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Fuelling the green transition

The direct and indirect effects of the subsidy reforms in the Andean region

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Abstract: The aim of this paper is to analyse the distributional effects of fuel subsidy reforms in four countries of the Andean region: Bolivia, Colombia, Ecuador, and Peru. The analysis combines tax–benefit microsimulation techniques with input–output analysis to estimate the direct and indirect distributional effects of the reforms, and the role played by enhanced social assistance in protecting vulnerable households. Our results show that the removal of fuel subsidies has a negative impact on household income, particularly for those at the bottom of the distribution, which increases poverty. Recycling the revenue saved from the removal of subsidies to increase the generosity of existing social protection programmes mitigates the increase in poverty but to different extents across countries. This reflects differences in the current targeting of social protection programmes in the countries under study and highlights the importance of designing fiscal policies that consider the socioeconomic disparities and benefit systems within each country, as well as the advantage of combining different research infrastructures for the analysis of fuel subsidy reforms.

Keywords: fuel subsidies, income distribution, microsimulation, Andean region, benefits

JEL classification: D13, H24, I32, I38

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The results presented here are based on the tax-benefit microsimulation models for Bolivia (BOLMOD), Colombia (COLMOD), Ecuador (ECUAMOD) and Peru (PERUMOD) in SOUTHMOD_A3.0. In collaboration with UNU-WIDER and Institute of International Inequalities (III) at London School of Economics (LSE), BOLMOD is developed and maintained by Cristina Arancibia and David Macas Romero, ECUAMOD by Facultad Latinoamericana de Ciencias Sociales (FLACSO) Ecuador, COLMOD by Fiscal Observatory of Pontificia Universidad Javeriana, and PERUMOD by Universidad del Pacifico, Peru. Models in the SOUTHMOD bundle are developed, maintained and managed by UNU-WIDER in collaboration with SASPRI (Southern African Social Policy Research Insights), the International Inequalities Institute at the London School of Economics and Political Science, and local partners in selected developing countries (Bolivia, Colombia, Ecuador, Ethiopia, Ghana, Mozambique, Peru, Rwanda, Mainland Tanzania, Uganda, Viet Nam, Zambia, and Zanzibar) in the scope of the SOUTHMOD project. The results presented here are based on EUROMOD version v3.8.6. Originally maintained, developed and managed by the Institute for Social and Economic Research (ISER), since 2021 EUROMOD is maintained, developed and managed by the Joint Research Centre (JRC) of the European Commission, in collaboration with EUROSTAT and national teams from the EU countries. We are indebted to the many people who have contributed to the development of SOUTHMOD and EUROMOD. The results and their interpretation presented in this publication are solely the authors' responsibility.

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1 Introduction

Despite the growing importance of phasing out fossil fuels in the context of the energy transition, worldwide financing of fuel subsidies reached USD1.4 trillion in 2022 (OECD 2024). Many Latin American and Caribbean (LAC) countries have fossil fuel subsidies aimed at reducing the impact of oil price volatility on consumers, especially to protect vulnerable households (Marchán et al. 2017).[1] According to IMF estimates, fuel subsidies (i.e. undercharging for the supply costs of fossil fuels) represented 0.7 per cent of GDP in 2022 in the LAC region (Black et al. 2023).[2] Fuel subsidies are an important fiscal cost in the Andean region, especially in Bolivia and Ecuador, where they represent 7.8 and 3.6 per cent of GDP, respectively. However, limited evidence is available on the distributional effects of such subsidies in the Andean countries. In particular, it is unclear whether fuel subsidies might be regressive in benefiting disproportionally households at the top of the income distribution, who might consume more fuel than those at the bottom (Feng et al. 2018; Marchán et al. 2017).

From an environmental perspective, fuel subsidies contribute to increasing greenhouse gas emissions and prevent the development and use of renewable energy options (Rentschler and Bazilian 2016).[3] Despite LAC countries' rich endowment of renewable energies, fossil fuels have historically been their energy backbone. In the context of households, replacing fuels presents both significant opportunities and significant challenges: 74.1 per cent of the fuel used for cooking food is gas, while 18.6 per cent is made up of firewood and its derivatives; coal; kerosene; and oil, and 6.1 per cent is electricity (ECLAC 2022). In 2022, oil was the most demanded fuel in Latin America, accounting for 40 per cent of the total energy supply, followed by natural gas with a 23 per cent share (IEA 2023). Oil and its derivatives, such as gasoline and diesel, predominate in transportation, but are less important in electricity generation, where gas plays a crucial role, generating a quarter of the electricity supply. Liquefied petroleum gas (LPG) is commonly used for cooking in areas lacking natural gas networks, being a cleaner option than firewood, whose combustion generates air pollution in homes and greenhouse gas emissions. Additionally, LPG is an alternative that offers significant time savings in household chores (IEA 2023).

Politically, the transition to cleaner and more sustainable energies requires not only investing in infrastructure and ensuring access to cleaner energies, but also changing public perceptions and introducing policies that will mitigate the impact of such a transition on the affected economic sectors, which are important sources of employment and fiscal income. International cooperation and investment in clean technologies are crucial, as reflected in the drive towards bioenergy and the potential for low-emission hydrogen in the region. The replacement of fossil fuels in homes can be accelerated through increased energy efficiency and support for renewable technologies. However,

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[1] Additionally, subsidies for liquefied petroleum gas (LPG) in LAC have contributed to a decrease in the use of solid fuels for cooking, which are a key environmental health risk factor (Troncoso and Soares da Silva 2017).

[2] IMF estimates refer to explicit subsidies as undercharging for supply costs and implicit subsidies as undercharging for environmental costs and forgone consumption tax revenues (Black et al. 2023). In this paper, the term 'fuel subsidies' refers to explicit subsidies.

[3] Consequently, between 2015 and 2020, more than 53 countries undertook efforts to reform fuel subsidies through gradual reductions, several accompanied by social protection policies (ILO 2024).

this process involves significant political challenges, including resistance from established industries and the need to ensure just transitions for affected communities (IEA 2023).

Against this background, this paper assesses the distributional effects of the removal of fuel subsidies in four Andean countries: Bolivia, Colombia, Ecuador, and Peru. Apart from their geographic proximity the choice of countries provides compelling grounds for a cross-country comparative perspective: all four countries rely on fuel production and three of them have fuel subsidies in place. All four countries have in place a range of means-tested social protection policies that have been leveraged in the past to support households through the COVID crisis and present a varying degree of targeting. However, inequality is high, with Gini coefficients exceeding 44 in all four countries, and the incidence of poverty being above 40 per cent in Peru and Colombia, 27.6 per cent in Bolivia, and 22.3 per cent in Ecuador, with a low redistributive capacity of the tax and transfer systems in all four countries.

Our analysis combines tax–benefit microsimulation techniques with input–output analysis to estimate the direct and indirect distributional effects of fuel subsidy reforms. The direct effect indicates how fuel subsidy reform translates directly into higher prices for fuels, assuming that households continue to consume the same quantities. The indirect effect refers to the increase in prices for non-fuel household expenditure items. The direct effect of the reforms is obtained through the use of harmonized tax–benefit microsimulation models applied to household survey data that have been compiled as part of the SOUTHMOD project (Decoster et al. 2019). The indirect effect is elicited using input–output analysis by means of social accounting matrices (SAMs) drawn from the Global Trade Analysis Project (GTAP) database (Aguiar et al. 2016). The removal of fuel subsidies is simulated in Bolivia, Colombia, and Ecuador, where domestic fuel prices are set at significant lower levels than international prices, while a 10 per cent increase in fuel prices is simulated in Peru, where fuel prices are broadly liberalized over the period analysed. Additionally, we take advantage of tax–benefit models to simulate the compensatory role in each country of enhanced social protection programmes that recycle (parts of) the government expenditure saved when removing or reducing fuel subsidies.

Our results show that a full removal of fuel subsidies would increase household expenditure by between 5.4 per cent (in Colombia) and 16.8 per cent (in Bolivia). The indirect effect accounts for more than half of increased expenditure in Bolivia, Colombia, and Ecuador, as well as in Peru, where a 10 per cent increase in fuel prices is simulated. The removal of subsidies for natural gas and LPG tends to be regressive in all countries, while the pattern of reforms to gasoline and diesel subsidies is progressive in Colombia, Ecuador, and Bolivia, and regressive in Peru. In all countries, the removal of fuel subsidies has a negative impact on consumable incomes across the whole distribution but with a larger incidence on low-income households. Recycling the additional government revenue from the removal of subsidies to increase the generosity of existing cash transfer programmes offsets the negative impact of the reforms in the first quintile of the distribution in Colombia and Peru, but not in Bolivia and Ecuador. The impact of the removal of fuel subsidies on household income translates into an increase in poverty, which is mitigated by enhanced social protection in all countries except Peru.

Our contribution is twofold. First, we provide estimates of the distributional effects of fuel subsidy reforms in the Andean region. To the best of our knowledge, the direct and indirect distributional effects of fuel subsidy reforms have been analysed only for Ecuador (Feng et al. 2018; Schaffitzel et al. 2020). Second, we contribute to the literature studying the role of social protection in alleviating climate mitigation policies (Mardones et al. 2024; Missbach et al. 2024; Vogt-Schilb et al. 2019), in our case the removal of fuel subsidies.

The rest of the paper is structured as follows. Section 2 provides a brief description of the design of fuel subsidies in the countries under study. Section 3 describes the linkage of tax–benefit microsimulation and input–output analysis as used in our study. Section 4 presents the results on the fiscal and distributional effects of fuel subsidy removal. Section 5 concludes with a discussion of policy implications and potential future avenues of research.

2 Fuel subsidy policies in the Andean region

In this section, we provide a brief background to and description of fuel subsidy policies in each of the countries analysed. The four countries have the common feature of being fuel producers, but Colombia, Ecuador, and Peru are classified by the World Bank as upper-middle income countries and Bolivia as a lower-middle income country. The countries also differ in terms of the fuels domestically produced: Colombia and Ecuador are among the largest producers of crude oil in Latin America, whereas Bolivia and Peru are large producers of natural gas.

In practice, governments implement fuel subsidies by regulating domestic prices relative to international prices. However, the degree of regulation of fuel prices varies across countries. Table 1 shows the size of subsidies for different types of fuel in the countries under study as a percentage of GDP in 2022. Government spending on fuel subsidies is particularly large in Bolivia, reaching 7.76 per cent of GDP, followed by Ecuador at 3.61 per cent and Colombia at 2.31 per cent. In contrast, fuel subsidies are presented as nil in the case of Peru, since fuel prices were broadly liberalized in 2022, although there is a system for setting fuel price bands that cushions the impact of international price fluctuations. In absolute terms, the estimated fiscal cost of fuel subsidies amounted to USD3,502 million in Bolivia, USD4,417 million in Ecuador, and USD5,031 million in Colombia.

Table 1: Government spending on fuel subsidies as a percentage of each country's GDP in 2022

	Coal	Natural gas	Oil	Total
Bolivia	0.00	0.77	6.99	7.76
Colombia	0.10	0.07	1.24	2.31
Ecuador	0.00	0.01	3.60	3.61
Peru	0.00	0.00	0.00	0.00

Source: authors' elaboration based on IISD & OECD (2024).

2.1 Bolivia

In Bolivia, prices for different types of gasoline, diesel, and gas have been regulated by law since 1997. In 2004, a new decree was introduced to determine the regulated prices of fuels and associated products, which is still in force. Table 2 shows the domestic prices in bolivianos (BOB) of the main fuels used by Bolivian households, as published by the National Hydrocarbons Agency (ANH) in 2024.

Table 2: Domestic fuel prices in Bolivia, 2022

Product	Domestic price (BOB)
Gasoline Premium (per litre)	4.79
Gasoline Super 91 (per litre)	4.40
Gasoline Especial (per litre)	3.74
Diesel oil (per litre)	3.72
Kerosene (per litre)	2.72
Liquified petroleum gas (LPG) (per kg)	2.25
Vehicle natural gas (per m^3)	1.66
Gas oil (per litre)	1.10

Note: average annual prices.

Source: authors' elaboration based on data from ANH (2024).

2.2 Colombia

In Colombia, a fuel price stabilization fund was established in 1998 with the purpose of cushioning fluctuations in international prices. As a result, a price for fuels is set in the domestic market that is typically lower than the international price and remains stable in the face of market fluctuations. Table 3 provides official information from the fuel distribution chain information system of the Ministry of Mines and Energy of Colombia on the official domestic price of diesel, gasoline, and vehicle gas. In 2022, the national prices per gallon were 9,006 Colombian pesos (COP) for diesel, COP9,355 for gasoline, and COP1,949 per cubic metre of vehicle gas. However, the gasoline subsidy decreased in subsequent years, the domestic price approaching the international price.

Table 3: Domestic fuel prices in Colombia, 2022

Product	Domestic price (COP)
Diesel (per gallon)	9,006
Gasoline (per gallon)	9,355
Vehicle gas (per m^3)	1,949

Note: average annual prices.

Source: Fuel distribution chain information system of the Ministry of Mines and Energy of Colombia (2022).

