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ABSTRACT

Carbon Pricing and Household Burdens in Newly Affluent Countries – an Application to Lithuania*

We assess household burdens from a carbon tax with revenue recycling, comparing them to burdens from price changes during the recent cost-of-living crisis. We focus on Lithuania, an OECD country that attained high-income status a decade ago, and that recently enacted a €60/ton CO2 carbon tax despite a challenging policy context, with high poverty rates and concerns about the affordability of energy. Households spend large parts of their budget on energy, but the impact of the carbon tax on overall cost of living is modest (3% on average), substantially smaller than the impact of inflation between 2021-24 (36%). Direct carbon-tax burdens, from higher fuel prices, fall disproportionately on lower-income households. But indirect effects, from higher prices of goods other than fuel, are sizeable and broadly "flat" across the income distribution, which dampens regressivity. We simulate seven different options for compensating households by recycling carbon-tax revenues back to them through transfers or by lowering other taxes. When carefully designed, revenue recycling allows considerable scope for cushioning burdens, and for addressing concerns about disproportionate costs for some groups of households and voters.

JEL Classification: C8, D12, D31, H23, Q52

Keywords: carbon pricing, revenue recycling, inflation, inequality

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1. Introduction

As part of strategies to tackle the causes of climate change, different forms of carbon pricing, such as carbon taxes, cap-and-trade systems and phase-outs of fossil-fuel subsidies, have been introduced or proposed to shift the marginal private cost of carbon towards its marginal social cost. These measures incentivise a reduction in emissions and the substitution of cleaner for dirtier fuels and technologies. They are recommended for their environmental effectiveness, because they are administratively simple and economically efficient, without being technologically prescriptive, and because they do not weigh on government budgets but, instead, create revenue (High-Level Commission on Carbon Prices, 2017; Pigou, 1920; Nordhaus, 1991; Pearson & Smith, 1991).

Across countries, including in the high-income OECD area, current carbon prices are well below levels that are considered in line with national and international commitments, notably the targets affirmed in the Paris Agreement (OECD, 2022). Numerous governments are therefore considering reforms to introduce or increase them. A particular challenge for carbon-pricing initiatives is their distributional impact, however. Mitigation policies are needed to prevent catastrophic impacts of climate change, and the associated costs for societies. In the short term, there can nevertheless be notable trade-offs between the intended incentives from higher carbon prices, and unintended distributional effects (Baranzini, Goldemberg, & Speck, 2000; Baumol & Oates, 1988). The pattern of these short-term gains and losses from climate-change mitigation measures, in turn, is a key driver of public and political support for fighting climate change (Büchs, Bardsley, & Duwe, 2011; Tatham & Peters, 2022). Understanding the size and incidence of household burdens from climate-change mitigation, even if temporary, is important for social welfare reasons (Baumol & Oates, 1988; Budolfson, et al., 2021). It is also a key input into designing mitigation measures that governments can afford, and that voters are likely to support (Beiser-McGrath & Bernauer, 2019).

Carbon pricing tends to be less regressive at lower GDP levels because significant shares of the population cannot afford to fully satisfy their energy needs. Nonetheless, with binding spending constraints among the poor and other disadvantaged groups, even small price increases can create significant welfare losses. The relationship between national income and emissions, and consequently carbon-price burdens, is well documented (Dorband, Jakob, Kalkuhl, & Steckel, 2019; Dasgupta, Laplante, Wang, & Wheeler, 2002), but non-linear and dependent on climate and other contextual factors (Ivanova, et al., 2017). As countries transition to higher income levels, poorer and middle-class households tend to spend growing shares of their budgets on energy, e.g., as they rely more on motorized vehicles and transition away from traditional biomass for heating. During that transition, lower-income households can therefore be especially exposed to energy price shocks. They are typically also ill-equipped to draw on savings, invest in energy-saving technology, or reduce other expenditures, and may therefore need to cut back on essentials (OECD, 2022; Sologon D. , O'Donoghue, Linden, Kyzyma, & Loughrey, 2025 (forthcoming)). Distributional impacts can be felt more strongly in countries with a high incidence of low household income or poverty, and where energy is a necessity due to climate conditions.

This paper studies the impact of a carbon charge recently adopted in Lithuania. Like other EU and OECD countries, Lithuania faces considerable need and pressures to reduce emissions (OECD, 2021). Lithuania is a high-income country, but with national income lower than in comparator countries. It joined the OECD in 2018 and, despite high growth rates, GDP remains below EU and OECD averages. Poverty rates are among the highest in Europe and households spend large parts of their budgets on energy. The affordability of necessities and associated equity concerns are therefore important concerns in national debates of price-based climate-change mitigation measures. The recent cost-of-living crisis has further heightened attention to household burdens from high or rising prices, and to higher energy prices in particular.

Regressive effects of carbon pricing, or a concentration of losses among specific groups, may therefore call for accompanying measures to compensate losers, while maintaining the fundamental price signals from carbon pricing (Carattini, Carvalho, & Fankhauser, 2018; World Bank, 2019). Compensation should be timely and may need to be suitably targeted to make it cost-effective, notably in a context of tightening fiscal space. Suitably designed, compensation for households can increase political support for carbon pricing by easing concerns over impacts on living costs (Beiser-McGrath & Bernauer, 2019).

The paper makes three main contributions to this debate and to the literature. First, we undertake the first comprehensive distributional analysis of carbon pricing for Lithuania, an EU country and OECD member with lower GDP and higher poverty rates than in comparator countries. Previous studies have analysed carbon-pricing burdens in upper-middle-income countries (e.g. Renner (2018) for Mexico, Rosas-Flores et al. (2017) for Peru), but there is limited evidence for countries that transitioned to the high-income group of countries relatively recently (e.g., Antosiewicz et al. (2022) in Poland). Second, we carefully examine options for compensating households, providing a richer assessment of revenue recycling than is typical in the literature, quantifying gains and losses, and estimating the number of gainers and losers, as key metrics related to voter support. We analyse seven different compensation policies, including cash transfers and tax reductions that commonly feature in policy debates. Third, we account for recent price and income changes to make results more realistic and, arguably, more policy relevant in the context of rapid changes in the cost of living. Much of the literature on the distributional impacts of carbon charges considers hypothetical carbon prices that are specified in nominal terms, evaluating their impact using income and consumption data that is between 5 and 10 years old. In periods of moderate to high inflation, such analysis can quickly become outdated and can be a blunt guide for policy. In the discussion, we compare the household burdens from carbon pricing with those from other price increases, which are unrelated but sometimes confounded in public and political debates.

The remainder of the paper is structured as follows. Section 2 briefly sketches the policy context for carbon taxes. Section 3 gives an overview of past assessments of their distributional impact. Section 4 lays out the methodology and describes the data. Section 5 presents results, distinguishing between (i) direct effects of carbon pricing on households' living standards (via their fuel consumption), (ii) indirect effects (via consumption of other goods and services with different carbon content), and (iii) effects of household compensation that can be financed from carbon-tax revenues. Section 6 compares burdens resulting from the carbon tax, with those from the recent cost of living crisis.

2. Carbon tax: policy context in Lithuania and internationally

Carbon taxes were first introduced in Finland in 1990 and in Norway in 1991. By 2019, 67 jurisdictions operated explicit carbon pricing schemes (Ramstein, et al., 2019). In Europe, 20 countries had implemented a carbon tax in 2021 with rates ranging from 75 cent/tonne of CO2 in Ukraine to 120 Euro/tonne in Switzerland. The OECD's (2022) Tax Policy Reforms report notes that "promoting environmental sustainability has become increasingly central to the policy goals of taxing energy and vehicle use", and successive editions provide additional details on new or higher carbon taxes that are planned or were recently adopted (e.g., in Austria, Canada, Iceland, Ireland, Netherlands).

The European Green Deal, approved in 2020, is a set of policy initiatives with the overarching goal of a climate-neutral EU by 2050. In light of this ambition, the 2021 European Climate Law set an interim emissions reduction target of 55% by 2030 (compared with 1990 levels). In order to meet this target, the European Commission has developed a set of proposals, also known as the Fit for 55 package, putting in place new climate policy initiatives in line with the increased ambition of the Green Deal. Fit for 55 comprises numerous legislative proposals and climate policy initiatives including, but not limited to, the taxation of energy and the extension of carbon pricing to transportation and residential sectors.

In accordance with EU-level commitments, Lithuania has targeted net-zero emissions by 2050. Achieving this will require considerable acceleration of emissions reductions, including by reversing detrimental emissions trends in the transport sector. Indeed, emissions from private vehicles and road freight have grown steadily and fuel taxes in Lithuania are among the lowest in the EU. Lithuania's expanding domestic renewable energy production helps to reduce its reliance on electricity imports. But decarbonising the economy through electrification will also significantly increase electricity demand; Energy efficiency is therefore key and will require a package of ambitious climate policies (OECD, 2021).

Until recently, Lithuania did not operate an explicit carbon tax. CO2 emissions from energy use were partly priced, through the EU Emissions Trading System (ETS) and through (comparatively low) fuel excise taxes[1]. In May 2023 and June 2024, the government adopted amendments to the Law on excise

1 (OECD, 2023), e.g. https://stat.link/2s67g0.

duties, including a tax based on the carbon intensity of fuels that is to be phased in from 2025. The carbon tax element was to start at 10 Euros per tonne of CO2 and rise by 10 Euro each year, to 60 Euros per tonne in 2030 (OECD, 2023). In addition to being the target carbon-tax rate in the specific Lithuanian reform, 60 Euros per ton also corresponded to a low to midpoint estimate for the social cost of carbon in 2020 and a low-end estimate for 2030 (High-Level Commission on Carbon Prices, 2017). As such, it is an informative benchmark value as countries seek to narrow or eliminate the gap between the private and social cost of carbon. More recent and forward-looking studies mostly support significantly higher values, however, illustrating the sizeable gaps between current policies and those needed to meet mitigation targets[2].

