finds that the carbon tax implemented in Sweden, the country with the highest carbon tax rate, reduced emissions from the transport sector by 6 percent. More recently there has been some discussion on the effect of carbon pricing on aggregate emissions. Evidence referred to in Metcalf (2019), an excellent and useful review of carbon pricing, has been challenged by Pretis (2022) in a thorough policy assessment of the carbon tax reform in British Columbia, Canada, where the author claims that carbon taxes do show an effect on transport sector emissions, but evidence does not show an effect on aggregate emissions. Evidence of effects of ECRs on emissions reported in Ahumada et al (2022) are consistent with the presence of an aggregate effect that operates through the road transport sector, as ECRs in non-road sectors are rather low, as documented in this paper.

compensated the carbon tax with reductions in excise taxes. This reduced the price signals and make carbon taxes relatively ineffective.

For countries with large energy subsidies, eliminating or reducing them should be a priority, both to increase effective carbon pricing and to protect fiscal sustainability. Despite the potential benefits in terms of emission reductions, international experiences have shown the political and social difficulties of reducing energy subsidies. This is partly a consequence of the possible impacts of these reforms on inequality and poverty. Given these difficulties, countries embarking on energy subsidy reforms should implement comprehensive strategies to ensure that they are economically and socially viable.[17] The literature on the theory and practice of carbon pricing addresses some needed compensatory measures.[18]

Beyond the general suggestions of prioritizing sectors other than road transport and energy subsidy reforms, and the general considerations about policy instruments, there is little else to recommend without referring to energy use in a specific country. LAC countries have very heterogeneous energy structures. These differences in structures affect the most appropriate path to be followed to increase ECR. The last column of Table 1 shows by country the energy product that is responsible for the highest share of carbon emissions in the sectors other than road transport. Countries such as Argentina, Bolivia, and Mexico, with a vast availability and use of natural gas, could make the main reform pillar increasing taxation of natural gas. Other countries could center their tax reform efforts on increasing taxation of oil products or biofuels. The direction for reform a country decides to follow also depends on the scope for substitution by alternative fuels. More specifically, reforms increasing carbon pricing should create incentives to substitute with clean energy and not just substitute with less-contaminant energy sources.

Finally, carbon pricing reforms should take into consideration undesired effects on poverty and inequality, and address them to make reform viable. For instance,

[17] In Cavallo, Powell, and Serebrisky (2020; see Chapters 1, 4, and 9) there are many discussions and analysis of energy subsidy reform in LAC. Reviews of energy subsidy reforms have identified some good practices that increase their likelihood of success. Some of these good practices are (Skovgaard and Van Asselt, 2018): (i) act at the right time, whether due to low fuel prices or political popularity, or in the context of a broader reform of the energy sector; (ii) involve early a wide range of stakeholders as well as different sectors of government; (iii) effectively communicate the subsidy reform, providing information on grant amounts and how funds spent on these subsidies could be redirected to other purposes; and (iv) implement compensatory measures for the main affected parties.

[18] Regarding compensatory measures, see, for example, Metcalf (2019). See also Missbach, Steckel, and Vogt-Schilb (2023) for a discussion relevant to LAC.

increasing fuel prices has been shown to impact more acutely regions where the extractive industries are located, and the poor and the middle class. These effects make reforms aiming at increasing energy prices hard to implement. Complementing these reforms with mechanisms to compensate the most-affected have proven effective in some contexts, both to mitigate undesired effects and make reforms viable. Compensation mechanisms, if introduced, should preferably be targeted and based on lump-sum transfers to avoid distorting fuel prices.

6. Conclusions

This paper estimates ECRs on carbon emissions from energy use for 18 LAC countries. The results indicate that carbon pricing policies seem to be underutilized in LAC countries when compared to OECD countries. This is mostly a consequence of lower rates of excise taxes on energy products as well as the emissions of some economic sectors being virtually untaxed. In several LAC countries, ECRs are also significantly reduced by the presence of large subsidies for fuel or electricity. At the sectoral level, we found that ECRs on sectors other than road transport face very low carbon price signals. This is mostly derived from the differential taxation of different fuels and preferential tax treatments for some sectors.