2.3 Ecuador

In Ecuador, prices for domestic gas (LPG), gasoline, and diesel have been subsidized since the 1970s. Prices for LPG have remained broadly unchanged. The only significant adjustment to LGP prices took place in April 2024, when the price of a 15 kg gas cylinder increased by executive decree from USD1.60 to USD1.65 due to a VAT-related adjustment. The actual cost for households, however, includes transportation costs, the gross price of LPG ranging between USD3.25 and USD3.50 per cylinder. In 2018, the government promoted the implementation of a gradual removal of subsidies for gasoline and price increases for diesel. Diesel prices increased gradually in 2018 and 2019. They were frozen temporarily in 2020 and later fluctuated under a capped price scheme. Subsidies for Gasolines Extra and Eco were gradually reduced from 2019, while a full removal of the

subsidy for Gasoline Super was implemented in the same year. In 2022, price reductions for all types of gasoline and diesel were implemented at the request of the indigenous movement.[4] Table 4 provides information on domestic prices for fuels in Ecuador in 2022.

Table 4: Domestic fuel prices in Ecuador, 2022

Product	Domestic price (USD)
Gasoline Extra (per gallon)	2.22
Gasoline Eco (per gallon)	2.22
Gasoline Super (per gallon)	3.52
Diesel (per gallon)	1.61
Domestic gas (per kg)	0.11

Note: average annual prices.

Source: authors' elaboration based on data from Petroecuador (2024).

2.4 Peru

In Peru, price-setting for fuels is managed by the Fuel Price Stabilization Fund (FEPC), which was created in 2004 to cushion fuel prices against variations in international prices and thus to protect consumers. The system sets price bands for different types of gasoline and LPG sold by wholesale retailers and importers. The FEPC's mechanism operates through these price bands and parity prices (PP) and influences the consumer price through the wholesale price (at the producer or importer level). LPG was temporarily removed from the fund in 2020 but reincorporated in late 2021, in the context of the war between Russia and Ukraine.[5] In Table 5, we present the price bands and the PP in 2022 (in Peruvian sol/PEN). However, the domestic price or retail price (PPI) may fall within the price band (between the lower and upper limits), below the lower band, or above the upper band. A fuel tax is applied when the domestic price falls below the lower limit. Conversely, a fuel subsidy is granted when the domestic price exceeds the upper limit.

In addition to the system of price bands for fuels managed by the FEPC, Peru has implemented the Energy Social Inclusion Fund (FISE), which is a cash transfer programme aimed at household purchase of LPG. In 2022, the FISE provided a voucher of PEN25 (around USD6.5), valid for 60 days, which beneficiaries could use to purchase an LPG cylinder of up to 10 kg. This initiative aimed to improve access to LPG and offered social compensation to families in rural and urban areas.[6]

[4] In June 2024, during the writing of this paper, subsidies for all types of gasolines were fully removed. Diesel subsidies were fully removed in September 2025.

[5] LPG was excluded from the fund again at the end of 2023.

[6] To be eligible for FISE subsidies, households must: (i) be residential electricity users at the national level; (ii) have an average annual electricity consumption of 70 kWh or less; (iii) have a dwelling whose floor is made predominantly of cement or wood; (iv) have an annual household income below PEN19,900; (v) live in a dwelling without access to a public natural gas service; and (vi) have a functioning LPG stove and gas cylinder.

Table 5: Fuel price bands and parity price in Peru, 2022

Product	Wholesale price (PEN)		
	Lower band	Upper band	PPI
LPG	2.68	2.74	2.68
Gasohol 84	11.70	11.80	11.76
Gasolina 90	13.38	13.48	14.43
Gasolina 84	11.63	11.73	11.70
Diésel B5 (0–2,500)	11.91	12.01	17.25
Diésel B5 (2,500–5,000)	11.91	12.01	14.94
Diésel 2 (0–2,500)	11.91	12.01	17.02
Diésel 2 (2,500–5,000)	11.91	12.01	14.60

Note: values are per gallon, except for LPG, where they are per kg. Average prices for June.

Source: authors' elaboration based on Organismo Supervisor de la Inversión en Energía y Minería (2022).

3 Methodology and data

Three main approaches have been used in the economics literature to assess the distributional impact of fuel subsidies. The first of these uses household consumption and the price gap between domestic consumer prices and reference international prices to calculate subsidy incidence for each household. See, for instance, Jara et al. (2018) for fossil fuel subsidies in Ecuador and Hernández Oré et al. (2018) for electricity subsidies in Central America. However, these studies do not account for the indirect effect of reforms on the prices of other goods and services.

The second approach combines information from consumption surveys and input–output tables to model the indirect impact of energy price changes on consumer prices for goods and services. Feng et al. (2018) apply this approach to 11 LAC countries (but only one Andean country, Ecuador) and show that the distributional impact of price increases for gasoline and diesel varies across countries and that the largest part of the impact is driven by the indirect effects, whereas price increases of natural gas and LPG tend to be regressive in most countries and the direct welfare effect dominates. Their study further shows that recycling 19 per cent of the additional budget from increased diesel and gasoline prices and 27 per cent of that for natural gas and LPG would be sufficient to compensate the bottom two quintiles for the price increase. A similar approach is used by Coady et al. (2015) to assess the welfare impact of increasing fuel prices in 32 developing countries (including Bolivia, Peru, El Salvador, Honduras, and Paraguay) and by Schaffitzel et al. (2020) to analyse the effect of energy subsidy reforms in Ecuador.

Finally, the third approach makes use of computable general equilibrium (CGE) models to analyse the effects of fuel subsidy reforms—see Burniaux and Château (2011) and Dennis (2016) for large cross-country studies; Clements et al. (2007), Lin and Jiang (2011), and Solaymani (2016) for Asian countries; Mastronardi and Mayer (2015) and Timilsina et al. (2013) for Argentina; Montenegro-Casa and Ramírez-Álvarez (2024) for Ecuador, among others. CGE analysis of fuel subsidy reforms is widely embedded in the literature of climate change research. Distributional analysis based on this method requires models incorporating different consumption patterns across income groups (household types) as well as differences in income sources across groups (Arze del Granado et al. 2012). Relative to CGE models, input–output analysis provides an upper-bound of the short-term

impact of fuel subsidy reforms on the price of consumption goods before firms can adjust production processes but has the advantage of exploiting the heterogeneity of the microdata for distributional analysis (Feng et al. 2018).

Most recently, Shahir and Lastunen (2026) have shown that electricity tariff and VAT reform in Ethiopia was regressive, with indirect effects (captured by linking ETMOD with the Ethiopian SAM) dominating. We proceed in a similar manner, combining the first and second approaches to estimate the effect of fuel price reform on household welfare in the four countries under study. We expand our analysis further by simulating different revenue recycling options. In a similar manner, Rodríguez et al. (2026) compares fuel subsidy policy and reform options for Ethiopia and Rwanda.

Our analysis proceeds in three steps. In the first step, we take advantage of detailed tax–benefit models to study how fuel subsidy reform translates directly into higher prices for fuels and overall household expenditure, assuming that households continue to consume the same quantities. We refer to this as the direct effect. In the second step, we use input–output tables to elicit the indirect effect of the reform, that is the increase in prices for non-fuel household expenditure items. We assume full pass-through of fuel price increases from firms to households. The total effect then is the combination of the direct and indirect price effects, which practically equals the increase in household expenditure. Lastly, in the third step, we propose several reform scenarios including different cash transfer compensatory measures that recycle the expenditure saved on fuel subsidies towards social protection.

The remainder of this section first lays out the data sources used and provides an overview of the tax–benefit microsimulation models used. The second part discusses how to assess the indirect effect of removing fuel subsidies on price levels for households. In the methodology section, we first present previous efforts to analyse price subsidy reforms before detailing how tax–benefit models allow us to study the direct welfare effect of fuel subsidy removal and of compensatory measures via cash transfers to households. Then we discuss the methodology to recover indirect price increases using input–output data. Lastly, we discuss how to measure the price effects of the reform.

3.1 Models and data

Tax–benefit microsimulation models and underlying survey data

Our analysis makes use of the harmonized tax–benefit microsimulation models for Bolivia, Colombia, Ecuador, and Peru developed as part of the SOUTHMOD project (Jara et al. 2026).[7] The data harmonization and modelling of tax–benefit simulations follow a series of protocols adapted from the

[7] SOUTHMOD is a collection of tax–benefit models maintained and managed by UNU-WIDER and partners (Jara et al. 2026). The results presented here are based on the tax–benefit microsimulation models for Bolivia (BOLMOD), Colombia (COLMOD), Ecuador (ECUAMOD), and Peru (PERUMOD) in SOUTHMOD_A3.0 (refer to the website for more information on the models, related materials and access to models: UNU WIDER : SOUTHMOD – simulating tax and benefit policies for development (phase 3)).

EUROMOD[8] platform for the labelling of variables, construction of income concepts, and software use, allowing cross-country comparability with other EUROMOD-based models.[9] Tax–benefit microsimulation models can be thought of as functions transforming individual market income into disposable income by simulating direct taxes and cash transfers. All SOUTHMOD models include simulations of indirect taxes: VAT, excise duties, and consumption taxes. The simulation of fuel subsidies in this study allows us to derive the concept of consumable income (i.e. disposable minus indirect taxes plus indirect subsidies), as described below.[10]

The models are based on nationally representative household survey data from 2022 in all countries under study. Table 6 summarizes the information about the household surveys used for the analysis. These surveys provide detailed information on demographics, employment, earnings, capital and property income, private transfers, pensions, expenditures, and quantities purchased.[11,12,13]

Table 6: Data sources and microsimulation models

Country	Dataset	Year	Sample		Microsimulation model	Expenditure imputed
			Individuals	Households		
Bolivia	Encuesta de Hogares	2022	40,955	12,535	BOLMOD	YES
Colombia	Gran Encuesta Integrada de Hogares (GEIH)	2022	917,250	304,459	COLMOD	YES
Ecuador	Encuesta Nacional de Ingresos y Gastos de Hogares Urbanos y Rurales (ENIGHUR)	2011	153,341	39,617	ECUAMOD	NO
Peru	Encuesta Nacional de Hogares (ENAHO)	2022	110,188	34,213	PERUMOD	NO

Source: authors' elaboration based on household surveys and SOUTHMOD country reports.

The simulations of taxes and benefits in the models have been validated against external statistics[14] and the models have been used in several research applications including a comparative analysis of the distributional effect of tax–benefit systems (Bargain et al. 2017), the distributional effects of the COVID-19 pandemic and its emergency policies (Corredor et al. 2021; Jara et al. 2022; Jara et al.

[8] EUROMOD version v3.8.6.

[9] See Lastunen et al. (2024) for a comparative study using SOUTHMOD models and Bargain et al. (2024) for a recent paper comparing 50 EUROMOD-based models.

[9] See Rodríguez-Guerrero (2019) for an overview of income definitions from a fiscal point of view.

[11] The household surveys used for the simulations in Colombian and Bolivia do not collect information on household expenditures. In these cases, expenditures and quantities are imputed from other surveys following Akoguz et al. (2020).

[12] Consumption data are harmonized using the Classification of Individual Consumption According to Purpose (COICOP).

[13] In the case of Ecuador, the 2011 data are uprated to 2022 using several income and prices indexes.

[14] For a full description of the models see Arancibia and Macas (2025) for Bolivia, Rodríguez and Silva (2025) for Colombia, Jara et al. (2025) for Ecuador, and Torres and Chang (2025) for Peru.

2024; Rodríguez et al. 2022), quantifying financial incentives to formal employment (Farné et al. 2025; Jara and Rodríguez 2019; Jara et al. 2023), and the study of gender income gaps (Deza et al. 2024).

Input–output data

For the four countries under study, we use social accounting matrices (SAMs) drawn from the Global Trade Analysis Project (GTAP) database (Aguiar et al. 2016). The reference year is 2011. Each SAM is a 1144 x 1144 square matrix in which intermediate demands are disaggregated into 57 goods/activities.[15] As well as intermediate demand, GTAP SAMs include household consumption, government spending, investment, imports, and exports on a country-by-country basis.[16,17] We focus on intermediate demand, final demand, and total output, as described in section 3.2 below.

3.2 Methodology

Direct price effects (Step 1)

We calculate the value of fuel subsidies by aligning domestic selling prices with international prices, using data for the year 2022 (Table 7). In practice, we simulate by how much households' expenditures would increase if quantities were kept constant at the higher price level once subsidies were taken away/reduced. We average price information for gasoline and diesel, on the one hand, and natural gas and LPG, on the other hand, as the information provided by GTAP input–output tables is close to this level of aggregation.