While carbon pricing is central to climate mitigation efforts in numerous countries, some governments have responded to cost-of-living concerns by recently easing or suspending environmental tax measures. For instance, Portugal suspended a proposed carbon-tax increase in carbon tax and Austria delayed the introduction of its carbon tax until October 2022. Already at an earlier stage, the French government withdrew a planned carbon-price increase and froze any further increases, following strong resistance from some groups of voters, notably in rural areas (the 'Yellow Vest' movement that formed in late 2018). Throughout the EU and OECD areas, concerns over high and increasing living costs have remained prominent in recent years.

3. Distributional effects of carbon taxes: Literature review

There is a common conjecture that, without revenue recycling, carbon pricing is regressive in high-income countries (Klenert & Mattauch, 2016). However, home fuel and electricity taxation tend to be more regressive than fuel taxation in the transport sector (Büchs, Ivanova, & Schnepf, 2021), which can be progressive, especially in countries with moderate car ownership and well-developed public transport systems (Wang, Hubacek, Feng, Wei, & Liang, 2016). In the EU, average impacts of a given carbon-tax rate on the cost of living are much larger in lower-GDP, primarily Central and Eastern European countries[3]. Taxation of both direct and indirect emissions, associated to the production of goods and services, tends to be less regressive than taxing direct emissions only (Ohlendorf, Jakob, Minx, Schröder, & Steckel, 2020; OECD, 2024).

In countries with lower GDP levels, larger shares of households are unable to satisfy their energy needs (Flues & van Dender, 2017), and carbon pricing is therefore less regressive. In poorer countries, progressive impacts are possible, as the carbon intensity of consumption baskets is low, and energy can

2 The US government currently relies on a mean value of USD 51/tCO2 (Interagency Working Group on Social Cost of Greenhouse Gases (IWG), 2021), a recent report by the European Commission (2021) suggests a central value of EUR 100/tCO2 through to 2030, while a recent comprehensive review indicates a preferred mean estimate of USD185/tCO2, at 2020 prices (Rennert et al., 2022). See also (Network for Greening the Financial System, 2023) and (Tol, 2023).

3 As a result, findings point to regressive impacts of uniform EU-wide carbon taxation (Feindt, Kornek, Labeaga, Sterner, & Ward, 2021).

be difficult to access or unaffordable for large shares of the population, and heating fuels may be less important due to climatic conditions (Ohlendorf, Jakob, Minx, Schröder, & Steckel, 2020; Dorband, Jakob, Kalkuhl, & Steckel, 2019; OECD, 2024).

The literature on net impacts, accounting also for revenue recycling, points to the quantitative importance of revenue recycling for overall distributional outcomes[4]. Lump-sum transfers financed through carbon pricing are progressive and poverty-reducing (Berry, 2019; Klenert, et al., 2018; Owen & Barrett, 2020; OECD, 2024). Depending on their reach, more targeted social welfare payments also support low-income earners and reduce inequality, but they can achieve effective compensation at lower fiscal cost (Callan, Lyons, Scott, Tol, & Verde, 2009). Across-the-board income tax cuts benefit the top and are regressive in their mechanical impact (Goulder, 1995), but can have progressive impacts if they lead to higher employment (Rausch, Metcalf, & Reilly, 2011). Recycling carbon-tax revenues through preferential rates of value-added tax (VAT) for specific goods, e.g. on public transport, can redistribute between income groups and regions (Brännlund & Nordström, 2004). Energy cheques tend to reduce fuel poverty (Berry, 2019), while public transport vouchers can be progressive and achieve sizeable emission reductions (Büchs, Ivanova, & Schnepf, 2021). Support for retrofitting residential buildings is progressive if it is targeted to the least efficient dwellings (Bourgeois, Giraudet, & Quirion, 2021), and if support is likely to be taken up by low-income earners (e.g., if it is provided in the form of direct grants, instead of subsidised loans).

A number of countries implemented explicit compensation policies financed through carbon tax revenues (Immervoll H. , 2024). In Ireland, the carbon tax includes a commitment to use the revenues to prevent fuel poverty and ensure a just transition. The carbon tax introduced in British Columbia, Canada, in 2008 was accompanied by a revenue-neutral tax shift that cuts other taxes and provides for direct transfers to households (Murray & Rivers, 2015). Switzerland earmarks one third of carbon-tax revenues for programmes to support a green transition and reduce energy consumption, with the remainder redistributed through lower health insurance premiums (Bureau, Henriet, & Schubert, 2019). Austria introduced a "climate bonus" paid to residents at different rates depending on access to the public transportation network (Budgetdienst, 2022). At the EU-level, countries have been designing Social Climate Plans, detailing how a share of revenues from the EU-ETS can be used to compensate vulnerable households (European Parliament and Council of the European Union, 2023).

4. Methodology and Data

We use a microsimulation approach to capture the heterogeneous impact of carbon taxation on households represented in detailed micro-data (O'Donoghue, 2021). We use two main data sources, the

4 This also holds for policies that raise effective carbon prices through a withdrawal of energy subsidies (Durand-Lasserve, Campagnolo, Chateau, & Dellink, 2015).

World Input-Output Database (WIOD) and the Lithuania portion of the EU Household Budget Survey (HBS). The section starts by describing the input-output analysis underpinning carbon-intensity estimates for each product category. WIOD is then combined with HBS data to estimate carbon-tax burdens at the household level[5].

We model a uniform carbon tax on all sectors within the country. This is a simplification, as the current version of Lithuania's carbon-tax reform does not cover installations already subject to emissions trading (EU-ETS).[6] An assessment of a uniform carbon tax is nevertheless informative, as EU-ETS does not yet include the transport and buildings sectors, where the effects of carbon taxes on prices are expected to be especially sizeable. By 2030, carbon prices will, to varying extents, also rise for ETS sectors, even if not through explicit carbon taxes. Given current policy trajectories and a growing urgency about countries' failure to meet emission targets required for the key 1.5 and 2-degree commitments, an average carbon price of 60 EUR/tonne of CO2 arguably presents a reasonable lower-bound value in 2030.

The reference period of the policy introduction and simulation is relevant, as available data refer to earlier periods, and household circumstances, consumption patterns and prices change over time, as do preferences, including for consumption. Modelling relies on available household expenditure microdata (HBS 2015). For the simulations, we uprate price data to account for the major recent price changes up until July 2022[7]. Relatedly, observed income levels are uprated via income inflators, and separately for each income quantile. This approach is standard in the literature, to side-step challenges involved in more ambitious now-casting approaches (Sologon D. , et al., 2022; O'Donoghue & Loughrey, 2014; Immervoll, Mustonen, & Riihelä, 2005). Indeed, now-casting of microdata can be informative when the objective is to approximate aggregate measures of inequality. They involve a range of data adjustments, however, which can be problematic when the resulting data are used as input into further modelling or analysis. Essentially, extensive data manipulations can obscure distributional results from the policy modelling that are of primary interest.

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5 A previous analysis of a carbon tax in Lithuania was published as a working paper (Immervoll, O'Donoghue, Linden, & Sologon, 2023). The distributional impact estimates presented here differ from those in the working-paper version for several reasons. Most importantly, the primary dataset here is the Lithuania Household Budget Survey, while the working paper uses the Survey on Income and Living Conditions with expenditure patterns imputed, rather than observed. The 2023 working paper also attempts to account for household behavioural responses, mainly for methodological illustration. Behavioural modelling is not included here.

6 The carbon tax was legislated to apply to coal, diesel, LPG and peat used for residential heating, but natural gas is to remain outside the carbon tax framework (OECD, 2025).

7 We use June 2022 as a reference period for this analysis because it reflects prices at the peak of the cost-of-living crisis in Lithuania (HCIP inflation was highest in 2022) and represents a mid-year estimate, thereby following the convention in the literature.

Computing household carbon footprints

Modelling the CO_2 emissions linked to all forms of household consumption requires data on households' (energy) expenditure, economy-wide data that capture carbon emissions by sector, and production linkages between sectors. Emissions associated to household consumption can be written as $\boldsymbol{E}_{HH} = \boldsymbol{E}_{dirHH} + \boldsymbol{E}_{indHH}$, where $\boldsymbol{E}_{dirHH}$ gives the direct emissions associated to households' fuel consumption, and $\boldsymbol{E}_{indHH}$ gives the indirect (embedded) emissions associated with households' consumption of all other goods and services.

We compute direct emissions ($\boldsymbol{E}_{dirHH}$) by sourcing energy prices and carbon intensity factors for each fuel consumed by households. For each fuel type, expenditure is then divided by its price to estimate the quantity of energy consumed, and multiplied by its carbon intensity factor. We differentiate between heating oil, gas, district heat, firewood, coal, diesel and petrol[8].