The ECR estimates obtained suggest directions for reform that could be followed by LAC countries willing to increase the use of carbon pricing as a policy instrument to combat climate change. Reforming already existing policy instruments could significantly increase carbon pricing. For instance, excise taxes could be reformed to eliminate preferential sector treatments and to better align taxation of energy products with their carbon content and other externalities from their consumption. Reforming the taxation of biofuels is also important. Similarly, reducing energy subsidies is an important direction for reform for some countries, and this is more important for fuel subsidies because electricity subsidies do not imply more emissions except where fossil fuels are used to generate electricity. Countries could also introduce new policy instruments, such as carbon taxes and tradable carbon emission permit systems. The design of any carbon pricing reform should be adapted to the realities of the specific countries, taking into consideration efficiency, cost effectiveness (including fiscal outcomes), and equity. This requires considering the structure of energy use and the feasibility of substituting energy products, the distributional effects of existing energy taxes and subsidies, and the economic and social impacts of sectoral preferential treatments.

References

Ahumada, H., S. Espina-Mairal, F. Navajas, and A. Rasteletti. 2022. Determinants of Effective Carbon Rates on Energy Use. Unpublished.

Andersson, Julius J. 2019. Carbon Taxes and CO_2 Emissions: Sweden As a Case Study. *American Economic Journal*: *Economic Policy* 11(4): 1–30. Available at https://www.aeaweb.org/articles?id=10.1257/pol.20170144.

Barreix, A. and M. Bès. 2023. Reflexiones sobre la propuesta bajo consideración de la Unión Europea de un mecanismo de ajuste de carbono en frontera y su impacto sobre América Latina y el Caribe. Inter-American Development Bank. Unpublished.

Cavallo, E., A. Powell, and T. Serebrisky (eds). 2020. From Structures to Services: Development in the Americas. Washington, DC: Inter-American Development Bank. Available at https://flagships.iadb.org/en/DIA2020/from-structures-to-services.

Coady, D., I. Parry, N.P. Le, and B. Shang. 2019. Global Fossil Fuel Subsidies Remain Large: An Update Based on Country-Level Estimates. IMF Working Paper No. 2019/089. Washington, DC: International Monetary Fund. Available at https://www.imf.org/en/Publications/WP/Issues/2019/05/02/Global-Fossil-Fuel-Subsidies-Remain-Large-An-Update-Based-on-Country-Level-Estimates-46509.

Conte Grand, M., A. Rasteletti, and J. Muñoz. 2022. Impuestos a los combustibles en la teoría y en la práctica. IDB Technical Note No. IDB-TN-2323. Washington, DC: Inter-American Development Bank. Available at http://dx.doi.org/10.18235/0003994.

EIA (United States Energy Information Administration). Carbon Dioxide Emissions Coefficients. Available at https://www.eia.gov/environment/emissions/co2_vol_mass.php

EPA (United States Environmental Protection Agency). 2018. Emissions Factors for Greenhouse Gas Inventories, March 19, 2018. Washington, DC: Environmental Protection Agency. Available at https://www.epa.gov/sites/default/files/2018-03/documents/emission-factors_mar_2018_0.pdf

FIEL (Fundación de Investigaciones Económicas Latinonamericanas). 2020, Análisis de la eficiencia e incidencia del gasto público en países seleccionados de la región. Washington, DC: Inter-American Development Bank.

Gago, A., X. Labandeira,, and X. López-Otero. 2014. A Panorama on Energy Taxes and Green Tax Reforms. *Hacienda Pública Española / Review of Public Economics* 208(1), 145–190.

IEA (International Energy Agency). 2021. Extended World Energy Balances: Energy Balances for 190 Countries and Regional Aggregates. Paris: International Energy Agency. Available at https://www.iea.org/data-and-statistics/data-product/world-energy-balances.

IMF (International Monetary Fund). 2019, Fiscal Monitor: How to Mitigate Climate Change. Washington, DC: International Monetary Fund. Available at https://www.imf.org/en/Publications/FM/Issues/2019/09/12/fiscal-monitor-october-2019.

International Tax Dialogue. 2015. Much Better Use Can and Must Be Made of Taxes to Help Reduce Pollution and Greenhouse Gas Emissions. Available at https://www.oecd.org/tax/much-better-use-can-and-must-be-made-of-taxes-to-help-reduce-pollution-and-greenhouse-gas-emissions.htm.

IPCC (Intergovernmental Panel on Climate Change) IPCC Emission Factor Database. Available at https://www.ipcc-nggip.iges.or.jp/EFDB/main.php.