Table 7: Domestic and international fuel prices, and simulated price change by country, 2022

Country	Fuel	Domestic price (USD)	International price (USD)	Simulated price increase (%)
Bolivia	Gasoline and diesel	2.10	4.39	108.70
	Natural gas and LPG	0.34	1.48	341.19
Colombia	Gasoline and diesel	2.16	4.39	103.30
	Natural gas and LPG	1.41	1.48	5.06
Ecuador	Gasoline and diesel	2.20	4.39	99.32
	Natural gas and LPG	0.32	1.48	362.8
Peru	Gasoline and diesel	5.18	4.39	10*
	Natural gas and LPG	1.41	1.48	10*

Note: prices in dollars, gasoline and diesel per gallon, and natural gas per kg. * 10 per cent price increase assumed for Peru due to actual market price differences in 2022.

Source: authors' elaboration using data from the U.S. Energy Information Administration (EIA) and SOUTHMOD microsimulation models from each country.

[15] Thus, we subsequently employ the sectoral definition used by the GTAP database, as presented by Narayanan and McDougall (2015), to merge the 57 sectors in GTAP with the Classification of Individual Consumption According to Purpose (COICOP) 2018, used in each household survey.

[16] The structure of each SAM is presented in Table A1 in the Appendix.

[17] The emphasis of the GTAP project is to build regional CGE models. However, we focus on domestic demand.

Note that in the case of Peru, for the analysed period, domestic prices of gasoline and diesel are above international prices, meaning that no subsidy applies. For natural gas and LPG, a small price difference (5 per cent) is observed in Peru. For this reason, in the case of Peru, we simulate the effect of an arbitrary 10 per cent increase in fuel prices in our analysis.

Indirect price effects and changes in the value of expenditure (Step 2)

In addition to the direct effect of fuel subsidy reforms, we analyse their indirect effect, where an increase in fuel prices results in increases in the prices of other commodities. Fuel subsidy reform is so pivotal in the economy that it will necessarily have general equilibrium effects. In this paper we try to put an upper bound to the effect by assuming that firms producing goods and services other than fuels will completely pass on the fuel price increases to final consumers. In that sense, we take advantage of the methodology proposed by Schaffitzel et al. (2020) and detailed by Rodríguez and Silva (2026) and use intermediate and final demands from input–output data to elicit the increase in prices.

We use the SAMs developed by the GTAP project and extract the matrix[18] of intermediate demand $\mathrm{Z}_{57\mathrm{x}57}$, the matrix of final demand $\mathrm{f}_{57\mathrm{x}1}$, and the vector of total value of production $\mathrm{X}_{1\mathrm{x}57}$. We recover the technical coefficients matrix by dividing each intermediate input a_{ij} by the total value of production x_{j}, in matrix notation:

$$\mathrm{A} = \mathrm{Z}{:}/\mathrm{X} \tag{1}$$

Where the $'{:}'$ expression in Equation (1) implies that the division is element-wise. We define the inverse Leontief matrix $\mathrm{L}_{57\mathrm{x}57}$ as:

$$\mathrm{L} = (\mathrm{I} - \mathrm{A})^{-1} \tag{2}$$

We denote l_{ij} as the value in row i and column j of the inverse Leontief matrix. Let us suppose that row $\mathrm{i} - \mathrm{th}$ of the L matrix represents the fuel we are interested in, following Schaffitzel et al. (2020), if we multiply this row by the price increase associated with eliminating the subsidy, we obtain a vector of price increases (i.e. one for each of the other 56 sectors).[19]

We take this vector and translate it to COICOP classification to obtain price increases for goods and services purchased by households in the survey data and combine this effect by increasing the value of household expenditures in the input data for the tax–benefit models (refer to the technical note in Rodríguez and Silva 2026 outlining the process in detail). Notice that changes in the value of expenditure will have an indirect effect through the tax–benefit system, via indirect taxes on consumption.

[18] Domestic and imported intermediate consumption are merged into one intermediate consumption matrix.

[19] In the case of the $\mathrm{i} - \mathrm{th}$ column—that is, the fuel column—the price increase is the one associated with eliminating the subsidy itself.

Reform scenarios and 'recycling' revenue savings to social protection expansion (Step 3)

We develop a number of policy reform scenarios to estimate the welfare effects of fossil fuel subsidy reform. We then compare these results with the outcomes in terms of welfare and income distribution in the countries under current policies.

The first set of policy scenarios includes 'full removal', 'full recycling', and a series of 'perfect compensation' scenarios, the aim of which is to frame the discussion in three important perspectives: what size, in a strictly arithmetic sense, is the fiscal space of these subsidies and, if they were repurposed, what size could be reached by simply expanding the generosity of the current system (abstracting away from questions of expanding the number of benefit recipients)? Second, assuming that some of the proceeds of fuel subsidy removal were repurposed to perfectly compensate those at the bottom of the income distribution, what would be the benchmark level of compensation to protect poor households from the reform? Lastly, would taking away or fully recycling that same fiscal space shape welfare outcomes differently? This first set of scenarios thus seems hardly feasible, either politically or practically, yet it helps to establish benchmarks.

Specifically, in the 'full removal' scenario, we consider fuel subsidy reforms without any compensatory measures. In the 'full recycling' scenario, we remove fuel subsidies entirely as in the 'full removal' scenario but additionally simulate a compensatory cash transfer to current recipients of existing social assistance benefits in the baseline. This basically results in a vertical expansion of the social protection system, increasing benefit amounts but not the number of recipients. The additional benefit amount is determined by dividing the fiscal surplus resulting from the fuel subsidy removal to households by the number of recipients of social assistance in the baseline. Finally, we develop a series of 'perfect compensation' scenarios (documented in detail in Appendix A) in which we perfectly compensate those households in the first quintile losing the subsidy with the exact value of the subsidy lost (i.e. Slutsky compensation).

We provide estimates that could be considered somewhat more feasible while still highly ambitious in a second set of scenarios, 'half removal, fully recycled' and 'half removal, perfect compensation', which reduce all subsidies by half and recycle proceeds as described above in the second and third scenarios, respectively. Finally, 'gasoline/diesel removal, fully recycled' and 'gasoline/diesel removal, perfect compensation' scenarios leave the subsidy policies for gas/LPG untouched and implement a full removal of subsidies to diesel and gasoline while recycling the proceeds as described above. In the case of Peru, 'half-removal' and 'gasoline/diesel removal' refer to a 5 per cent and 10 per cent increase in the prices of all gasoline and diesel fuels, respectively.

Welfare effects of fuel subsidy reform

Tax–benefit microsimulation models allow us to simulate two income-based welfare measures: Disposable income (Y_i) and Consumable income (C_i). In the case of the former, we define Y_i for household i following Equation (3), where market income, i.e. labour (ω_i) and non-labour (μ_i), is taken from the data. We simulate direct tax liabilities (T_i^{dir}), social insurance contributions (S_i), and direct benefits, i.e. cash transfers (B_i^{dir}), while contributory pensions (P_i) are taken from the data.

$$Y_i = \omega_i + \mu_i + B_i^{dir} + P_i - S_i - T_i^{dir} \quad (3)$$

Consumable income, on the other hand, departs from disposable income by the addition of indirect subsidies (B_i^{ind}) and subtraction of indirect taxes (T_i^{ind}).

$$C_i = Y_i + B_i^{ind} - T_i^{ind} \quad (4)$$

Departing from previous exercises, for this paper we assume that B_i^{ind} is further decomposed into two components:

$$B_i^{ind} = F_i^{ind} + O_i^{ind} \quad (5)$$

F_i^{ind} is the subsidy on fuels. In what follows we call this term the 'direct price effect' because it relates directly to the fuels. On the other hand, O_i^{ind} is the indirect effect of the fuel subsidy subsidizing the price of other items. We call this term the 'indirect price effect'. This implies that, when we remove fuel subsidies, both terms decrease, constituting a welfare loss in terms of consumable income.

In conclusion, when removing an indirect subsidy and compensating for it, we have four welfare effects at the level of consumable income: 1) the change in direct benefits, B_i^{dir} (i.e. the compensating direct transfer), 2) the change in T_i^{ind} (mainly due to increases in VAT because of higher prices and higher values of expenditure under the assumption of fixed quantities), 3) the direct price effect, F_i^{ind} (resulting from the indirect benefit removal), and 4) the indirect price effect, O_i^{ind} (resulting from the increase in the value of household consumption items other than fuels).

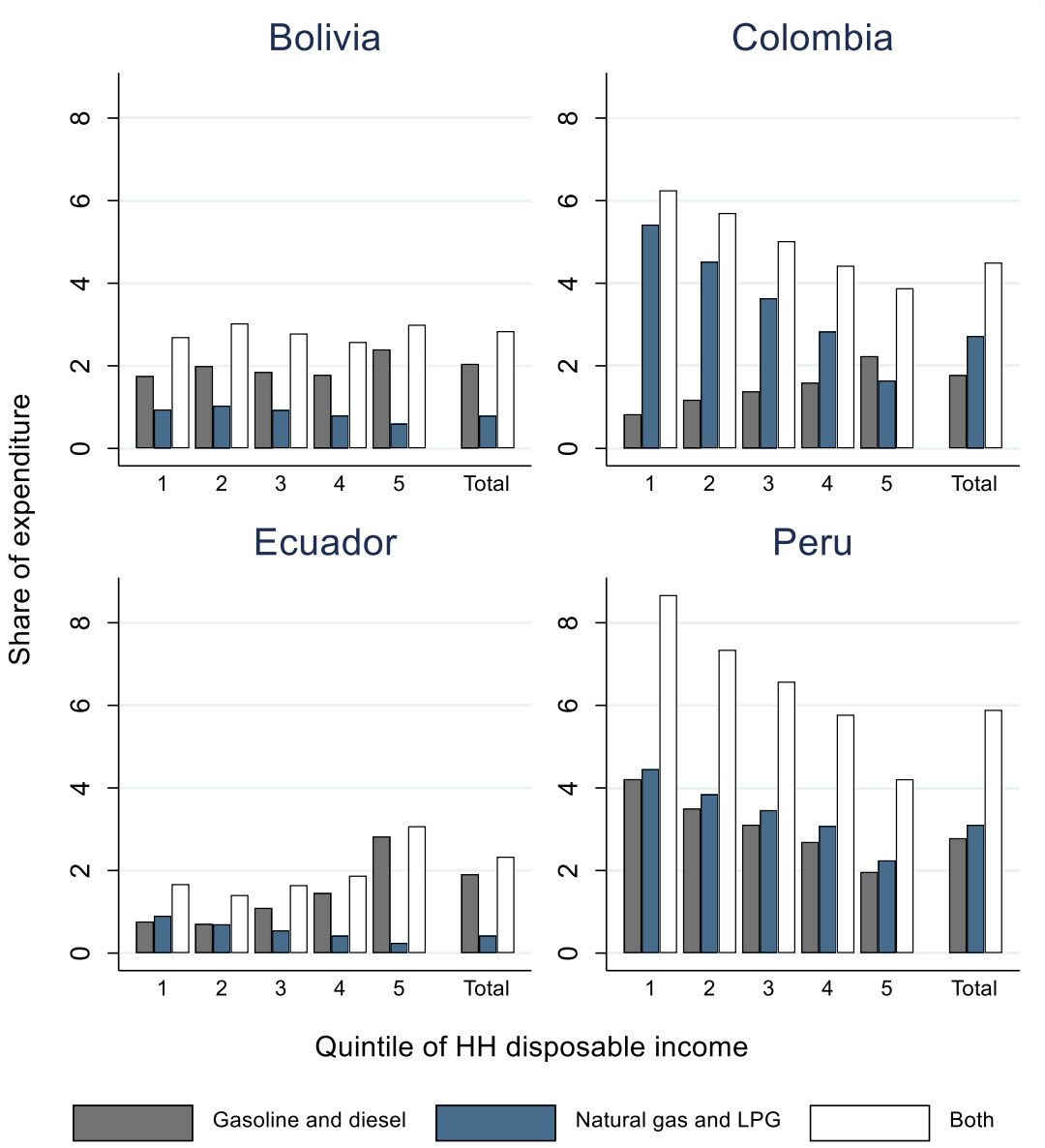
4 Results

Throughout the results section, estimates are mostly presented separately for gasoline and diesel on the one hand, and natural gas and LPG on the other hand, to reflect the subsidy policies at the most granular level the data allow and to capture the implications of fuel subsidy-specific policies. The section starts with the profile of household expenditure on fuels, followed by analyses of the direct and indirect effects of fuel subsidy reforms by looking at changes in household expenditure across the income distribution. Next, we present the results of changes in household consumable income due to the removal of fuel subsidies, and the winners and losers across different policy scenarios. Finally, we discuss the effects of fuel subsidy reforms on poverty and inequality with and without compensation via increased social protection in the countries under study.

As a starting point, Figure 1 provides a first impression of the potential distributional impact of fuel subsidy reforms, breaking down fuel expenditure as reported by households. It shows the share of fuel subsidies out of total expenditure by quintiles of disposable income for each country and by type of fuel: gasoline and diesel (grey bars), natural gas and LPG (blue bars), and both (white bars). Figure 1 shows significant variation across countries: in Bolivia, a relatively homogeneous pattern is observed in the proportion of fuel expenditure across quintiles, with minor differences between income groups. The share of fuel expenditure is low, at around 3 per cent (white bars) across quintiles. In Ecuador, the share of fuel expenditure is also low but increases with income, driven by the pattern of expenditure in gasoline and diesel (grey bars), whereas the share of expenditure in natural gas and LPG (blue bars) decreases with income. In contrast, spending on fuels as a share of

expenditure overall is higher in Colombia and Peru. In Peru, spending on both fuel types decreases with income. In Colombia, as in Ecuador, gasoline and diesel consumption increase with income, but the opposite is true for gas.