We compute indirect emissions using the Input Output (IO) methodology (Miller & Blair, 2009; Leontieff, 1951) and data from the WIOD's Multi-region input-output (MRIO) tables. MRIO datasets map monetary flows between n sectors and m regions, $\boldsymbol{Z} \in \mathbb{R}^{(m\cdot n)(m\cdot n)}$. A final demand vector $\boldsymbol{Y} \in \mathbb{R}^{(m\cdot n)(m\cdot n)}$ captures the final demand for each industry output in each region. The technology matrix, A$\in \mathbb{R}^{(m\cdot n)(m\cdot n)}$, contains all input coefficients for all sectors in all regions. Using the technology matrix, we calculate the Leontief inverse matrix, $L = (I - A)^{-1}$, which gives the economy-wide input requirements of output o, $o = \mathrm{f}(I - A)^{-1} = f\ (I + A + A^2 + \cdots + A^n)$.

To compute carbon emissions associated with industries' outputs, we multiply the Leontief inverse matrix with a vector capturing industry-level CO_2 emissions, resulting in an environmentally-extended Multi-regional Input-Output (EE-MRIO) model (see Kitzes (2013) for an introduction to EE-MRIO modelling). Briefly, let $\mathbf{E} \in \mathbb{R}^{(1\cdot p)}$ denote a vector of emissions for each sector and region, where $p = m * n$. We compute CO2 emissions per monetary unit of the sector's output by dividing $\mathbf{E}$ entry-wise by the corresponding sector's output. Finally, we compute households' indirect emissions. Emission vectors are sometimes provided alongside MRIO models. In the case of the WIOD, this emission vector consists of a value of total CO2 emissions per euro of industry output per region, and includes energy-based, progress-based, and fugitive emissions. In this paper, we simulate a carbon tax on energy-based emissions only. Therefore, rather than using the full EE provided by WIOD, we compute carbon emissions for each fuel type. We then compute the carbon emissions of each industry's output as a

8 We source natural gas and electricity prices from Eurostat, prices of oil products (Diesel, Petrol, Heating oil) from the European Commission Weekly Oil Bulletin, and firewood and coal prices were provided by the Lithuanian Statistical Office upon request. We take district heating prices from Werner (2017). Carbon Intensity factors are sourced from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006) and Werner (2017) for district heat.

function of industry inputs[9]. Finally, we match the HBS expenditure groups[10] in COICOP to WIOD industries in NACE rév. 2 using bridging matrices provided by Cai and Vandyck (2020)[11], enabling us to compute indirect carbon emissions at the household level ($\boldsymbol{E}_{indHH}$).

Revenue recycling

Carbon-tax revenues can be used to finance compensation to households. Such revenue recycling can ease a regressive distributional impact of carbon taxation and could even render it progressive (Klenert, et al., 2018). Popular proposals include uniform lump-sum transfers, reductions in consumption, labour, or capital taxes, or subsidies to accelerate household adoption of low-carbon heating and transportation technologies. In this paper, we draw on HBS data to simulate options for recycling carbon-tax revenues. Past studies demonstrate that distributional impact of revenue recycling can be bigger than that of the carbon tax (Fremstad & Paul, 2019). We therefore explore this channel in detail, simulating a total of seven different compensation options; per capita transfers, per capita transfers targeted to rural households, a reduction in energy excise duties, a reduction in energy excise duties with remaining revenues used for per capita transfers, a transfer aimed at closing the energy-poverty gap with remaining revenues returned as per capita transfers, a reduction in food value added taxes (VAT), and a reduction in all indirect tax liabilities.

5. Results

At carbon tax levels that countries currently apply or discuss, the impact on household living costs can be significant, as can their distributional effects. At the outset, it is useful to put the resulting burdens into context, however. In Lithuania, the impact on living costs would be much smaller than the effects of high inflation rates seen across the OECD since 2021. A carbon tax at 60 EUR/tonne as currently discussed would increase the consumer price index by less than 4% in total.

Consumption patterns across the income distribution

The impact on different population groups depends upon various factors, including notably the distribution of expenditures across the income spectrum. Carbon taxes affect household budgets directly

9 Given difficulties in measuring process-based and fugitive emissions, we view it as more realistic to simulate a carbon tax levied in relation to energy consumption. A challenge with this approach pertains to the high volatility in the energy mix consumed by industries. In Lithuania in particular, the energy mix produced by energy industries within the country and used by industries has changed substantially since 2014 (the WIOD reference year). To attenuate the impact of changes in the Lithuanian energy sectors, we approximate energy industries' fuel mix through the average fuel mix across EU energy industries, sourced from UNIDO MINSTAT.

10 Expenditure categories are Food and Non-alcoholic beverages, Alcoholic beverages, Tobacco, Clothing and footwear, Heating fuels, Electricity, Rents, Household services, Health, Private transport, Public transport, Communication, Recreation and culture, Education, Restaurants and hotels, Other goods and services, Childcare costs, Motor fuels, Durable goods.

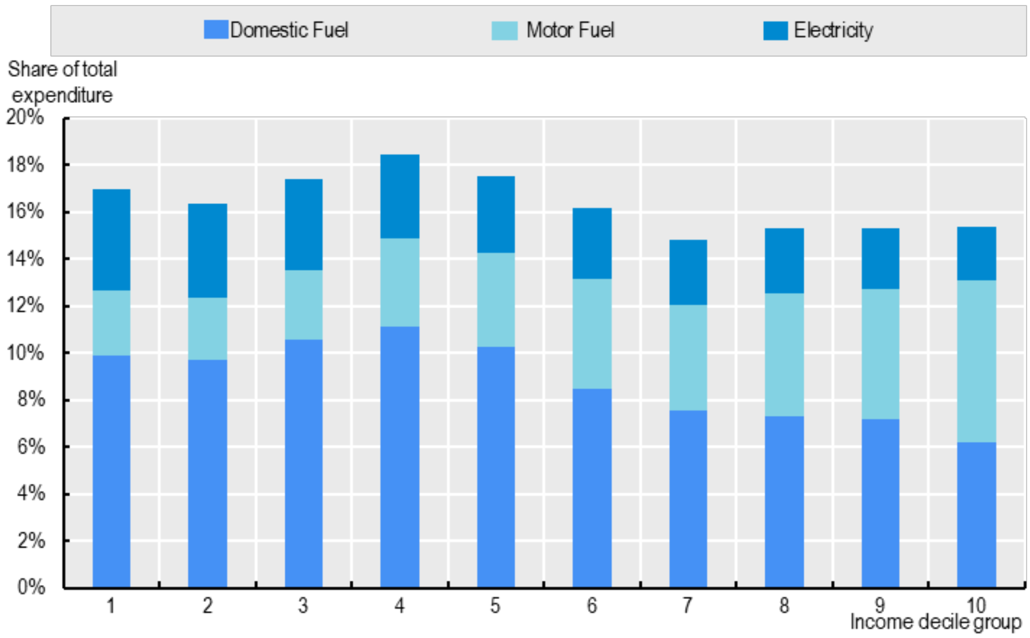
11 Further detail on the procedure is provided in O'Donoghue et al (2023).

through fuel consumption, and indirectly via the consumption of other goods and services that give rise to CO2 emissions during the production process.

The direct incidence of carbon taxes across households is shaped by the pattern of fuel expenditures. Domestic heating fuels are ‘necessities’ in the sense of the term as commonly used by economists, i.e. people will buy them regardless of income and low-income households tend to devote larger shares of their total income and expenditures to heating fuels than better-off households. An opposite pattern can emerge for motor fuels, reflecting higher rates of car ownership among middle and higher-income households.

Figure 1 plots the distribution of fuel expenditures in Lithuania, along with electricity, accounting for price changes up until mid-2022. Spending shares for heating fuel are highest in income deciles 3, 4, and 5. Overall, spending on heating fuels and electricity is regressive. Expenditure on domestic fuels in particular is substantial across the income distribution. Nevertheless, shares are lower in the poorest 2 deciles compared to deciles 3 and 4, which may be related to budget constraints and the poorest households needing to prioritise other essentials over adequate heating. Expenditures on electricity are substantially lower than for heating fuel in all deciles and follow a mildly regressive pattern overall. Spending on motor fuels is top-heavy, with smaller spending on this item in the bottom 30% but a higher share than heating fuels at the top. Taken together, overall fossil-fuel (and energy) expenditure is broadly flat in Lithuania, albeit following a slight inverted U-shape.

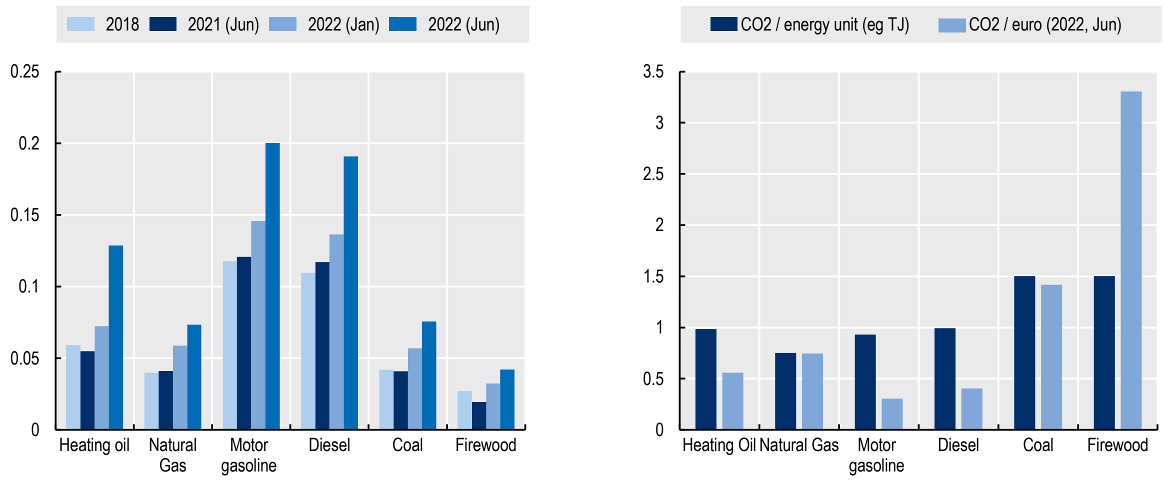
Figure 1. High-income households spend large shares of their budgets on energy



Note: Domestic fuel includes expenditure on gas (natural gas and town gas), liquified hydrocarbons, liquid fuels, heat energy, coal and other solid fuels. Motor fuels include expenditure on diesel and petrol for transportation.
Source: Household budget survey, combined with 2022 price data.