Kaufman, N et al. 2020. A Near-Term to Net Zero Alternative to the Social Cost of Carbon for Setting Carbon Prices. *Nature Climate Change* 10, 1010–1014. Available at https://www.nature.com/articles/s41558-020-0880-3.

Martin, R., M. Muûls, and U. Wagner. 2016. The Impact of the European Union Emissions Trading Scheme on Regulated Firms: What Is the Evidence After Ten Years? *Review of Environmental Economics and Policy* 10(1): 129–48.

Metcalf, Gilbert E. 2019. On the Economics of a Carbon Tax for the United States. *Brookings Papers on Economic Activity* Spring, 405–458.

Missbach, L., J. C. Steckel, and A. Vogt-Schilb. 2023. Cash Transfers in the Context of Carbon Pricing Reforms in Latin America and the Caribbean. IDB Working Paper Series No. IDB-WP-01404. Washington, DC: Inter-American Development Bank. Available at http://dx.doi.org/10.18235/0004568.

Navajas, F., M. Panadeiros, and O. Natale. 2012. Workable Environmentally Related Energy Taxes. IDB Working Paper Series No. IDB-WP-351. Washington, DC: Inter-American Development Bank. Available at https://publications.iadb.org/en/publication/11086/workable-environmentally-related-energy-taxes.

Nordhaus, W. 2014. Estimates of the Social Cost of Carbon: Concepts and Results from the DICE-2013R Model and Alternative Approaches. *Journal of the Association of Environmental Resource Economists* 1(1/2): 273–312. Available at https://www.journals.uchicago.edu/doi/full/10.1086/676035.

OECD (Organisation for Economic Co-operation and Development). 2016. Effective Carbon Rates: Pricing CO_2 Through Taxes and Emissions Trading Systems. Paris: OECD Publishing. Available at https://doi.org/10.1787/9789264260115-en.

———.2018. Effective Carbon Rates 2018: Pricing Carbon Emissions Through Taxes and Emission Trading. Paris: OECD. Available at https://doi.org/10.1787/9789264305304-en.

———.2019. Taxing Energy Use 2019: Using Taxes for Climate Action. Paris: OECD. Available at https://www.oecd.org/tax/taxing-energy-use-efde7a25-en.htm.

———.2021a. Effective Carbon Rates 2021: Pricing Carbon Emissions Through Taxes and Emission Trading. Paris: OECD. Available at https://www.oecd.org/tax/tax-policy/effective-carbon-rates-2021-0e8e24f5-en.htm.

———.2021b. Taxing Energy Use for Sustainable Development: Opportunities for Energy Tax and Subsidy Reform in Selected Developing and Emerging Economies. Paris: OECD. Available at https://www.oecd.org/tax/tax-policy/taxing-energy-use-for-sustainable-development.htm.

———.2022. Pricing Greenhouse Gas Emissions: Turning Climate Targets Into Climate Action, OECD Series on Carbon Pricing and Energy Taxation. Paris: OECD. Available at https://doi.org/10.1787/e9778969-en.

Parry, I., S. Black, and N. Vernon. 2021. Still Not Getting Energy Prices Right: A Global and Country Update of Fossil Fuel Subsidies. IMF Working Paper Series No. 2021/236. Washington, DC: International Monetary Fund. Available at https://www.imf.org/en/Publications/WP/Issues/2021/09/23/Still-Not-Getting-Energy-Prices-Right-A-Global-and-Country-Update-of-Fossil-Fuel-Subsidies-466004.

Pretis, F. 2022. Does a Carbon Tax Reduce CO_2 Emissions? Evidence from British Columbia. *Environmental and Resource Economics* 83: 115–44. Available at https://doi.org/10.1007/s10640-022-00679-w.

Sen, S., and H. Vollebergh. 2018. The Effectiveness of Taxing the Carbon Content of Energy Consumption. *Journal of Environmental Economics and Management* 92: 74–99.