Figure 1: Share of expenditure on fuels by quintile of disposable income, by type of fuel, 2022



Source: authors' calculations based on SOUTHMOD microsimulation models.

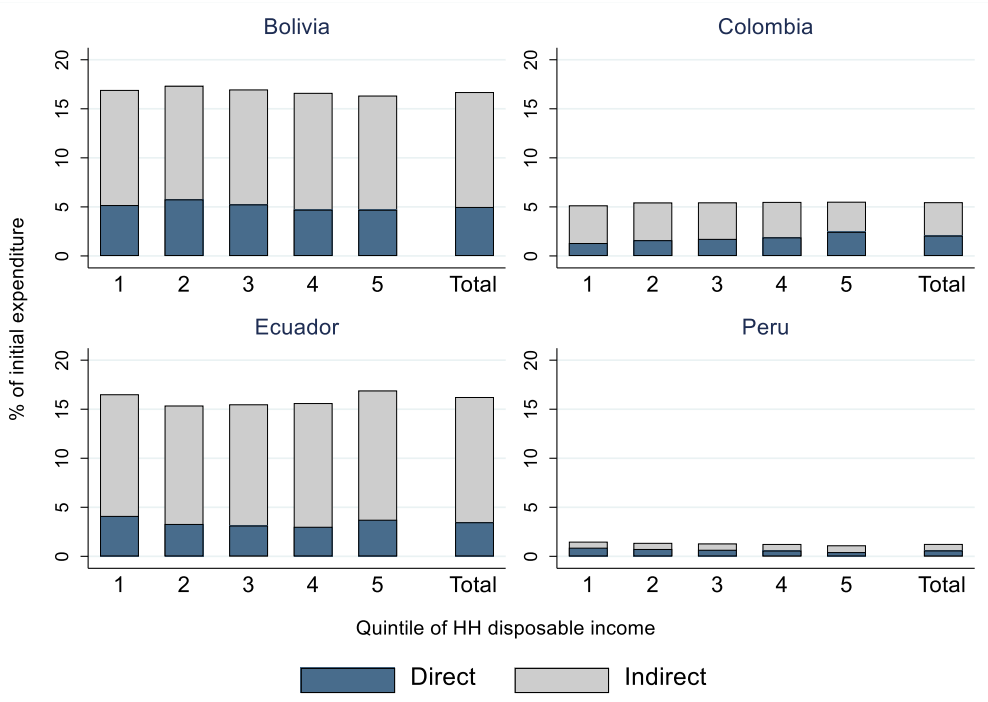
4.1 Direct and indirect distributional effects of fuel subsidy reforms

Figure 2 illustrates the potential increase in expenditure that households would face with the full removal of fuel subsidies. Results are presented by quintiles of per capita household disposable income in the baseline, distinguishing between the direct (blue bars) and indirect effects (grey bars).

The simultaneous removal of subsidies on gasoline, diesel, natural gas, and LPG would, on average, increase household expenditures by 5.4, 16, and 16.8 per cent in Colombia, Ecuador, and Bolivia, respectively. The small effect observed in Peru is explained by the fact that a 10 per cent increase in fuel prices has been simulated, as no price subsidy applies to gasoline and diesel (domestic prices in Peru are above international prices in 2022).

The results further highlight the importance of accounting for the indirect effects of fuel subsidy reforms. In all countries, indirect effects account for more than half the average increase in household expenditure: 50.3 per cent in Peru, 66 per cent in Colombia, 70 per cent in Bolivia, and 78 per cent in Ecuador. The pattern of effects across the income distribution also varies across countries. In Bolivia and Peru, the simulated reforms have a slightly regressive effect, with a larger increase in expenditures for households at the bottom of the distribution. In Ecuador, the effect follows a U-shaped pattern, with a larger increase in expenditure observed in the first and last quintiles, whereas in Colombia the effect is broadly uniform.

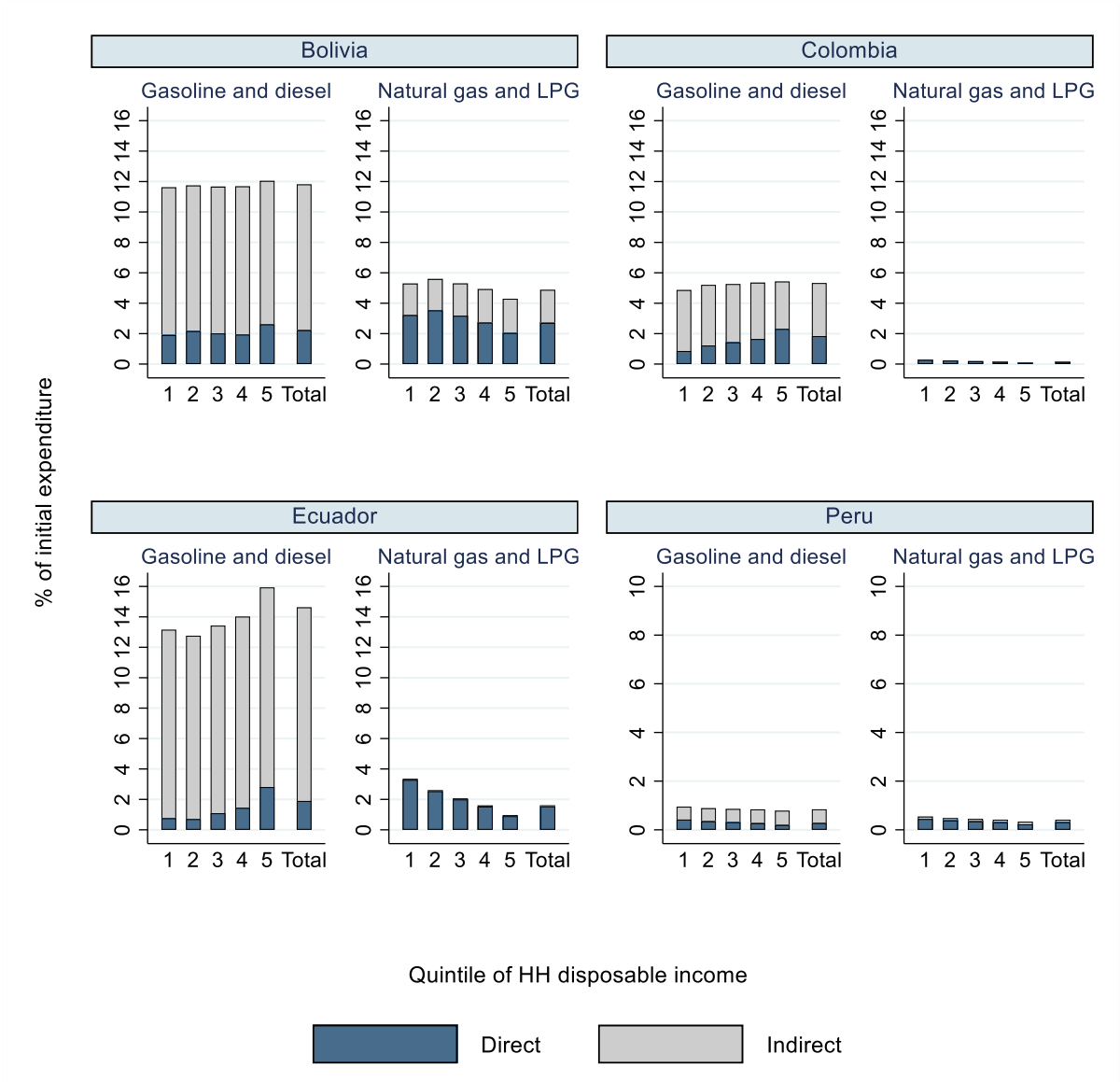
Figure 2: Direct and indirect effects of 'full removal' fuel subsidy reform on household expenditure, all fuels, 2022



Source: authors' calculations based on input–output data and SOUTHMOD microsimulation models.

The results presented in Figure 2 depict the effects of subsidy reforms for all types of fuel (i.e. gasoline and diesel, and natural gas and LPG). However, subsidy reforms for different categories of fuel are likely to have different distributional effects. To show these differences, Figure 3 presents the results of the direct and indirect distributional effects of fuel subsidy reforms with a distinction between two broad categories of fuel: (i) gasoline and diesel; and (ii) natural gas and LPG.

Figure 3: Direct and indirect effects of 'full removal' of fuels on household expenditure, by type of fuel, 2022



Note: a different y-axis scale is applied to results for Peru.

Source: authors' calculations based on input–output data and SOUTHMOD microsimulation models.

Figure 3 shows that the impact of removing subsidies on gasoline and diesel is very different from that of natural gas and LPG. In terms of gasoline and diesel, removing subsidies results, on average, in a large increase in household expenditure in Bolivia (11.8 per cent), Colombia (5.2 per cent), and Ecuador (14 per cent). In contrast, Peru experiences a small (0.9 per cent) increase, as a

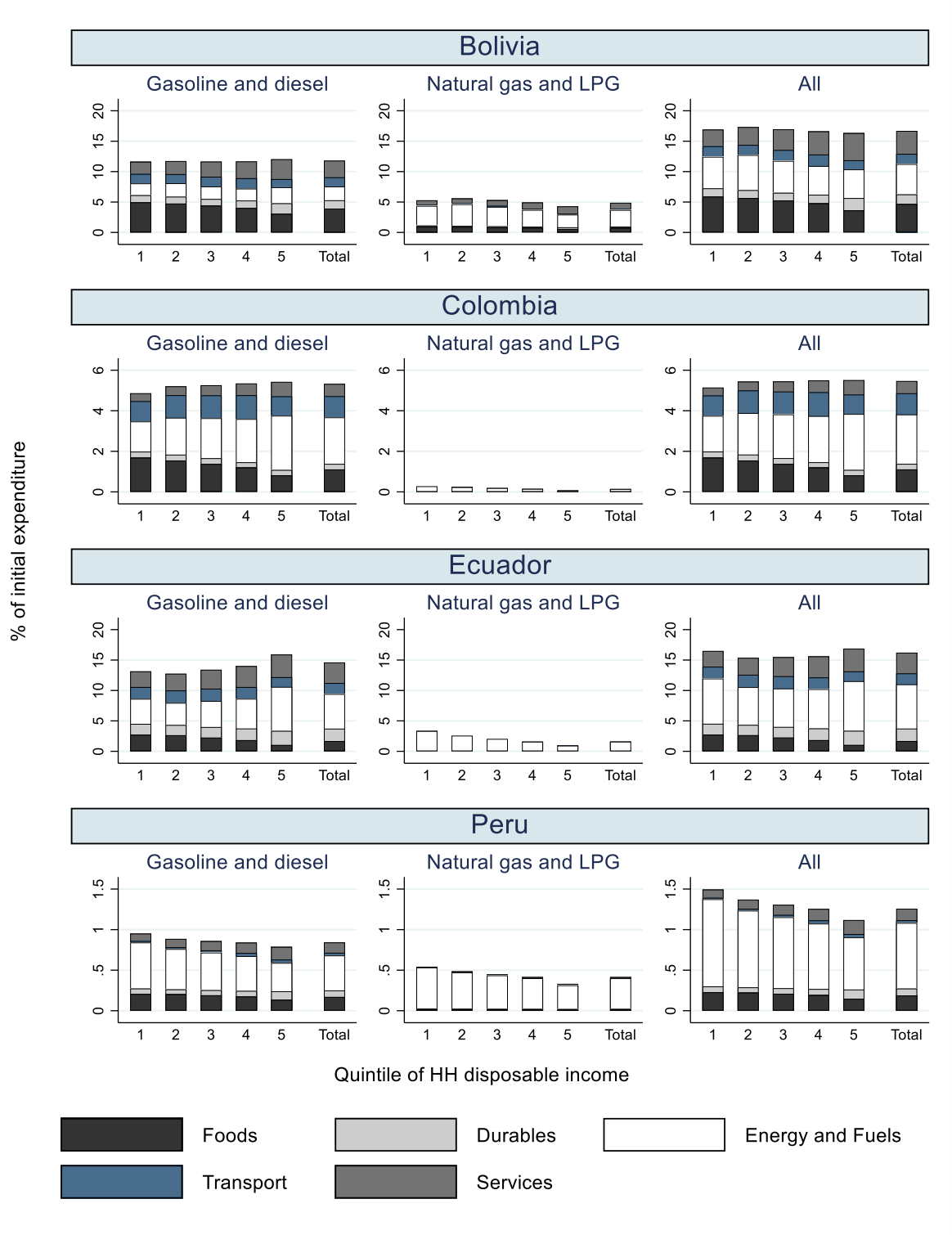
consequence of the simulated 10 per cent increase in fuel prices in this country. The removal of gasoline and diesel subsidies is progressive in Bolivia, Colombia, and Ecuador, but slightly regressive in Peru. Across all four countries, the indirect effect of the reform dominates the direct effect. Conversely, the reforms to gas and LPG subsidies are regressive in all countries and the largest contribution comes from direct effect. The largest increases in expenditures are observed in Bolivia (5 per cent) and Ecuador (2 per cent), whereas the impact is smaller in Colombia (0.2 per cent) and Peru (0.4 per cent).[20]

The stacked bar charts in Figure 4 provide a more granular picture of the price repercussions of fully removing fuel subsidies across five different expenditure categories: food and beverages (black bars), durables (light grey bars), energy and fuels (white bars), transport (blue bars), and services (dark grey bars). Considering the overall effect of removing subsidies on all types of fuel (third column), we observe that on average, for the whole population, the largest share of additional expenditure comes from expenditure on energy and fuels, followed by expenditures on food and beverages, and services. In Bolivia, Colombia, and Ecuador, transport also represents an important share of additional expenditure.