Figure 2. Fuel prices and CO2 emissions

A. Prices in Lithuania, EUR per kWh   B. CO2 emissions, tonnes per unit (1=average)



Note: Firewood also includes wood waste.
Source: Author calculations using UNFCCC, Eurostat, EC Weekly Oil Bulletin.

Fuel prices and the composition of fuel consumption also drive distributional outcomes. Population groups that use higher-emitting “dirtier” fuels will see a greater absolute impact of carbon taxes on prices. The relative price change depends also on initial prices, with cheaper fuels affected more strongly by a given carbon tax per unit. As is commonly the case, motor fuels in Lithuania are more expensive (due to higher taxation) than domestic fuels (Figure 2, Panel A). As a result, the energy usage and emissions per unit of fuel expenditure are higher for domestic fuels (which account for a large share of spending for low-income people) than for motor fuels (mostly consumed by higher-income groups). Domestic fuels include high shares of solid fuels (coal, coke, firewood), which have much higher emissions than liquid fuels. Emission factors are lower for natural gas (Figure 2, Panel B).

Like the direct burden from fuel expenditure, the distribution of the indirect burden from carbon taxes on everything else is also driven by a range of factors, and their net effect is difficult to anticipate. Budget shares for goods other than fuel can be comparatively “flat”, with similar shares of total expenditures across income groups. But since poorer households save less, they spend a higher proportion of their income than better-off households. A relatively flat indirect impact of carbon taxes across households with low and high spending can therefore translate into a distributionally regressive impact across the income spectrum (with carbon tax burdens making up a larger share of income for low-income groups).

Carbon-tax burdens across income groups

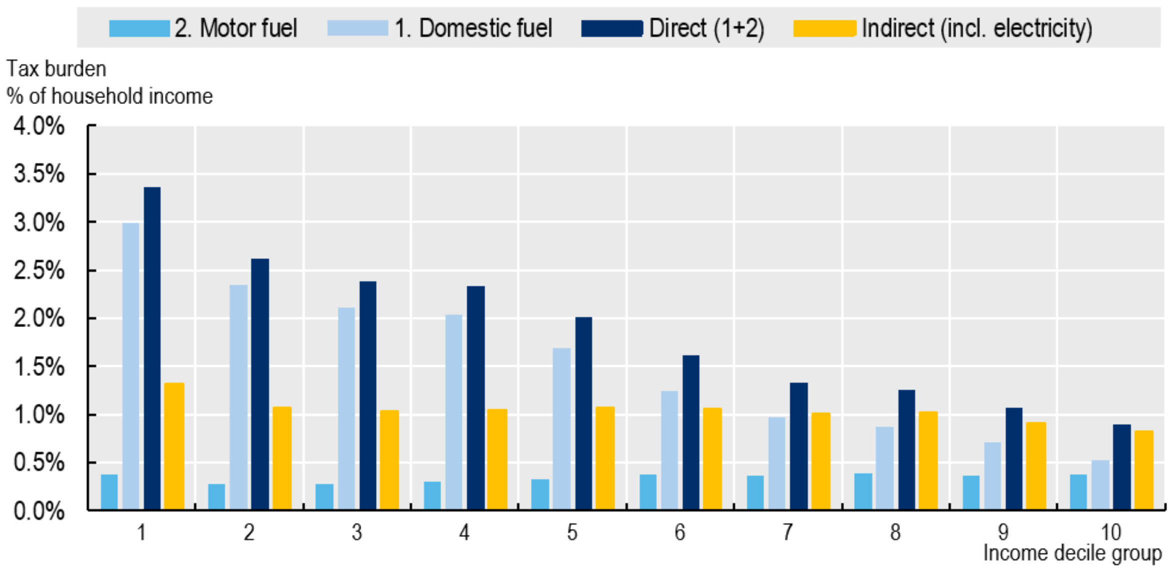
The carbon tax incidence is shaped by (i) the distributional patterns of households’ fuel expenditures, and (ii) the indirect effects of a 60 EUR carbon tax on the cost of other goods, based on emissions released during production in different parts of the value chain.

Figure 3 decomposes the carbon-tax burden into components related to domestic and motor fuels, and indirect emissions. The carbon-tax burden on domestic fuels (ca. 1.8% of household income on average across all income groups) is much higher than for motor fuels (less than 0.5% on average). This reflects the higher expenditure on heating, as well as the higher emissions per euro of domestic fuel. In line with fuel expenditure profiles, the direct carbon tax burden for domestic fuels is concentrated in the bottom half (regressive), while carbon taxes on motor fuels are more progressive. The direct burden on households from overall fuel expenditures is regressive.

At just over +1% of household income on average, the costs from indirect emissions related to the domestic production of other goods and services are lower than the direct component, but remain important, as households spend much more on non-energy than on fossil fuel overall. This highlights the quantitative importance of accounting for all consumption categories, and a careful Input-Output analysis. The scale of the indirect effect is partly driven by spending on electricity, and the carbon intensity of electricity generation, with the largest contributions due to food and electricity consumption. Although the lowest-income households spend greater shares of total expenditure on electricity than higher-income groups (Figure 2), the carbon content of electricity is lower than for other energy sources, and overall indirect effects (including also electricity) are essentially flat as a share of income.

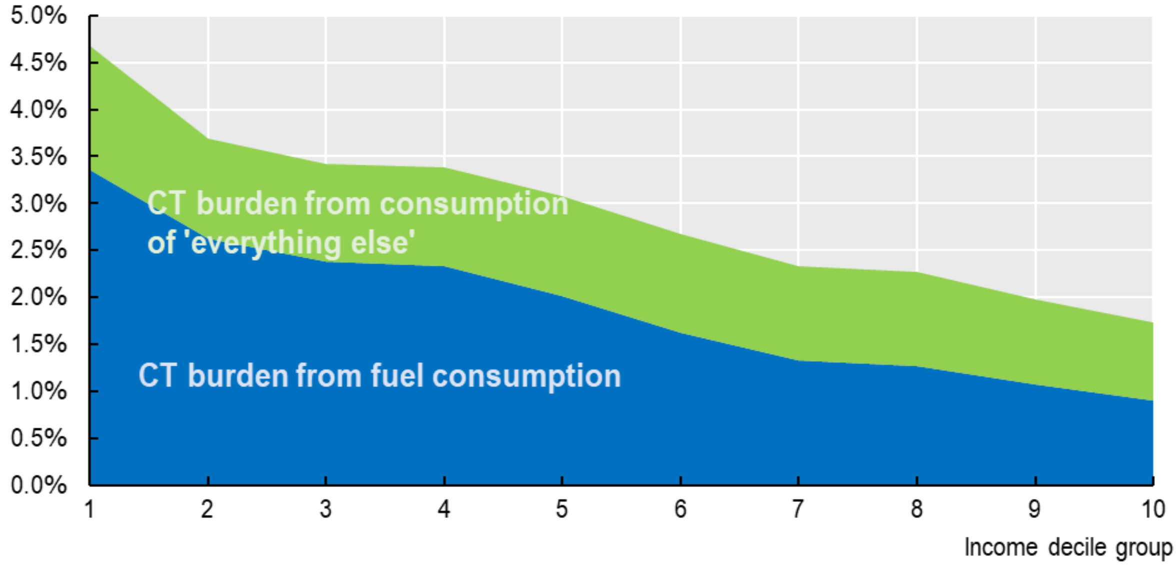
Overall carbon-tax burdens are regressive, with around 3.5% of income for the bottom half of the distribution, and 2.15% for the top half – they are also largest for decile 1, and smallest for decile 10 (see Figure 4). As noted, multiple drivers and country idiosyncrasies shape this result. There is no a-priori reason to expect it to apply more generally and carry over to other country settings.

Figure 3. Components of a EUR 60/t carbon tax (% of household disposable income)



Source: Authors' calculations using data on household expenditure, emission levels and industry inputs and outputs.

Figure 4. Incidence of a EUR 60/t carbon tax (% of household disposable income)



Source: Authors' calculations using data on household expenditure, emission levels and industry inputs and outputs.

Revenue recycling

The carbon tax generates revenue, which can be used to shape its overall distributive impact via revenue recycling. Such revenue recycling can alleviate distributional concerns of carbon pricing and increase their public acceptability (Klenert, et al., 2018). The policies financed with carbon tax revenues measures as part of a broader carbon-tax policy package however also produce gains or losses for different income groups and each revenue recycling option has strengths and weaknesses (Nachtigall, Ellis, & Errendal, 2022). We consider seven stylised compensation measures. All are budget-neutral and can thus be fully financed through the carbon tax.