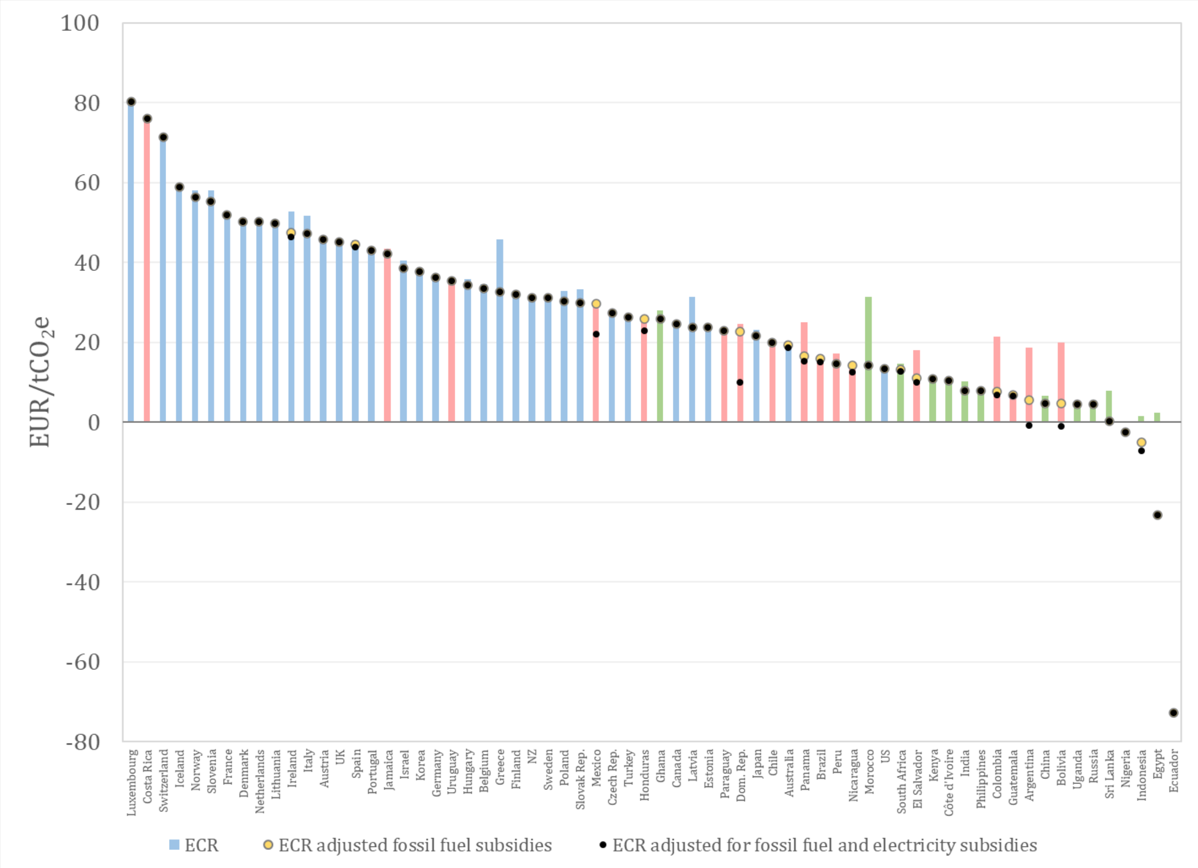
Skovgaard, J., and H. Van Asselt. 2018. The Politics of Fossil Fuel Subsidies and Their Reform. J. Skovgaard and H. Van Asselt (ed.). London, UK: Cambridge University Press.

CPLC (Carbon Pricing Leadership Coalition) 2019. Report of the High-Level Commission on Carbon Prices. Washington, DC: World Bank. Available at: https://www.carbonpricingleadership.org/report-of-the-highlevel-commission-on-carbon-prices.

World Bank. Available at https://data.worldbank.org/.