The middle column in Figure 4 shows that the additional expenditures resulting from the removal of natural gas and LPG subsidies are mostly in the energy and fuels category and apply considerably less to other categories. In contrast, increases in the prices of gasoline and diesel in the wake of subsidy removal show more variation across countries and expenditure categories (left column). In Colombia, the largest share of additional expenditures comes in the energy and fuels category (i.e. from the direct effect of fuel subsidy removal, as shown in Figure 3), followed by increased expenditure on foods. In Peru, a similar picture is observed, with expenditure on energy and fuel representing slightly more than half of additional expenditure, foods and transport representing 0.2 and 0.03 per cent of additional expenditure, respectively, and durables representing around 0.07 per cent of additional expenditure. In Bolivia and Ecuador, the additional expenditure spreads rather evenly across all five expenditure categories, documenting important indirect effects of the removal of gasoline and diesel.

[20] Our findings on direct and indirect effects are comparable to those reported by Schaffitzel et al. (2020) for Ecuador, although they do not match exactly. While both studies use the same household database, they differ in the input–output matrix employed and in the simulated price increases.

Figure 4: Additional expenditure from fuel subsidy removal, by expenditure groups, 2022



Note: different y-axis scales are applied to each country.

Source: authors' calculations based on input–output data and SOUTHMOD microsimulation models.

4.2 Changes in household income from fuel subsidy removal and compensatory mechanisms

From a purely budgetary perspective, a standalone removal of fuel subsidies translates into increased government revenue. However, such reform also acutely affects household income and ultimately welfare. In this subsection, we present the results of simulations where the additional government revenue from fuel subsidy reforms is recycled to compensate households by means of increasing the generosity of cash transfers for current beneficiaries in the countries under study. More precisely, the total revenue is equally divided between beneficiaries of existing social assistance benefits, i.e. social assistance is increased by the corresponding amount. Appendix A shows similar results for various 'perfect compensation' scenarios in which additional government revenue is used to compensate households in the first quintile from their losses due to the direct effect of fuel subsidy removal.

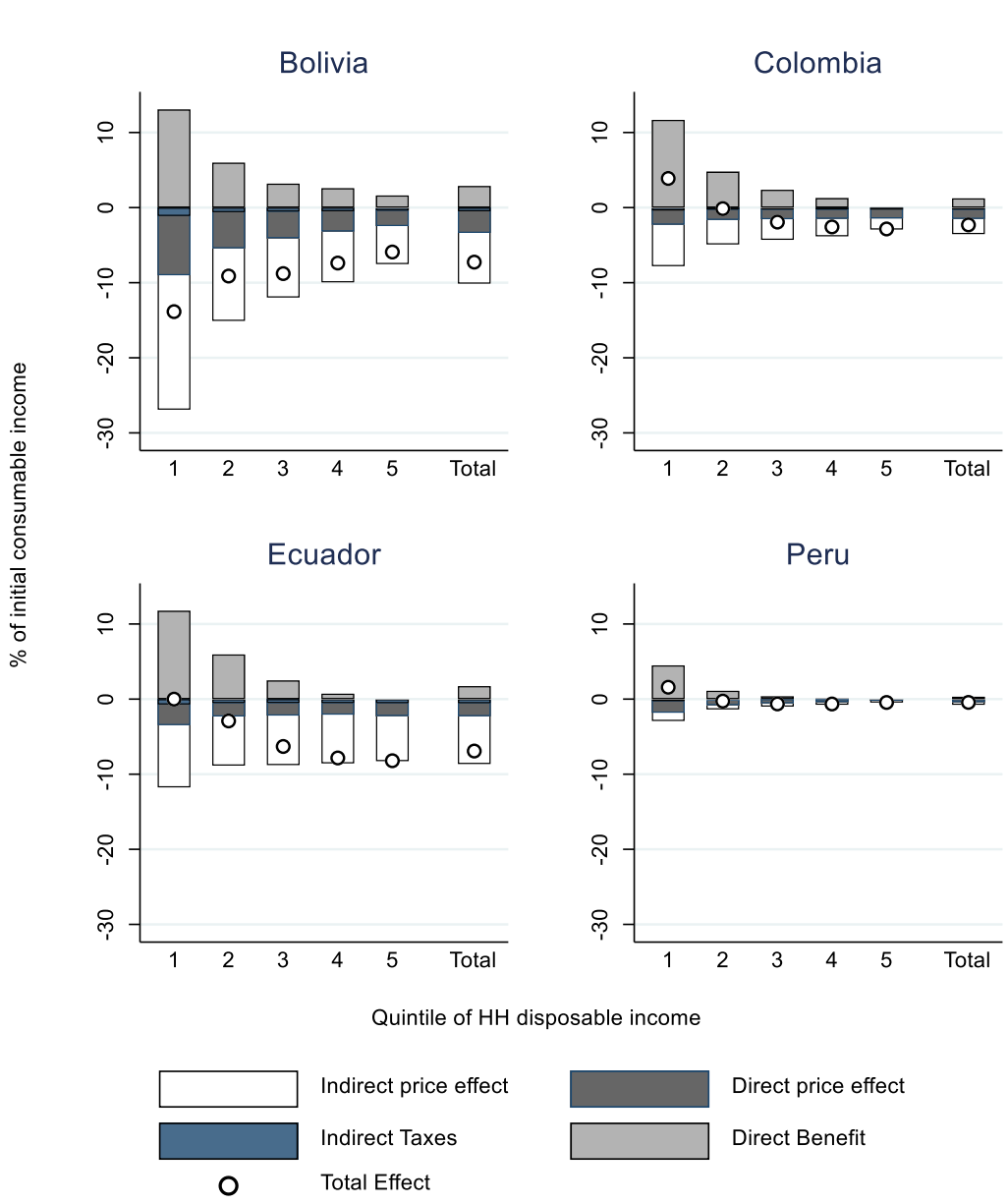
Full removal and compensation

Figure 5 shows the changes in household consumable income due to the removal of fuel subsidies and the recycling of this budget to increase the generosity of existing social assistance benefit programmes. The total change in household consumable income is depicted by the white circle in Figure 5. The total effect is decomposed into the contribution of direct (dark grey bars) and indirect (white bars) price effects of fuel subsidy reforms, the compensating effect of increased cash transfers (light grey bars), and changes in indirect taxes, mainly VAT (blue bars). Results are presented by quintiles of per capita household disposable income.

In all countries, the direct and indirect effects of fuel subsidy reforms have a larger incidence on low-income households. In Colombia and Ecuador, increased social assistance has a strong effect in the first quintile of the distribution, offsetting the negative impact of fuel subsidy removal for this income group. In Bolivia, the increased generosity of cash transfers is not sufficient to counteract the negative effect of fuel subsidy removal at the bottom of the distribution. In this country, there is a 13.9 per cent decrease in consumable income in the first quintile. The contrasting situations between Bolivia, Ecuador, and Colombia might be partly explained by differences in the targeting of cash transfers in these countries. In Ecuador and Colombia, cash transfers are proxy means-tested and aimed at households at the bottom of the distribution, whereas in Bolivia cash transfers are categorical for specific groups of the population considered vulnerable. In Peru, the average effect of the simulated 10 per cent increase in fuel prices is relatively small, although the impact is more pronounced among households in the lowest income quintile. Nevertheless, the compensatory policy substantially mitigates the adverse effects of the fuel price increase on this group.

The graph reveals the extent to which fuel subsidy reforms and compensatory measures affect different households differently in each country. Households with lower incomes tend to experience a greater negative impact, although cash transfers mitigate this effect in some cases. This highlights the importance of designing fiscal policies that consider the socioeconomic disparities and benefit systems within each country.

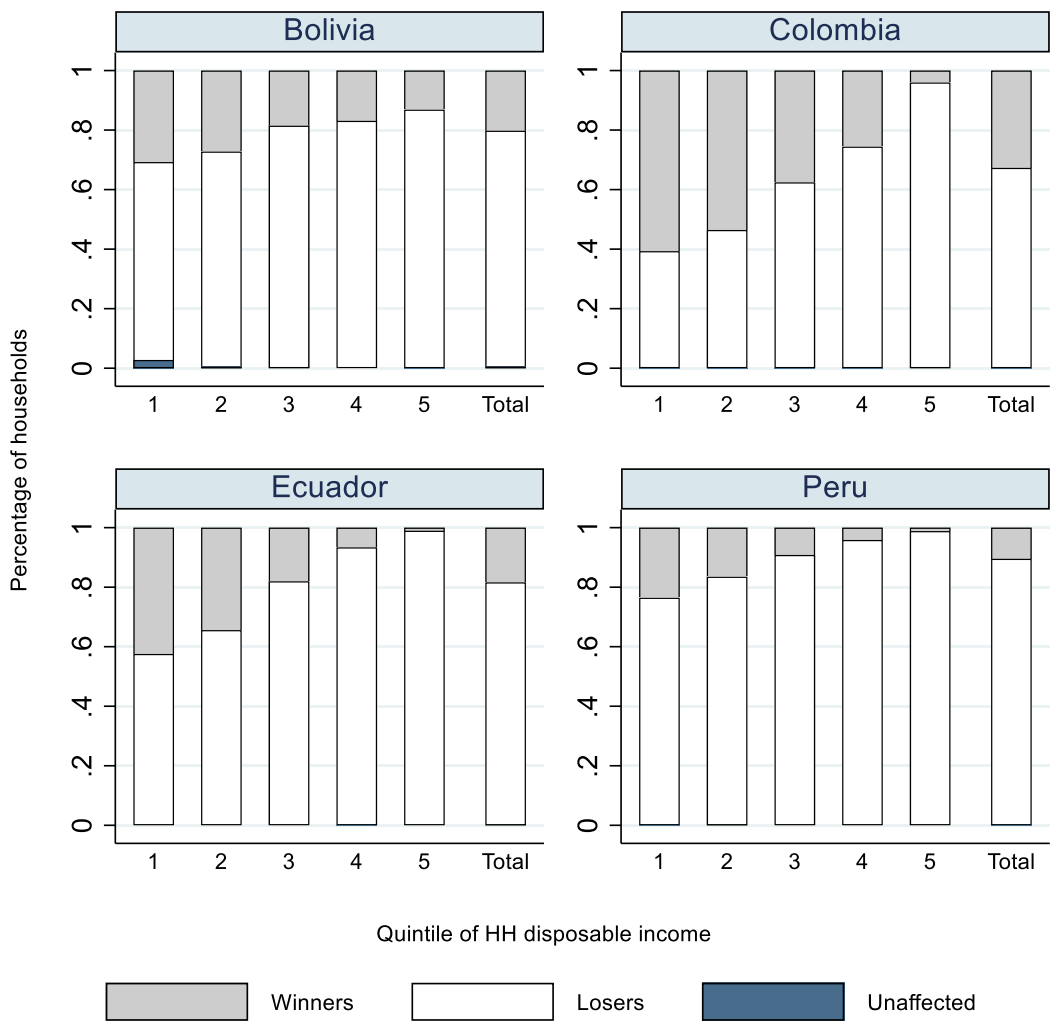
Figure 5: Changes in household consumable income: full removal, fully recycled scenario, 2022



Source: authors' calculations based on input–output data and SOUTHMOD microsimulation models.

Figure 6 shows the winners and losers of this scenario in terms of changes in consumable income. Overall (last column of each country), the reform has an important negative effect, which translates into a high percentage of losers—ranging between 67.3 per cent in Colombia and 89.5 per cent in Peru. The increased generosity of social assistance benefits households in the lowest quintile, where the proportion of winners represents 23.5 per cent in Peru, 30.7 per cent in Bolivia, 42.4 per cent in Ecuador, and 60.7 per cent in Colombia. The percentage of winners falls as income increases, reflecting the targeting of existing social assistance programmes.