Option (1) is a stylised per capita transfer, paid at the same individual rate to all residents. Similar to a universal basic income, a per capita payment is often less redistributive than established social transfers. When conceived as a standalone benefit that replaces other transfers, a basic income is difficult to finance without a substantial tax increase (Browne & Immervoll, 2017)However, in the context of a carbon tax, per capita compensation can be an attractive option, as it is built around a novel revenue source, and can be introduced "on top of" existing transfers, without needing to substitute for them. It is also simple to communicate and, as everyone receives a recurring payment, it may act as a signal that the carbon tax aims to alleviate climate change, without creating an additional overall burden for households. The universal lump-sum payment to everybody is indeed sometimes argued to be the optimal revenue recycling option (Klenert, et al., 2018).

Alternatively, carbon-tax revenues can be used to compensate households more selectively, e.g. by adapting/expanding existing policies or introducing new targeted support payments.

Option (2) is a cut in food VAT rates. Because food is a necessity and purchased by everyone, this option distributes resources across all households and provides most support to low-income households, who spend larger shares of their budget and incomes on food.

Option (3) is a per capita transfer to households in rural areas only. Because of higher energy needs due to reliance on personal transportation and larger, often detached, houses, rural households are particularly likely to be disproportionally affected by a carbon tax.

Option (4) is a reduction in excise taxes levied on energy, to mitigate the effect of the carbon tax on energy prices. Such rebalancing of the tax burden has been implemented in some countries, for instance in Finland, France, and Germany (OECD, 2024). As it reduces the carbon price for some emissions, it also weakens the overall incentives for emission reductions. And because excise duties are commonly levied on motor fuels, but not on domestic fuels, this primarily directs resources towards higher earners. The tax base of the carbon tax is much broader than that of energy excise duties, therefore the revenues generated by a carbon tax exceed those needed to eliminate energy excise duties. Remaining revenues are returned to households on a per capita basis under Option (5).

Option (6) is designed to address energy poverty, a particularly salient concern with carbon taxation, and especially in Lithuania. The transfer is designed to close the energy poverty gap, defined as energy expenditure exceeding twice the median energy income share (before the carbon tax), following the 'High Share' definition of energy poverty (see Menyhért (2024) for a comparison of energy poverty definitions). Because carbon tax revenues are more than sufficient to close this energy poverty gap for all households, the remaining revenues are returned as per capita transfers.

Finally, Option (7) is a general and proportional reduction in the indirect tax liability, including Value added tax, excise duties, and ad valorem taxes for all products.

For each option, Figure 5 reports two measures of gains/losses by income group; average gain or loss of a carbon tax with revenue recycling, and the share of individuals with net gains[12].

As a baseline, Figure 5, Panel (a) first shows household losses in the absence of any compensating transfers, to facilitate assessing the impact of revenue recycling. The results elaborate Figure 4 by showing also the variation of impacts within income deciles and can be interpreted as a scenario where the government does not spend the carbon-tax revenue. Aggregate revenues are sizeable (ca. €560 million or 0.75% of GDP according to our calculations), providing the government with considerable scope to cushion losses and shape the distributional profile as part of a broader policy package.

When all carbon-tax revenues are channelled back to individuals via a per capita transfer (Panel b), most people are better off than without the carbon-tax package. Revenues are sufficient for financing a per-capita transfer of 16 Euros per month. Most households in the bottom decile gain, and at least half

12 A household is considered to be reform winners if their net gains exceed 0.5% of their disposable income.

do throughout deciles 1 to 4. Low-income households pay smaller absolute amounts in carbon tax than the better-off, because they spend less. However, substantial heterogeneity in fuel consumption among low-income households implies that a significant share of low-income households still loses out under per capita transfers. As a percentage of household income, gains quickly decline as one moves up the income spectrum. Even for high-income earners in the top decile, the per capita payment substantially reduces the average net carbon-tax burdens (compare Panels a and b).

Lowering VAT on food (Panel c) has a neutral impact and on average neutralizes the impacts of the carbon tax across income deciles. Lower gains for the poorest and higher gains for the richest compared to a per-capita payment also reflect in the share of reform winners, with higher shares of reform winners in all deciles except the lowest. Recycling revenues through reduced VAT rates on food therefore compensates households relatively well across the entire income spectrum, but it provides less support to the poorest than in the per capita scenario.

The per capita transfer scenario examined in Panel (b) is very simple and its distributional properties could be further tailored, e.g. by making it taxable, or by differentiating payments across groups, to approximately account for higher energy dependence (in a similar spirit as in the revenue recycling scheme in Austria noted above). Targeting transfers to rural households can mitigate high carbon tax burdens if rural households require more energy for heating and mobility. Rural households generally have poorer access to public transportation infrastructure and lower carbon heating options, such as district heating or gas networks. Panel (d) shows a per capita transfer to rural households[13]. In Lithuania, low-income households are primarily concentrated in rural areas, with 90% of households in the lowest decile living in rural areas, as compared to below 20% among high income households. The average impact of the carbon tax on the cost of the consumption basket in rural areas is twice as high (ca. 4%) as in urban areas (ca. 2%). When compensation payments are targeted entirely to households outside of cities, a higher share of low-income households gains from the reform compared to untargeted payments (compare Panels b and d). The per capita transfer to rural households is noticeably more progressive with the majority of households in deciles 1 to 5 gaining from this reform, though the overall share of gainers is slightly below that with untargeted payments (38.5% against 41.8%). Transfers to rural households may therefore be politically attractive, particularly if impacts on low-income households are a concern (Dechezleprêtre, et al., 2022).

Using revenues to lower energy excise taxes is regressive as shown in Panel (e) because existing excise taxes are levied on motor fuels but not domestic fuels or electricity. The tax base on which energy taxes are levied is much narrower than that of a carbon tax, and while energy excise rates are higher than average carbon tax rates, a small share of carbon tax revenues are sufficient energy excise tax rates can

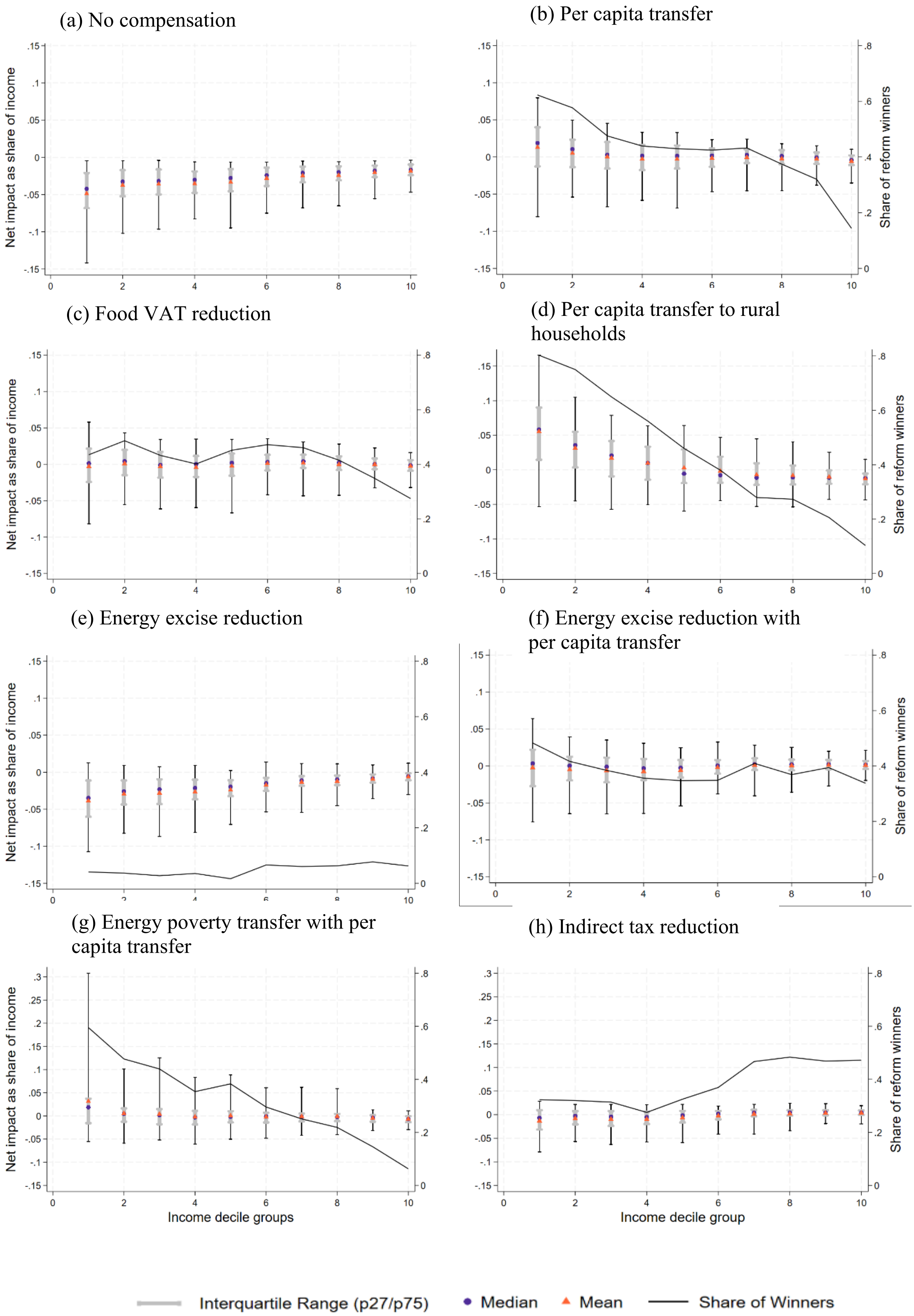
13 We consider households to live in rural areas if they live in thinly populated or intermediate density areas, using the 'Degree of urbanisation (DEGURBA)' classification.

be reduce to zero. The remaining revenues can be returned to households as per capita transfers. The impact of this reform is shown in Panel (f) and smoothens average losses across income groups.