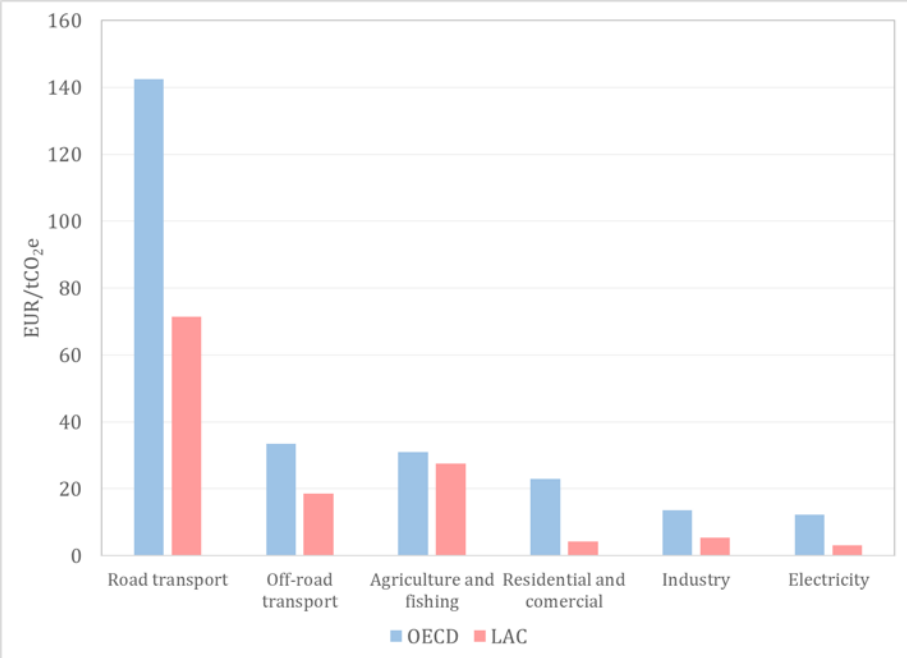
Appendix I. Additional Figures

Figure A1: Effective Carbon Rates by Country, 2018



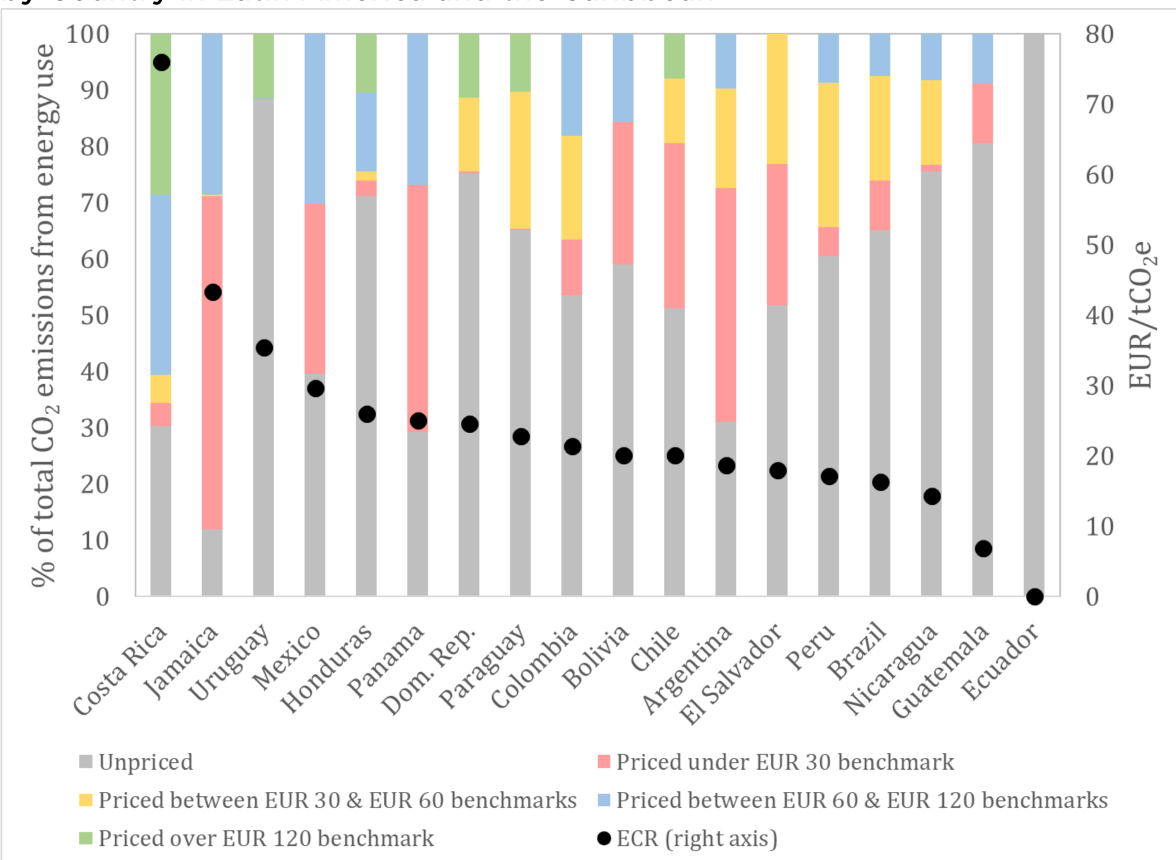
Source: Authors' estimation of ECRs are used for LAC countries. For other countries, OECD (2021a, 2021b). ECR estimates are used and later adjusted to consider subsidies. These adjustments are based on data from the OECD Inventory of Support Measures for Fossil Fuels, considering only budgetary transfers. Carbon emissions and local currency exchange rates are taken from World Bank data, except for emissions from LAC countries, which are from IEA World Energy Balances.