Figure 6: Share of winners and losers in terms of consumable income: full removal, fully recycled scenario, 2022

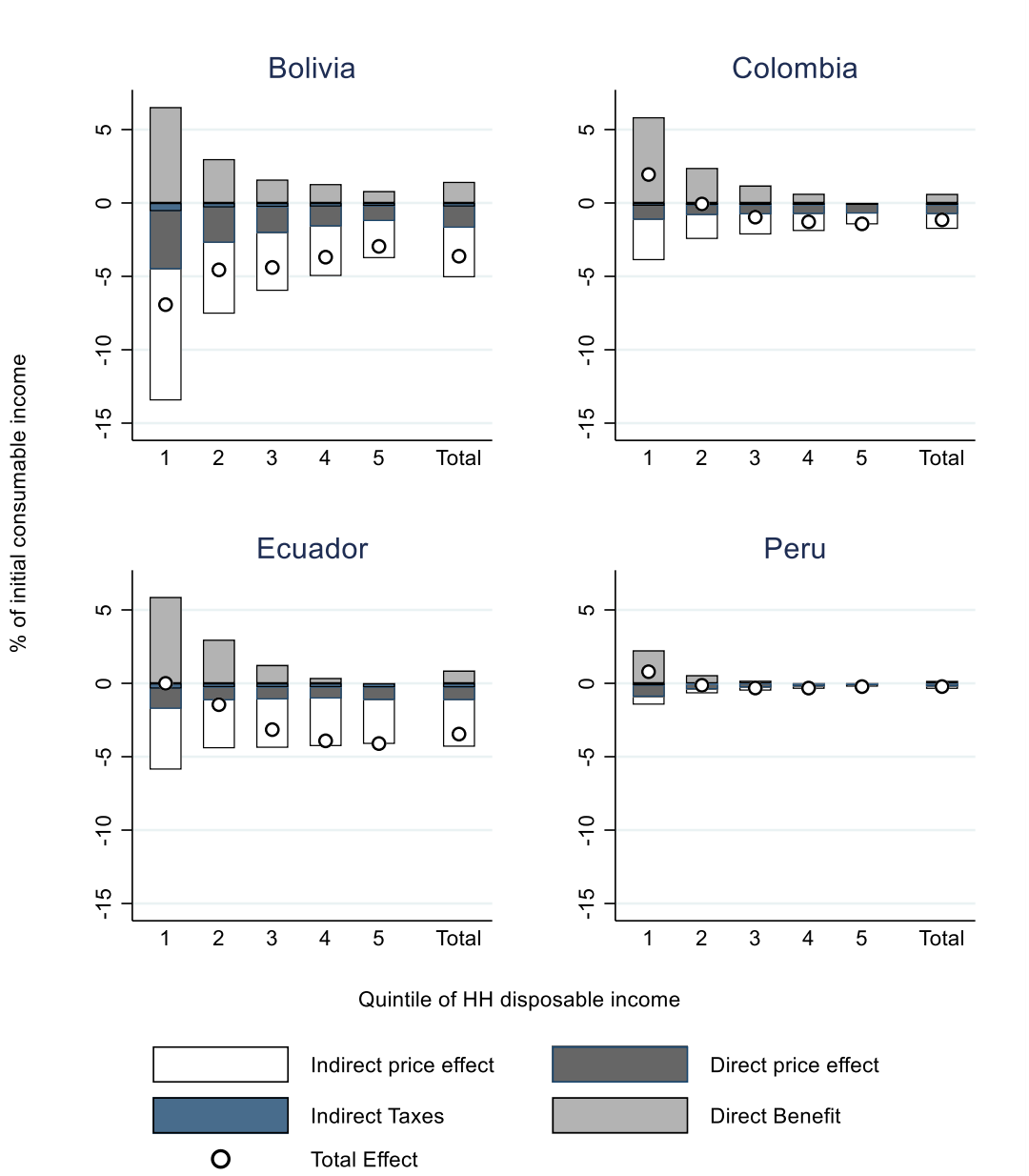


Source: authors' calculations based on input–output data and SOUTHMOD microsimulation models.

Half removal and compensation

Figure 7 shows the effects of reform when only 50 per cent of fuel subsidies are removed and the recycling of this budget is used to increase the generosity of existing social assistance benefits. The direction of results is similar to that in the previous scenario. In Bolivia, households in the first quintile are more affected by the direct and indirect effects of the reform and by the change in VAT, resulting in a combined reduction of 13.5 per cent of consumable income. In contrast, the impact of these effects is lower in Colombia and Ecuador, with an effect of 3.9 and 5.9 per cent for the first quintile, respectively. However, in Colombia, Ecuador, and Peru, the increased social assistance compensation mechanism offsets the negative effect in the first quintile. Conversely, in Bolivia, the compensation does not fully counteract the negative effect, with a total effect representing a reduction of 6.9 per cent relative to consumable income for the first quintile. Overall, for all four countries and the remaining quintiles, the total effect observed is negative.

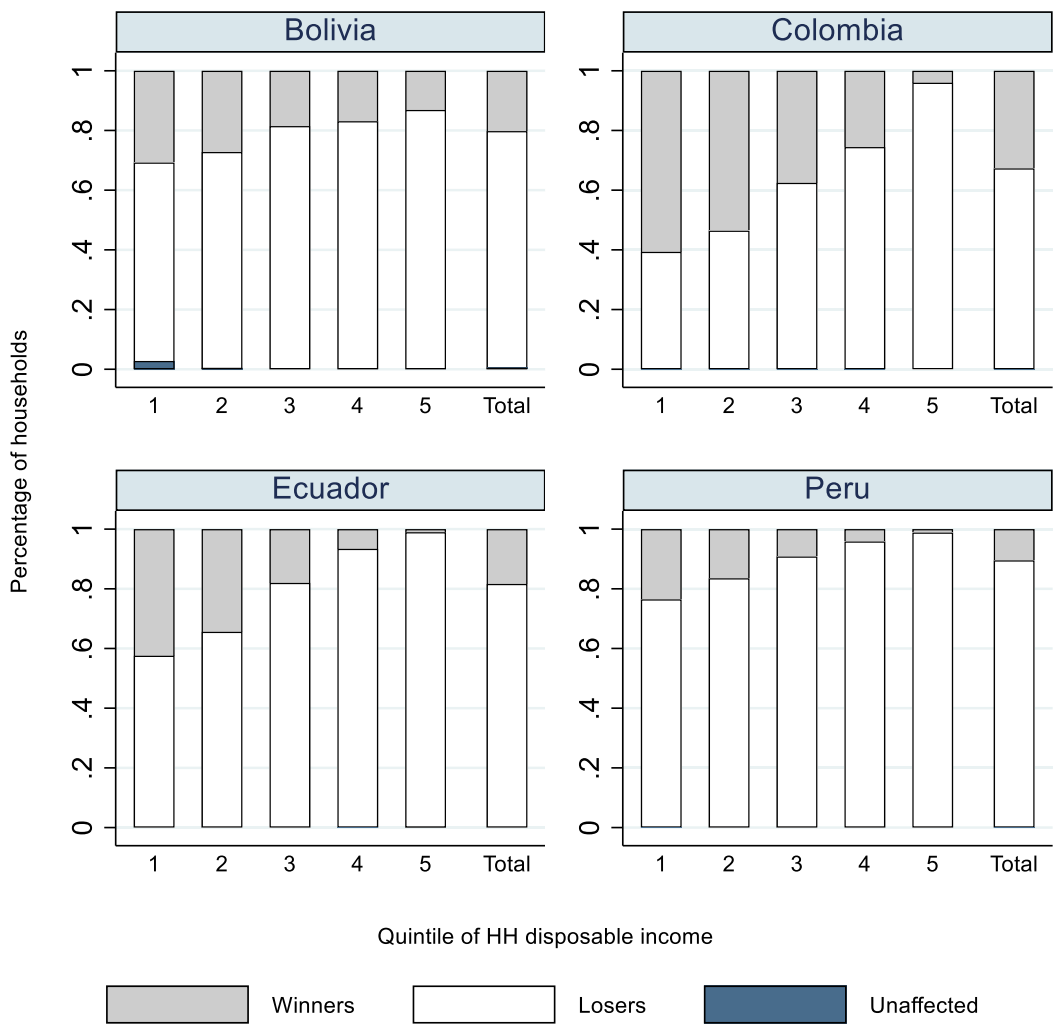
Figure 7: Composition of changes in household consumable income: half removal, fully recycled scenario, 2022



Source: authors' calculations based on input–output data and SOUTHMOD microsimulation models.

Figure 8 shows the winners and losers in terms of changes in consumable income under this scenario. The pattern of winners and losers is identical to that of the previous scenario because both the government revenue from the subsidy removal and (therefore) the increased amount to be allocated to beneficiaries of social assistance have proportionally decreased by 50 per cent.

Figure 8: Share of winners and losers in terms of consumable income: half removal, fully recycled scenario, 2022

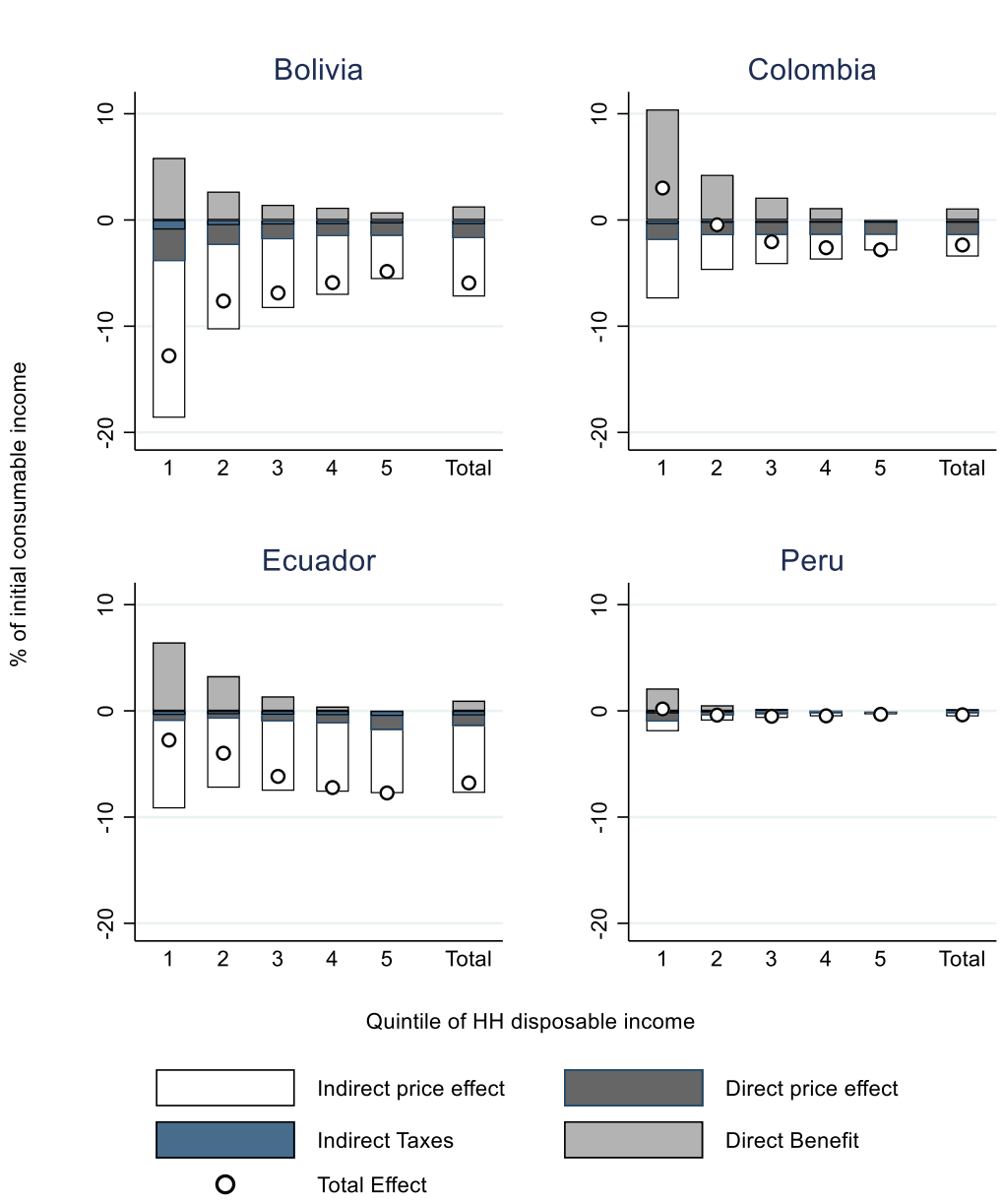


Source: authors' calculations based on input–output data and SOUTHMOD microsimulation models.

Gasoline and diesel removal and compensation

Figure 9 shows the total effect relative to consumable income when subsidies on gasoline and diesel are removed, and the total revenue collected is recycled to compensate social assistance beneficiaries. In Bolivia and Ecuador, the compensation measure does not fully mitigate the impact of removing gasoline subsidies. However, in Ecuador, the total effect for the first quintile is smaller than for the other quintiles, representing a 2.8 per cent reduction in consumable income. On the other hand, in Colombia and Peru, the compensating benefits offset the negative effects of subsidy removal for households in the first quintile, resulting in a total effect of 3 and 0.2 per cent, respectively.