Another approach to mitigating the impact of a carbon tax on energy expenditure is to identify households that struggle to meet their energy needs, and that are therefore deemed energy poor. While there is no generally agreed definition of energy poverty (Menyhért, 2024), targeting compensation to the energy poor is sometimes suggested in the public and political discourse (European Parliament and Council of the European Union, 2023; Berry, 2019). Panel (g) shows a progressive impact of targeting households with energy-to-income shares that are greater than twice the population median. In fact, the reform impact is broadly flat and only slightly progressive when comparing decile averages, but it leads to substantial gains for some low-income households (note the adjusted vertical axis in the two panels).

The patterns of gains and losses of a proportional reduction of all indirect taxes (VAT, excise, and ad valorem taxes) shown in Panel (h) is slightly regressive, with net losses for approximately two thirds of households with incomes below the median, and just over half of high-income households winning. While most low-income households are net losers under this reform, the broad-based reduction in indirect tax rates means that net carbon-tax burdens are reduced for all households (compare Panels a and h).

Figure 5. Carbon tax with revenue recycling – Gains and losses by income decile



6. Discussion – Carbon taxes when price levels are volatile

Our results show a significant impact of a €60 per ton carbon tax on the cost of living in Lithuania. The carbon tax-induced price rise further adds to price hikes for energy and other goods during the cost-of-living crisis. Indeed, the recent high-inflation period heightened concerns over rising prices, and energy prices in particular, and the impact of carbon prices on the cost of living is a major source of public opposition to price-based climate mitigation (Dechezleprêtre, et al., 2022; Douenne & Fabre, 2022). Despite this link between rising prices and concerns about carbon pricing, few studies compared the impacts of carbon prices and the recent inflationary period on the cost of living[14].

The aftermath of the COVID-19 crisis and Russia's war against Ukraine resulted in the steepest price increases in the EU in decades. Initially, the price surge was driven by rising energy and freight costs and supply-chain disruptions (Michail, Melas, & Cleanthous, 2022) but these later spilled over to multiple industries and most goods (OECD, 2022). In Lithuania, price inflation peaked in the third quarter of 2022. At the end of 2024, inflation in Lithuania has stabilized at 1.5% relative to 2023. Simultaneously, income growth in Lithuania has been substantial over the last decade. Between 2021 and 2024, wages and salaries increased by between 35% and 54%, with the lowest wage growth registered in the 'Other service activities' sector and the highest growth registered in the 'Administrative and support service activities' sector.

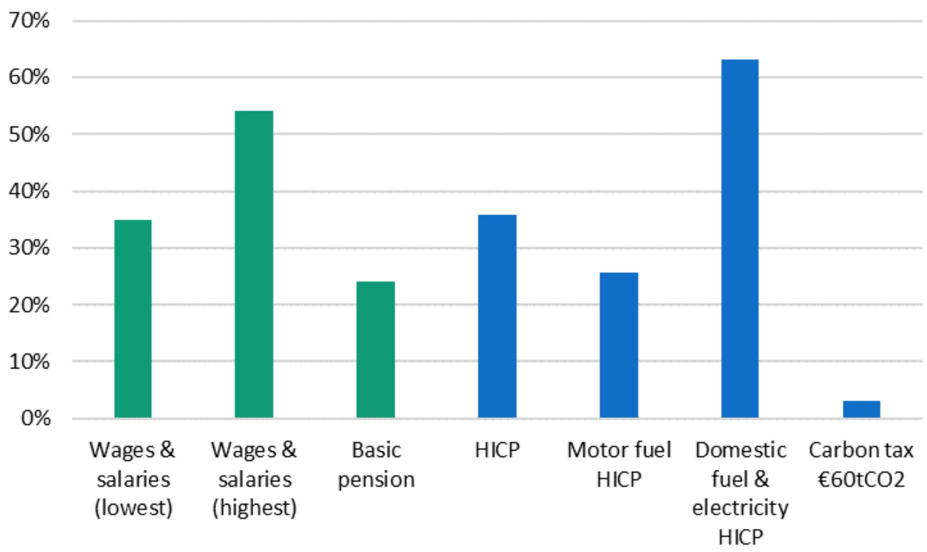
Figure 6 shows that the cost-of-living impact of a €60 per ton of CO_2 carbon tax is small compared to both income and price growth. On average, HICP changes between 2021 and 2024 are ten times as large as estimated price changes from the carbon tax. For most Lithuanian households, income growth outpaced inflation (wages and salaries grew by 46% on average, not shown in Figure 6) and many Lithuanian households therefore became richer over the period. This would still be true if a carbon tax of €60 per ton of CO_2 were implemented.

While the average impact of a carbon price on overall price levels is clearly small compared to HICP changes, changes in the cost of living differ substantially across income groups. This paper found a regressive carbon tax that impacts domestic fuel and electricity prices most. Similarly, Sologon et al. (2025 (forthcoming)) found that inflation in Lithuania between 2021 and 2022 was regressive and that domestic fuel and electricity prices increased most. For some households, and likely many pensioners and low-income households, the combined price change may make heating and electricity unaffordable. Comparatively small impacts of a carbon price may therefore plausibly encounter public opposition, even if burdens may not be noticed by the average household. Such opposition may, e.g., be driven by

14 To our knowledge, only (Konradt, McGregor, & Toscani, 2024)compare the average impact of a €150 tax per ton of CO2 to that of the 2022 cost of living crisis in the euro area, finding that such a carbon price would have comparatively smaller impacts.

the fact that the carbon tax is directly under the governments' control, unlike many of the forces that triggered the cost of living crisis. Disadvantaged people, who suffer the largest combined increase in their cost of living, may also be more likely than the average household to voice opposition (Büchs, Bastianelli, & Schnepf, 2024). As shown in this paper, compensating households through revenue recycling provide powerful levers for compensating households, and future research could identify households that are disproportionately impacted by both inflation and carbon pricing.

Figure 6. Selected price and income changes after 2021



Note: The impact of the EUR 60/t carbon tax on the average cost of a consumption basket is found by estimating the resulting price increases. Wage and salary changes refer to the period from 2021 Q1 to 2024 Q2. Harmonized index of consumer price (HICP) changes refer to the period between January 2021 and September 2024. Basic pension changes refer to period between 2021 and 2023.

7. Conclusion and policy implications

There is broad consensus that setting a price for carbon is a necessary part of urgent strategies to avert catastrophic climate change. Carbon pricing is economically efficient, as it promotes emission reductions in a cost-effective way that leverages, rather than hinders, entrepreneurship, markets and innovation. At the same time, there is a view that public support for carbon taxes is limited, largely because of perceived welfare losses and distributional concerns, and also in view of exceptionally high and volatile energy prices in recent years. These concerns highlight the need for careful distributional analyses that support policy design, and the communication of the benefits and costs of a green transition.

In this paper, we use a rich set of available data and policy models to assess the effect of a €60 per ton carbon tax in Lithuania, along with compensatory government transfers financed through carbon-tax revenues. The context of Lithuania is a challenging one for carbon pricing and is therefore of particular interest. It is a former transition country that has achieved high-income status relatively recently.

Lithuania faces similar pressures to reduce emissions and increase carbon prices as other EU countries, but incomes are lower and poverty rates are higher. The climate is comparatively cold and, while Lithuanian households are sufficiently rich to prioritize energy consumption over other essentials, such as food, energy budget shares remain high, particularly among low-income households.

Results in this paper confirm that, without compensation measures, a carbon tax is regressive. For instance, the "direct" burden from the emissions associated to households' own fuel consumption, sums to about 3.3% of household income for the bottom income decile, compared to less than 1% for the richest 10%. "Indirect" burdens, associated to emissions released in the production of all other goods and services, are sizeable but essentially "flat", with averages of around 1% of incomes in all income groups

We study seven specific revenue recycling options for compensating households. In line with previous research, we find that carbon tax revenues give the government substantial leverage for shaping distributional outcomes of a carbon-price reform (Klenert, et al., 2018). It is possible to avoid detrimental distributional impacts, but compensation strategies need to be designed carefully. Recycling revenues as per capita payments, particularly if they are targeted to rural or energy-poor households, is fiscally costly, but renders the overall reform progressive, with bigger gains for lower-income households. By contrast, using carbon-tax revenues to reduce other indirect taxes is regressive, and reducing VAT for food has a broadly proportional impact. We show that all policy packages create large numbers of winners and losers, including among households with similar income levels. The per capita transfers produce the largest share of reform winners, particularly among low-income households. Tax cuts create more winners among high-income households, but fewer overall. Results suggest that combining tax cuts with per-capita transfers can make the overall impact progressive, but this may not hold if only part of the carbon-tax revenue is available for compensating households.

We contextualize carbon tax burdens by comparing associated price changes to (unrelated) price increases and income trends during the recent cost-of-living crisis. The impact of a €60 per ton carbon tax on households' living costs is much smaller (ca. 3%) than cumulative inflation during the 2021-2024 period (ca. 36%). Inflation led to particularly fast price increases for domestic fuels, highlighting that, without specific support measures, low-income households may be left behind. Yet, despite very high inflation, wage and salary growth outpaced prices and, even with the carbon tax, real incomes grew for many Lithuanian households. This comparison is relevant because burdens from carbon pricing and unrelated price increases are sometimes confounded in public debates and may weaken support for price-based mitigation approaches.