Figure A2: Effective Carbon Rates in Regions, by Sector



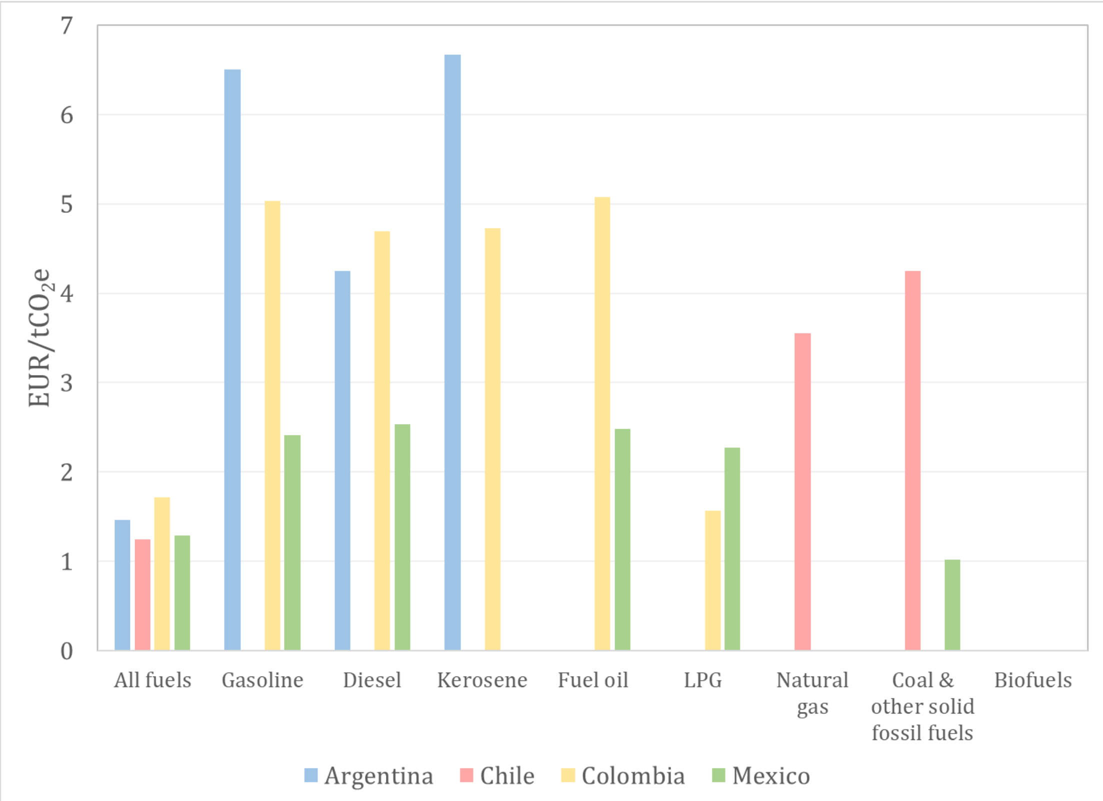
Source: Authors' estimations for LAC countries. For other countries, see OECD (2021a, 2021b).

Figure A3: Percentage of Carbon Emissions Priced and Effective Carbon Rates, by Country in Latin America and the Caribbean



Source: Authors' estimations.

Figure A4: Effective Carbon Rates for Argentina, Chile, Colombia, and Mexico, by Fuel Type



Source: Authors' estimations.

Appendix II. Effects on Effective Carbon Rates of Removing Sectoral Preferential Treatments

Carbon emissions are taxed asymmetrically across sectors. This asymmetric taxation of sectors come from two sources. First, sectors use different fuels at different levels. As different fuels are usually taxed at different rates, or can even be untaxed, these differences in fuel use by sector translate into sectoral differences in effective taxation. Second, countries give explicit exemptions, refunds, and special treatment to certain sectors. This Appendix presents a simple simulation to depict the magnitude of underlying sectoral preferential treatments. To determine what would happen to economywide ECRs if these sectoral preferential treatments were removed, the exercise assumes a static scenario, with no fuel substitution effects following relative price changes. The list of preferential treatments that were lifted in the simulation exercise are presented in the Table A2.1.