Figure 9: Composition of changes in household consumable income: gasoline and diesel removal, fully recycled scenario, 2022

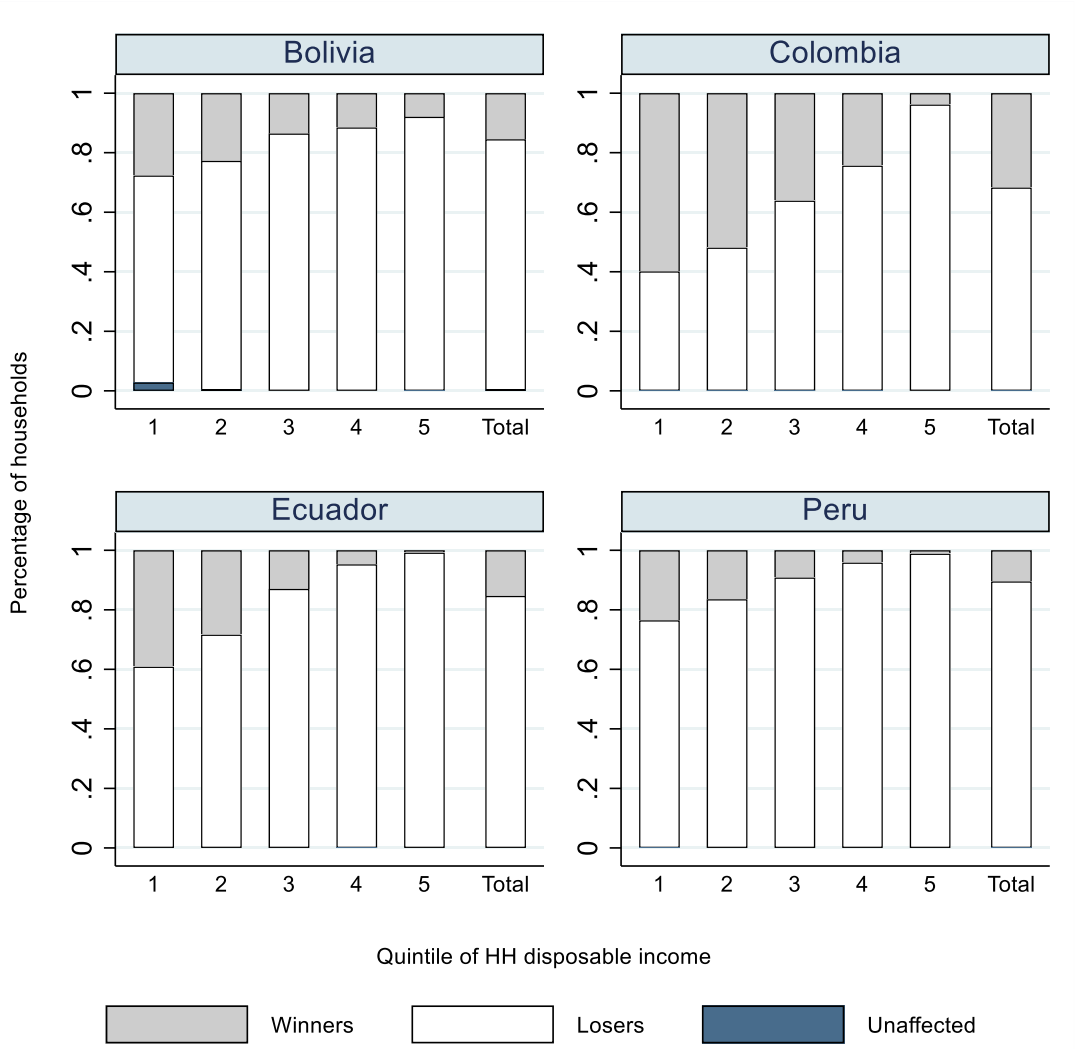


Source: authors' calculations based on input–output data and SOUTHMOD microsimulation models.

Figure 10 shows the winners and losers in terms of changes in consumable income when subsidies on gasoline and diesel are removed and the total revenue collected is recycled to compensate social assistance beneficiaries. Compared with the previous scenario, the average share of winners declines in all four countries. The largest reductions are observed in Bolivia and Ecuador, where the proportion of winners decreases by 4.7 and 3.0 percentage points (pp), respectively. Overall, winners are more prevalent among households in the lower income quintiles. In the first quintile, the proportion of winners is 23.5, 27.7, 39.1, and 59.9 per cent in Peru, Bolivia, Ecuador, and Colombia, respectively. Notably, Colombia is the only country where winners outnumber losers in both the first and second

quintiles. The corresponding shares of losers are 40.1 per cent in the first quintile and 48.1 per cent in the second.

Figure 10: Share of winners and losers in terms of consumable income: gasoline and diesel, fully recycled scenario, 2022



Source: authors' calculations based on input–output data and SOUTHMOD microsimulation models.

4.3 Changes in income poverty and inequality

This subsection analyses the impact of fuel subsidy reforms on income poverty and inequality in terms of consumable income. Three scenarios are considered in relation to baseline indicators of poverty and inequality. Scenario 1 (S1) considers the effect of a full removal of fuel subsidies without any compensation in terms of social assistance. Scenario 2 (S2) corresponds to a counterfactual where fuel subsidies have been removed and the additional government revenue from the fuel subsidy removal is fully recycled to increase social assistance benefits to current beneficiaries (as in the

previous section). In Scenario 3 (S3) half of the fuel subsidies are removed and social assistance beneficiaries are compensated. Finally, in Scenario 4 (S4), only gasoline and diesel subsidies are removed and social assistance beneficiaries are compensated. Inequality and poverty indicators are based on per capita household consumable income. National poverty and extreme poverty lines are used in the analysis.[21]

Table 8 presents changes in inequality under our baseline and counterfactual scenarios. Overall, the effects of the proposed reforms on inequality are relatively small for all countries. Results show that following the removal of fuel subsidies under S1, inequality measured by the Gini coefficient increases slightly in all countries. Under S2, the Gini coefficient declines relative to the baseline in Colombia, Ecuador, and Peru by 0.005, 0.011, and 0.001 points, respectively. Bolivia is the only exception, with an increase of 0.010 points. Notably, the largest reduction in the Gini coefficient in Colombia and Ecuador is observed under S2. The results based on the Theil index are broadly consistent with these findings.[22]

Relative to the 'full recycling' scenario, in the 'half removal' scenario Gini coefficients are slightly higher in all countries bar Bolivia, for which we observe a 0.006 Gini point decrease. Similar results are found for S4, where inequality results are slightly worse than in the 'full removal, full recycling' scenario for all countries except Bolivia.

Table 8: Changes in income inequality (Gini coefficient) by scenario, 2022

	Baseline	Full removal		Half removal	Only gasoline and diesel
		No compensation (S1)	Full recycling (S2)	Full recycling (S3)	Full recycling (S4)
Bolivia	0.453	0.473	0.463	0.457	0.460
Colombia	0.553	0.558	0.548	0.550	0.549
Ecuador	0.444	0.448	0.433	0.438	0.436
Peru	0.482	0.484	0.481	0.482	0.482

Source: authors' calculations based on input–output data and SOUTHMOD microsimulation models.

The effect of the reforms in terms of income poverty is more pronounced when poverty is measured in terms of consumable income, as shown in Table 9. In all countries, poverty increases under S1 (full removal of fuel subsidies without compensation), although to different extents across countries. The largest increases are observed in Bolivia and Ecuador, where poverty increases by 5.1 and 4.1 pp, respectively, whereas poverty increases by 2 pp in Colombia and 0.4 pp in Peru. The smallest increase is observed in Peru, where it is most likely related to the small increase in fuel prices simulated for this country. The results under S2 highlight the important role of expanded social

[21] In 2022, according to the World Bank (n.d.), national poverty lines were set at the following values: BOB574.2, COP390,998.1, USD115.8, and PEN479.1 for Bolivia, Colombia, Ecuador, and Peru, respectively. National extreme poverty lines were set at the following values: BOP207.5, COP141,324.6, USD41.8, and PEN173.2 for Bolivia, Colombia, Ecuador, and Peru, respectively.

[22] These results can be made available upon request to the authors.

assistance in mitigating the adverse effects of removing fuel subsidies on households. Although poverty still increases in all countries, the rise is smaller than in S1.

The smallest increases in poverty are observed across all countries under S3, in which only 50 per cent of fuel subsidies are removed. Removing only gasoline and diesel subsidies marginally increases poverty in all countries relative to the baseline, with results ranging from 2.2 pp in Bolivia to 0.3 pp in Peru.

Table 9: Income poverty rates (%) by scenario, 2022

	Baseline	Full removal		Half removal	Only gasoline and diesel
		No compensation (S1)	Full recycling (S2)	Full recycling (S3)	Full recycling (S4)
Bolivia	24.4	29.5	27.1	25.8	26.6
Colombia	44.4	46.4	44.9	44.6	45.0
Ecuador	19.4	23.5	20.2	19.6	20.6
Peru	44.7	45.1	45.0	44.9	45.0

Note: percentages are the ratio of poor people to total population multiplied by 100.

Source: authors' calculations based on input–output data and SOUTHMOD microsimulation models.

5 Conclusions

This paper analyses the distributional effects of fuel subsidy reforms in four Andean countries: Bolivia, Colombia, Ecuador, and Peru. For this purpose, we combine detailed tax–benefit microsimulation models with input–output data analysis. A full removal of fuel subsidies is simulated in Bolivia, Colombia, and Ecuador, where domestic fuel prices are set at significant lower levels than international prices. A benchmark 10 per cent increase in fuel prices is simulated in Peru, where fuel prices are broadly liberalized. To mitigate the negative impact of the reforms on household income, we simulate an increase in the generosity of existing social protection programmes, making use of the additional government revenue from fuel subsidy removal.

Our analysis shows that the removal of fuel subsidies has a negative impact on household welfare, in particular for households at the bottom of the income distribution. Using the additional government revenue generated from fuel subsidy reforms to increase the generosity of existing cash transfer programmes mitigates the negative impact at the bottom of the distribution and reduces poverty, although to different extents across countries. This effect is related to the design of social protection programmes, which might target households at the bottom of the income distribution differently.

Our analysis highlights the advantage of combining different research infrastructures for the analysis of fuel subsidy reforms. SOUTHMOD microsimulation models provide detailed information about the design and the parameters of tax–benefit policies in selected countries of the Global South, and, when combined with harmonized input–output tables from the GTAP, allow us to account for the direct and indirect effects of fuel subsidy reforms. Such a linkage can be further exploited for the analysis of the distributional impact of climate change policies such as carbon taxes and the role played by social protection in mitigating their impact on household welfare.

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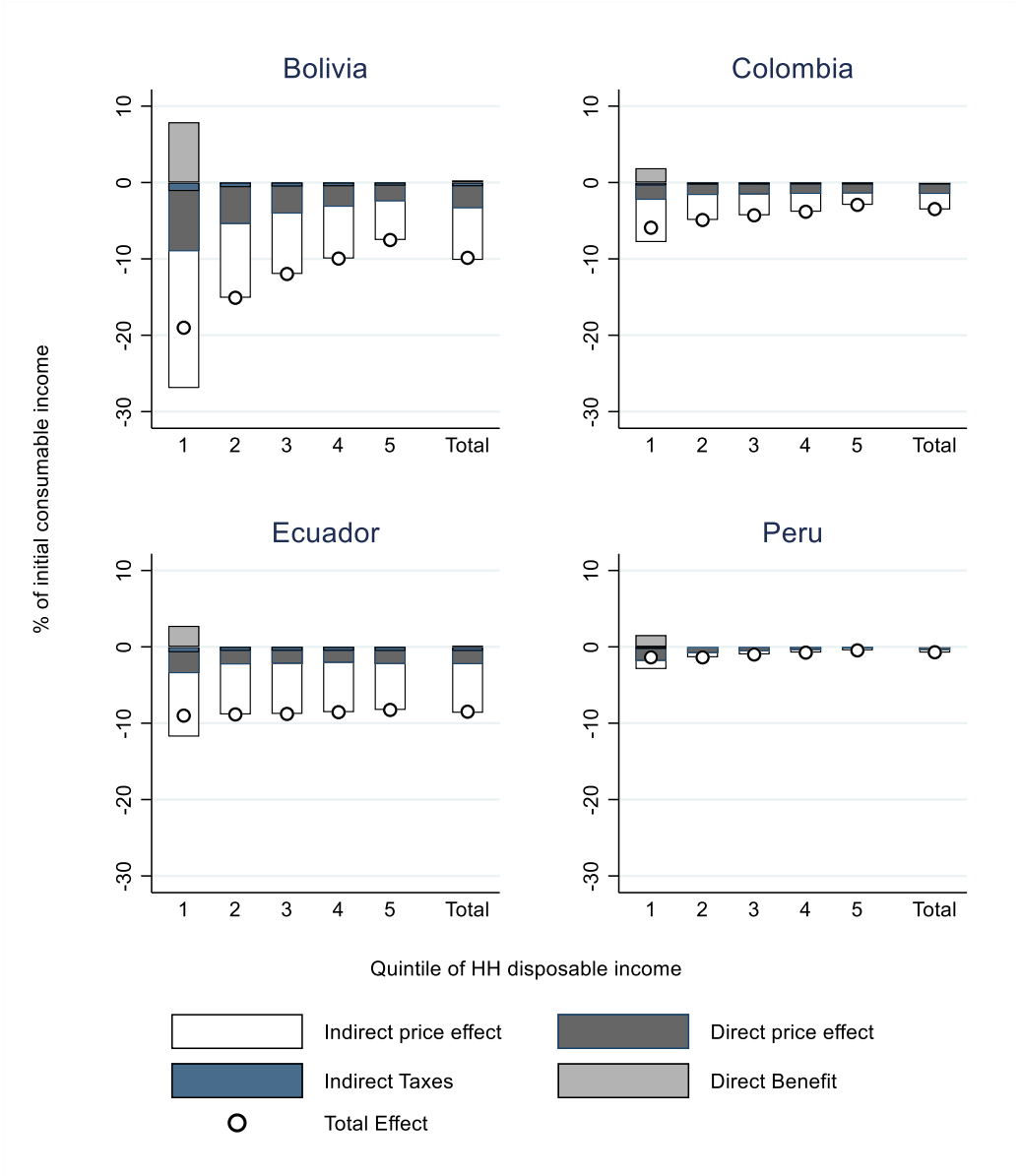
Appendix A – ‘Perfect compensation’ scenarios

Figure 1A shows the change in household consumable income when fuel subsidies are removed and households in the first quintile of per capita disposable income are compensated with an equivalent amount to the indirect benefit lost, i.e. the direct increase in prices.