The modelling approach combines different data sources to derive patterns of household burdens that are needed for distributional analysis. As all modelling, it nevertheless abstracts from certain parts of reality, and these limitations suggest possible priorities for future research. Importantly, carbon taxes have effects beyond those on consumption expenditures by altering the incomes of the owners of the different factors of production, including natural resources, "brown industry" equity and labour (Rausch, Metcalf, & Reilly, 2011; Metcalf & Stock, 2020; Metcalf G. , 2021) by changing the pace and direction of innovation (Dechezleprêtre & Kruse, 2022; Dechezleprêtre & Sato, 2017; Dechezleprêtre, Nachtigall, & Venmans, 2023), and by affecting jobs in high-carbon industries (Metcalf & Stock, 2020; OECD, 2021; OECD, 2024). Further, households adjust their consumption behaviour following price changes, affecting the distributional outcomes of a carbon tax (Shang, 2023; Ohlendorf, Jakob, Minx, Schröder, & Steckel, 2020). These effects are not considered here. Finally, a complete assessment of the distributional impacts of carbon pricing should include the cost of *inaction* or, vice versa, the benefits of mitigation (Tovar Reaños & Lynch, 2022), and the research agenda for distributional assessments is closely linked to the broader evolving evidence on the economic impact of climate change, and of policies to avert it. A key question concerns the counterfactual that is adopted in distributional studies. The status quo, as adopted in this paper, can be a natural starting point, and the scale of economic damages from climate change remains uncertain (Auffhammer, 2018; Howard & Sterner, 2022). They are, however, by definition of the same order of magnitude as carbon prices that internalise the negative externalities of greenhouse-gas emissions.

References

Antosiewicz, M., Fuentes, J., Lewandowski, P., & Witajewski-Baltvilks, J. (2022). Distributional effects of emission pricing in a carbon-intensive economy: The case of Poland. *Energy Policy, 160*, 112678. doi:10.1016/j.enpol.2021.112678

Auffhammer, M. (2018). Quantifying Economic Damages from Climate Change. *Journal of Economic Perspectives, 32*(4), 33-52. doi:10.1257/jep.32.4.33

Baranzini, A., Goldemberg, J., & Speck, S. (2000). A future for carbon taxes. *Ecological Economics, 32*(3), 395-412. doi:10.1016/s0921-8009(99)00122-6

Baumol, W. J., & Oates, W. E. (1988). *The theory of environmental policy.* Cambridge: Cambridge University Press.

Beiser-McGrath, L. F., & Bernauer, T. (2019). Could revenue recycling make effective carbon taxation politically feasible?. Science advances. *2019, 5*(9).

Berry, A. (2019). The distributional effects of a carbon tax and its impact on fuel poverty: A microsimulation study in the French context. *Energy Policy, 124*, 81-94. doi:10.1016/j.enpol.2018.09.021

Bourgeois, C., Giraudet, L.-G., & Quirion, P. (2021). Lump-sum vs. energy-efficiency subsidy recycling of carbon tax revenue in the residential sector: A French assessment. *Ecological Economics, 184*, 107006. doi:10.1016/j.ecolecon.2021.107006

Brännlund, R., & Nordström, J. (2004). Carbon tax simulations using a household demand model. *European Economic Review, 48*(1), 211-233. doi:10.1016/s0014-2921(02)00263-5

Browne, J., & Immervoll, H. (2017). Mechanics of replacing benefit systems with a basic income: comparative results from a microsimulation approach. *The Journal of Economic Inequality, 15*(4), 325-344. doi:10.1007/s10888-017-9366-6

Büchs, M., Bardsley, N., & Duwe, S. (2011). Who bears the brunt? Distributional effects of climate change mitigation policies. *Critical Social Policy, 31*(2), 285-307. doi:10.1177/0261018310396036
Büchs, M., Bastianelli, E., & Schnepf, S. V. (2024). Public opposition to fuel taxes in Europe: how important is social disadvantage and how do welfare regimes compare? *Journal of European Social Policy, 34*(5), 495--510.
Büchs, M., Ivanova, D., & Schnepf, S. (2021). Fairness, effectiveness, and needs satisfaction: new options for designing climate policies. *Environmental Research Letters, 16*(12), 124026. doi:10.1088/1748-9326/ac2cb1
Budgetdienst. (2022). *Verteilungswirkung des ersten und zweiten Teils der Ökosozialen Steuerreform.* Parliament of the Republic of Austria.
Budolfson, M., Dennig, F., Errickson, F., Feindt, S., Ferranna, M., Fleurbaey, M., . . . Zuber, S. (2021). Climate action with revenue recycling has benefits for poverty, inequality and well-being. *Nature Climate Change, 11*(12), 1111-1116. doi:10.1038/s41558-021-01217-0
Bureau, D., Henriet, F., & Schubert, K. (2019). Pour le climat : une taxe juste, pas juste une taxe. *Notes du conseil d'analyse économique, n° 50*(2), 1. doi:10.3917/ncae.050.0001
Cai, M., & Vandyck, T. (2020). Bridging between economy-wide activity and household-level consumption data: Matrices for European countries. *Data in brief, 30*(105395). doi:https://doi.org/10.1016/j.dib.2020.105395
Callan, T., Lyons, S., Scott, S., Tol, R., & Verde, S. (2009). The distributional implications of a carbon tax in Ireland. *Energy Policy, 37*(2), 407-412. doi:10.1016/j.enpol.2008.08.034
Carattini, S., Carvalho, M., & Fankhauser, S. (2018). Overcoming public resistance to carbon taxes. *WIREs Climate Change, 9*(5). doi:10.1002/wcc.531
Dasgupta, S., Laplante, B., Wang, H., & Wheeler, D. (2002). Confronting the environmental Kuznets curve. *Journal of economic perspectives, 16*(1), 147-168.
Dechezleprêtre, A., & Kruse, T. (2022). The effect of climate policy on innovation and economic performance along the supply chain: A firm- and sector-level analysis. In *OECD Environment Working Papers.* OECD Publishing, Paris. doi:10.1787/3569283a-en
Dechezleprêtre, A., & Sato, M. (2017). The Impacts of Environmental Regulations on Competitiveness. *Review of Environmental Economics and Policy, 11*(2), 183-206. doi:10.1093/reep/rex013
Dechezleprêtre, A., Fabre, A., Kruse, T., Planterose, B., Sanchez Chico, A., & Stantcheva, S. (2022). Fighting climate change: International attitudes toward climate policies. In *OECD Economics Department Working Papers.* OECD Publishing, Paris. doi:10.1787/3406f29a-en
Dechezleprêtre, A., Nachtigall, D., & Venmans, F. (2023). The joint impact of the European Union emissions trading system on carbon emissions and economic performance. *Journal of Environmental Economics and Management, 118*, 102758. doi:10.1016/j.jeem.2022.102758
Dorband, I., Jakob, M., Kalkuhl, M., & Steckel, J. (2019). Poverty and distributional effects of carbon pricing in low- and middle-income countries – A global comparative analysis. *World Development, 115*, 246-257. doi:10.1016/j.worlddev.2018.11.015
Douenne, T. (2020). The vertical and horizontal distributive effects of energy taxes: A case study of a french policy. *The Energy Journal, 41(3)*.
Douenne, T., & Fabre, A. (2022). Yellow Vests, Pessimistic Beliefs, and Carbon Tax Aversion. *American Economic Journal: Economic Policy, 14*(1), 81-110. doi:10.1257/pol.20200092

Durand-Lasserve, O., Campagnolo, L., Chateau, J., & Dellink, R. (2015). Modelling of distributional impacts of energy subsidy reforms: an illustration with Indonesia. In *OECD Environment Working Papers* (Vol. 2015). OECD Publishing, Paris. doi:10.1787/5js4k0scrqq5-en

European Parliament and Council of the European Union. (2023). Regulation (EU) 2023/955 of the European Parliament and of the Council of 10 May 2023 establishing a Social Climate Fund and amending Regulation (EU) 2021/1060. *OJ L 130, 16.5.2023*, pp. 1--51. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R0955

Feindt, S., Kornek, U., Labeaga, J., Sterner, T., & Ward, H. (2021). Understanding regressivity: Challenges and opportunities of European carbon pricing. *Energy Economics, 103*, 105550. doi:10.1016/j.eneco.2021.105550

Flues, F., & van Dender, K. (2017). The impact of energy taxes on the affordability of domestic energy. In *OECD Taxation Working Papers.* OECD Publishing, Paris. doi:10.1787/08705547-en

Fremstad, A., & Paul, M. (2019). . The impact of a carbon tax on inequality. *Ecological Economics, 163*, 88-97.

Goulder, L. H. (1995). Environmental taxation and the double dividend: a reader's guide. . *International tax and public finance, 2*, 157-183.

High-Level Commission on Carbon Prices. (2017). *Report of the High-Level Commission on Carbon Prices.* High-Level Commission on Carbon Prices, Washington DC. Retrieved 03 28, 2022, from https://static1.squarespace.com/static/54ff9c5ce4b0a53decccfb4c/t/59b7f2409f8dce5316811916/1505227332748/CarbonPricing_FullReport.pdf

Howard, P. H., & Sterner, T. (2022). Between Two Worlds: Methodological and Subjective Differences in Climate Impact Meta-Analyses. *Resources for the Future Working Paper, 22*(10).

Immervoll, H. (2024). Financing social protection in OECD countries: Role and uses of revenue earmarking. In *OECD Social, Employment and Migration Working Papers.* OECD Publishing, Paris. doi:10.1787/0d53155c-en

Immervoll, H. L., Mustonen, E., & Riihelä, M. (2005). Accounting for population changes in tax-benefit microsimulation models. A note on static data 'ageing' techniques. *EUROMOD Working Paper, 7*(5).