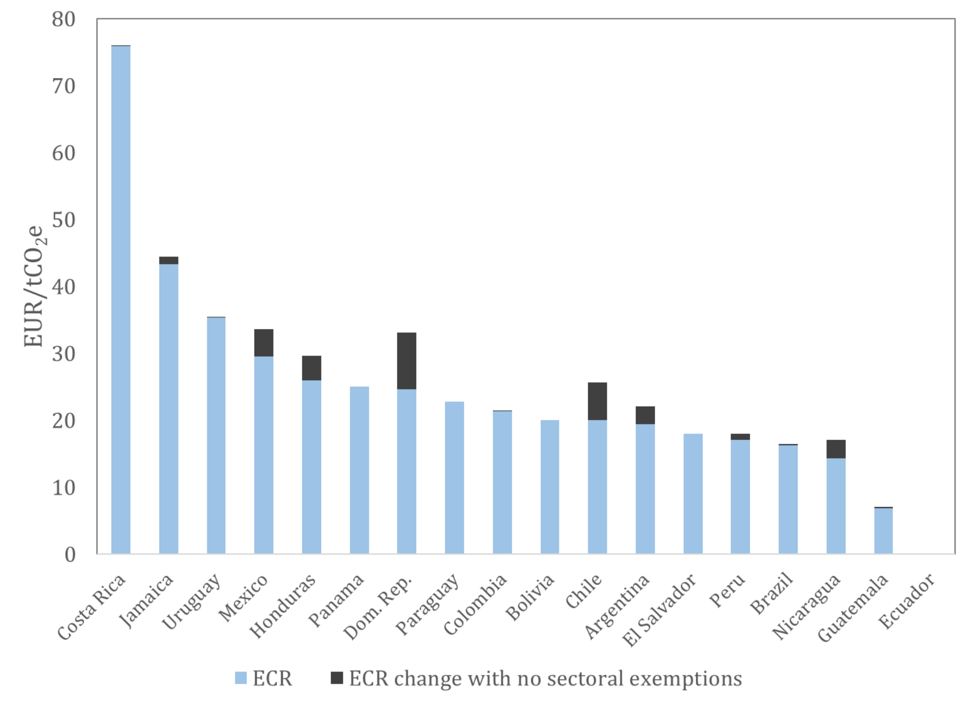
Table A2.1: Sectoral Preferential Treatments Considered in the Simulation Exercise

Countries	Exemptions removed
Argentina	• Tax exemptions on marine fuels and industrial end use • Special treatment regarding diesel in the agriculture sector • Geographically differential (reduced) excises were replaced by the standard tax.
Bolivia	• None
Brazil	• Exemptions on marine fuels (later eliminated in 2019) • Aviation gasoline and off-road transport exemptions
Chile	• Fuel tax exemption for all non-road sectors[19]
Colombia	• Specific industrial targeting of the carbon tax regarding liquefied and natural gas
Costa Rica	• Off-road transport exemptions
Dominican Republic	• Exemptions on fuel used for electricity generation
Ecuador	• None
El Salvador	• None[20]
Guatemala	• Exemptions on electricity generation (diesel and fuel oil) and residential end use (LPG)
Honduras	• Refunds on taxes levied on fuels used to generate electricity
Jamaica	• Refunds on taxes levied on fuels used to generate electricity
Mexico	• Fuel tax exemption for all non-road sectors regarding the national tax
Nicaragua	• Exemptions on fuels used for electricity generation • Exemptions for sectors other than road transport and industrial own use
Panama	• None
Paraguay	• None
Peru	• Specific exemptions on off-road transport
Uruguay	• Reduced rate for aviation gasoline for domestic aviation

The results from the simulation exercise indicate that removing preferential treatments for sectors would have minor effects on ECRs for most countries. The regional average ECR would be increased from 24.21 EUR/tCO_2e to 25.88 EUR/tCO_2e. The largest increase would be observed in the Dominican Republic, where the ECR would increase by about 9 EUR/tCO_2e. The second largest increase would be observed in Chile, with the ECR increasing by almost 6 EUR/tCO_2e.

[19] Because carbon tax exemptions were introduced in an ad hoc manner following OECD (2019), these were not modified in this exercise. Carbon tax rates were left unaltered.
[20] El Salvador has exemptions for the off-road transport sectors. However, as the IEA's World Energy Balances corresponding to 2018 does not register energy use in this sector, it was not possible to analyze the effects on ECRs of removing these exemptions.