Figure 1A: Composition of changes in household consumable income: full removal of fuel subsidies and compensating those in the first quintile



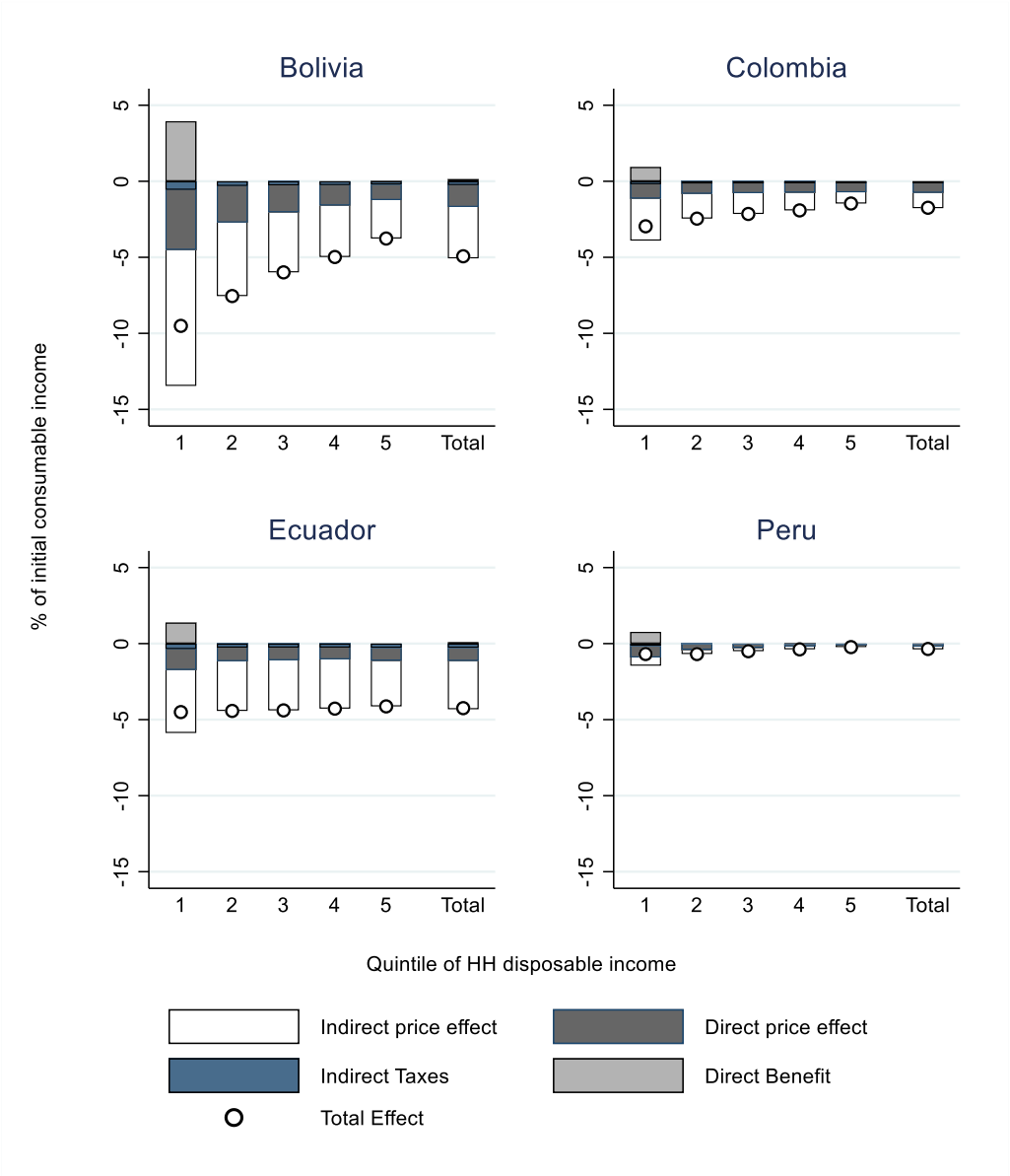
Source: authors’ calculations based on input–output data and microsimulation models.

Overall, in the four countries, the compensation for the first quintile does not fully offset the negative effects but results in a 26.9, 7.8, 11.8, and 2.9 per cent combined negative effect in terms of consumable income for this quintile in Bolivia, Colombia, Ecuador, and Peru, respectively.

Additionally, the policy has a greater negative impact on lower-income households, and compensating those in the first quintile counteracts part of the effect, making its impact less severe for them.

Figure 2A shows the effects when 50 per cent of fuel subsidies are removed and households in the first quintile of per capita disposable income are compensated with an equivalent amount.

Figure 2A: Composition of changes in household consumable income: half removal of fuel subsidies and compensating those in the first quintile



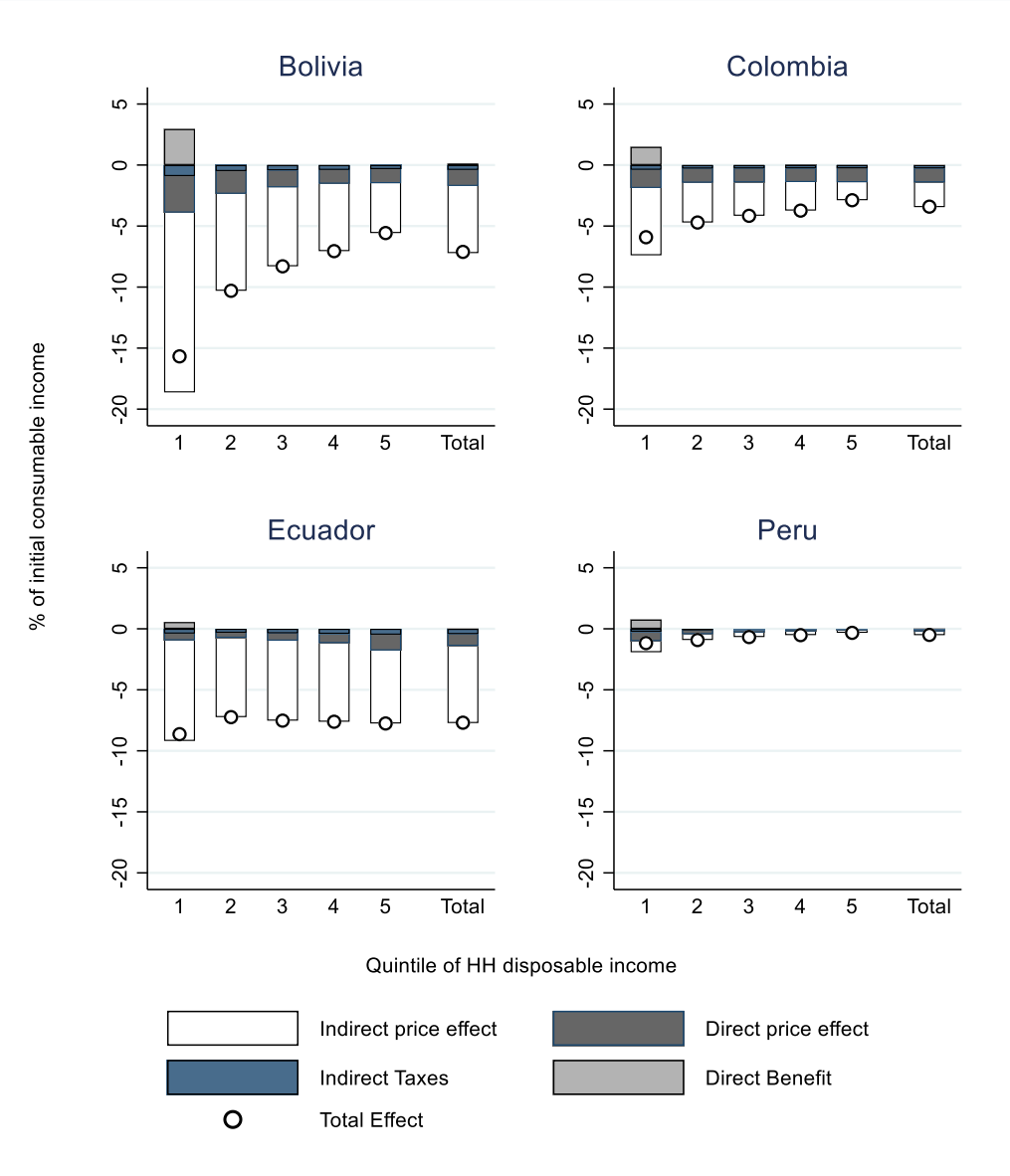
Source: authors' calculations based on input–output data and microsimulation models.

Overall, the compensation for the first quintile in all four countries does not fully offset the negative effects. Consequently, consumable income in this quintile declines by 9.5 per cent in Bolivia, 3.0 per cent in Colombia, 4.5 per cent in Ecuador, and 0.7 per cent in Peru. In Bolivia and Ecuador, the impact of subsidy removal, the indirect effects, and the impact of changes in VAT are more

pronounced among the lowest-income households. This results in a combined negative effect relative to consumable income of 13.5 per cent in Bolivia and a 5.9 per cent in Ecuador for the first quintile. In contrast, the impact of these changes is smaller in Colombia, where the total effect amounts to 3.9 per cent.

Figure 3A shows the change in consumable income when subsidies on gasoline and diesel are removed and households in the first quintile of per capita disposable income are compensated with an equivalent amount to the subsidy removed.

Figure 3A: Composition of changes in household consumable income: gasoline and diesel removal of fuel subsidies and compensating those in the first quintile



Source: authors' calculations based on input–output data and microsimulation models.

Overall, in all four countries, compensation for the first quintile does not fully offset the negative effect. This results in a decrease in consumable income of 15.7, 5.9, 8.6, and 1.2 per cent for this quintile in Bolivia, Colombia, Ecuador, and Peru, respectively.

Appendix B: Structure of the GTAP SAM

Table B1: Structure of the GTAP social accounting matrix

	Imported commod.	Domestic commod.	Activities	Factors	Regional household	Private household	Trade taxes	Import sales taxes	Domestic sales tax	Factor taxes	Prod'n taxes	Direct taxes	Gov't	Capital	Import margins	Export margins	Rest of world	Total
Imported commod.			Intermediate inputs			Private demand							Government demand	Investment demand				
Domestic commod.			Intermediate inputs			Private demand							Government demand	Investment demand		Exports of transport services	Exports of goods and services	
Activities		Supply matrix																
Factors			Payments to factors															
Regional household				Distributed factor incomes			Import and export duties	Import sales taxes	Domestic sales taxes	Factor use taxes	Production taxes	Income taxes						
Private household					Private household income													
Trade taxes	Import duties	Export duties																
Import sales taxes			Sales taxes – imports			Sales taxes – imports							Sales taxes – imports	Sales taxes – imports				
Domestic sales tax			Sales taxes – domestic			Sales taxes – domestic							Sales taxes – domestic	Sales taxes – domestic				
Factor taxes			Factor use taxes															
Production taxes			Production taxes															
Direct taxes				Factor income taxes														
Gov't					Government income													
Capital				Depreciation	Savings											Trade balance	Trade balance	
Import margins	Transport margins on imports																	
Export margins															Imports of transport services			
Rest of world	Imports of goods and services																	
Total																		

Source: authors' construction based on McDonald and Thierfelder (2004).