Figure A5: Simulated Effective Carbon Rates in Latin American and Caribbean Countries After Removing Sectoral Preferential Treatments



Source: Authors' estimations.
Note: The simulation assumes a static scenario with no fuel substitution effects following relative price changes.

Appendix III. Incorporating Energy Subsidies in Effective Carbon Rates

This Appendix describes the methodology used to adjust economywide ECRs obtained using the OECD methodology to consider energy and electricity subsidies. The adjustments introduced follow two steps, with the first step adjusting for fossil fuel subsidies and the second step adjusting for electricity subsidies.

The adjustment of ECRs for fossil fuel subsidies requires expressing these subsidies in comparable units to ECRs (e.g., EUR/tCO_2e). This enables a direct adjustment through a simple subtraction of subsidies from taxes. The first requirement in the adjustment is obtaining information about the monetary amount of fossil fuel subsidies and converting them into euros. The baseline data on subsidies for LAC countries comes from FIEL (2020), which is derived from country-level budgetary information. As the FIEL data is expressed as percentage of GDP, the figures in the database were converted into 2018 euros using current-price GDP data and referencing exchange rates. Then, to express these subsidies in terms of tCO_2e units, subsidy values were divided by CO_2e emissions. The emissions values were obtained from fuel consumption information and their conversion factor into emissions. In the summary, the value of the fuel subsidy per unit of tCO_2e (fuel subsidy) was obtained using the following formula:

$$Fuel\ subsidy = \left(\frac{Subsidy\ amount}{Nominal\ GDP} \times Nominal\ GDP \times exchange\ rate\right) \Bigg/ \left(\sum_{i=1} fuel_i \times conversion\ factor_i\right)$$

where fuel is the consumption of the energy products in the IEA database.

The adjusted ECR considering only fuel subsidies can then be expressed as:

$$ECR_{Fuel\ Adjusted} = ECR - Fuel\ subsidy$$

The second step adjusts for subsidies on electricity. For this adjustment, we consider that even though electricity consumption does not directly generate carbon emissions, it can increase the consumption of fossil fuels if these are used as inputs in the process of generating electricity. Thus, the impact of electricity subsidies on carbon emissions will depend on how the electricity is produced. Additionally, the impact of electricity subsidies on emissions depends on the cost structure of the electricity sector. More specifically, electricity subsidies can be used to cover fixed costs of production, which are irrelevant for emissions, as well as variable costs (e.g., fossil fuel inputs). The share used for covering variable costs is the relevant one that translates into a higher demand for fossil fuels. Given the consideration above, the electricity subsidy per unit of tCO_2e (fuel subsidy) is calculated with the following equation:

$$Electricity\ subsidy = \frac{\frac{Subsidy\ amount}{Nominal\ GDP} \times Nominal\ GDP\ \times ex.rate \times variable\ cost\ share\ \times (1 - renew_{elec})}{\sum_{i=1}^{n} fuel_i \times conversion\ factor_i}$$

where $renew_{elec}$ is the share of energy coming from renewable sources. For variable costs, we assume a conservative share of variable costs of 50 percent. Therefore, the ECR adjusted by fuel and electricity subsidy is given by:

$$ECR_{Adjusted} = ECR - Fuel\ subsidy - Electricity\ subsidy$$

Several data sources are used to implement the adjustment described above. For LAC countries, information on fuel and electricity subsidies are obtained from FIEL (2020) while information on renewable electricity production was taken from IEA. For remaining variables, the same sources discussed in Section 2.2 are used. For non-LAC countries, different data sources were used to obtain energy and electricity subsidies. OECD (2021a) provides fossil fuel subsidy data in comparable units to ECRs. Thus, for countries in the OECD study, data on fossil fuel subsidies could be easily compiled, but not electricity subsidies. For non-LAC countries and countries not covered in OECD (2021a), the authors referenced the OECD Inventory of Support Measures for Fossil Fuels, which provides detailed information on policies that encourage consumption or production of fossil fuels. These support measures are divided into budgetary transfers and tax expenditures. The latter were not considered in this document as they are already accounted for in the OECD methodology (i.e., they are already discounted from ECRs by construction). The support measures that were classified under the category of "electricity-based support" were taken as reference for electricity subsidies. Finally, for non-LAC countries, carbon emissions were taken from World Bank data. These do not include emissions from biofuels, and thus estimated subsidies measured in EUR/tCO_2e may be overestimated for countries with intensive biofuel use.