Immervoll, H., O'Donoghue, C., Linden, J., & Sologon, D. (2023). Who pays for higher carbon prices?: Illustration for Lithuania and a research agenda. In *OECD Social, Employment and Migration Working Papers.* OECD Publishing, Paris. doi:10.1787/8f16f3d8-en

Ivanova, D., Vita, G., Steen-Olsen, K., Stadler, K., Melo, P. C., Wood, R., & Hertwich, E. G. (2017). Mapping the carbon footprint of EU regions. *Environmental Research Letters, 12*(5), 054013.

Kitzes, J. (2013). An Introduction to Environmentally-Extended Input-Output Analysis. *Resources, 2*(4), 489-503. doi:10.3390/resources2040489

Klenert, D., & Mattauch, L. (2016). How to make a carbon tax reform progressive: The role of subsistence consumption. *Economics Letters, 138*, 100-103. doi:10.1016/j.econlet.2015.11.019

Klenert, D., Mattauch, L., Combet, E., Edenhofer, O., Hepburn, C., Rafaty, R., & Stern, N. (2018). Making carbon pricing work for citizens. *Nature Climate Change, 8*(8), 669-677. doi:10.1038/s41558-018-0201-2

Konradt, M., McGregor, T., & Toscani, M. F. (2024). Carbon prices and inflation in the euro area. . *IMF WP/24/31.*

Leontieff, W. W. (1951). Input-output economics. *Scientific American, 185*, 15-21.
Menyhért, B. (2024). Energy poverty in the European Union. The art of kaleidoscopic measurement. . *Energy Policy, 190*, 114160.
Metcalf, G. (2021). Carbon Taxes in Theory and Practice. *Annual Review of Resource Economics, 13*(1), 245-265. doi:10.1146/annurev-resource-102519-113630
Metcalf, G., & Stock, J. (2020). *The Macroeconomic Impact of Europe's Carbon Taxes.* National Bureau of Economic Research, Cambridge, MA. doi:10.3386/w27488
Michail, N. A., Melas, K. D., & Cleanthous, L. (2022). The relationship between shipping freight rates and inflation in the Euro Area. *International Economics, 172*, 40--49.
Miller, R., & Blair, P. (2009). *Input-Output Analysis.* Cambridge University Press. doi:10.1017/cbo9780511626982
Murray, B., & Rivers, N. (2015). British Columbia's revenue-neutral carbon tax: A review of the latest "grand experiment" in environmental policy. *Energy Policy*, pp. Pages 674-683.
Nachtigall, D., Ellis, J., & Errendal, S. (2022). Carbon pricing and COVID-19: Policy changes, challenges and design options in OECD and G20 countries. In *OECD Environment Working Papers.* OECD Publishing, Paris. doi:10.1787/8f030bcc-en
Network for Greening the Financial System. (2023). *NGFS Scenarios for central banks and supervisors.* Paris: NGFS.
Nordhaus, W. D. (1991). A sketch of the economics of the greenhouse effect. *Amercian Economic Review, 81*(2), 146-150.
O'Donoghue, C. (2021). *Practical Microsimulation Modelling.* Oxford University Press.
O'Donoghue, C., & Loughrey, J. (2014). Nowcasting in Microsimulation Models: A Methodological Survey. *Journal of Artificial Societies and Social Simulation, 17*(4). doi:10.18564/jasss.2635
ODonoghue, C., Amjad, B., Linden, J., Lustig, N., Sologon, D., & Wang, Y. (2023). The Distributional Impact of Price Inflation in Pakistan: A Case Study of a New Price Focused Microsimulation Framework, PRICES.
OECD. (2021). *Assessing the Economic Impacts of Environmental Policies: Evidence from a Decade of OECD Research.* OECD Publishing, Paris. doi:10.1787/bf2fb156-en
OECD. (2021). OECD Environmental Performance Reviews: Lithuania 2021. In *OECD Environmental Performance Reviews.* OECD Publishing, Paris. doi:10.1787/48d82b17-en
OECD. (2022). *Coping with the cost-of-living crisis: Income support for working-age individuals and their families.* OECD. Retrieved from https://www.oecd.org/social/Income-support-for-working-age-individuals-and-their-families.pdf
OECD. (2022). Tax Policy Reforms 2022: OECD and Selected Partner Economies. doi:10.1787/067c593d-en
OECD. (2022). *Towards a sustainable recovery? Carbon pricing policy changes during COVID-19.* OECD, Paris. Retrieved from http://oecd.org/coronavirus
OECD. (2023). Effective Carbon Rates 2023: Pricing Greenhouse Gas Emissions through Taxes and Emissions Trading. In *OECD Series on Carbon Pricing and Energy Taxation.* OECD Publishing, Paris. doi:10.1787/b84d5b36-en
OECD. (2023). *Reform Options for Lithuanian Climate Neutrality by 2050.* OECD Publishing, Paris. doi:10.1787/0d570e99-en
OECD. (2024). OECD Employment Outlook 2024: The Net-Zero Transition and the Labour Market. doi:https://doi.org/10.1787/ac8b3538-en.

OECD. (2024). Who pays for higher carbon prices? Mitigating climate change and adverse distributional effects. In *OECD Employment Outlook 2024: The Net-Zero Transition and the Labour Market.* OECD Publishing, Paris. doi:10.1787/9138d7e3-en

OECD. (2025). OECD Economic Surveys: Lithuania 2025. *2025/6*. doi:10.1787/4abf1ea5-en

Ohlendorf, N., Jakob, M., Minx, J., Schröder, C., & Steckel, J. (2020). Distributional Impacts of Carbon Pricing: A Meta-Analysis. *Environmental and Resource Economics, 78*(1), 1-42. doi:10.1007/s10640-020-00521-1

Owen, A., & Barrett, J. (2020). Reducing inequality resulting from UK low-carbon policy. *Climate Policy, 20*(10), 1193-1208. doi:10.1080/14693062.2020.1773754

Pearson, M., & Smith, S. (1991). The European carbon tax: An assessment of the European Commission's proposals. Institute for Fiscal Studies. Retrieved from https://discovery.ucl.ac.uk/id/eprint/17288/1/17288.pdf

Pigou, A. C. (1920). *The economics of welfare.* London: Macmillan.

Ramstein, C., Dominioni, G., Ettehad, S., Lam, L., Quant, M., Zhang, J., & ... & Trim, I. (2019). State and trends of carbon pricing 2019. *The World Bank*.

Rausch, S., Metcalf, G., & Reilly, J. (2011). Distributional impacts of carbon pricing: A general equilibrium approach with micro-data for households. *Energy Economics, 33*, S20-S33. doi:10.1016/j.eneco.2011.07.023

Reaños, M. A. (2021). Fuel for poverty: A model for the relationship between income and fuel poverty. Evidence from Irish microdata. *Energy Policy, 156*, 112444.

Renner, S. (2018). Poverty and distributional effects of a carbon tax in Mexico. *Energy Policy, 112*, 98-110.

Rosas-Flores, J. A., Bakhat, M. R.-F., & Zayas, J. (2017). Distributional effects of subsidy removal and implementation of carbon taxes in Mexican households. *Energy Economics, 61*, 21-28.

Shang, B. (2023). The poverty and distributional impacts of carbon pricing: Channels and policy implications. *Review of Environmental Economics and Policy, 17*(1), 64--85.

Sologon, D., O'Donoghue, C., Kyzyma, I., Li, J., Linden, J., & Wagener, R. (2022). The COVID-19 resilience of a continental welfare regime - nowcasting the distributional impact of the crisis. *The Journal of Economic Inequality, 20*(4), 777-809. doi:10.1007/s10888-021-09524-4

Sologon, D., O'Donoghue, C., Linden, J., Kyzyma, I., & Loughrey, J. (2025 (forthcoming)). *Welfare and Distributional Impact of Soaring Prices in Europe.* Review of Income and Wealth.

Symons, E., Speck, S., & Proops, J. (2002). The distributional effects of carbon and energy taxes: the cases of France, Spain, Italy, Germany and UK. *European Environment, 12*(4), 203-212. doi:10.1002/eet.293

Tatham, M., & Peters, Y. (2022). Fueling opposition? Yellow vests, urban elites, and fuel taxation. *Journal of European Public Policy*, 1-25. doi:10.1080/13501763.2022.2148172

Többen, J., Pichler, P. P., Jaccard, I. S., Kratena, K., Moran, D., Zheng, H., & Weisz, H. (2023). Unequal carbon tax impacts on 38 million German households: assessing spatial and socio-economic hotspots. . *Environmental Research: Climate*.

Tol, R. (2023). Social cost of carbon estimates have increased over time. *Nature Climate Change, 13*(6), 532-536. doi:10.1038/s41558-023-01680-x

Tovar Reaños, M., & Lynch, M. (2022). The benefits of action on implementing carbon taxation in Ireland: a demand system approach. *Journal of Environmental Planning and Management*, 1-25. doi:10.1080/09640568.2021.2006157

Vandyck, T., Weitzel, M., Wojtowicz, K., Los Santos, L. R., Maftei, A., & Riscado, S. (2021). Climate policy design, competitiveness and income distribution: A macro-micro assessment for 11 EU countries. *Energy Economics, 103*, 105538.
Vogt-Schilb, A., Walsh, B., Feng, K., Di Capua, L., Daniela, Z., Marcos, R., & Hubaceck, K. (2019). Cash transfers for pro-poor carbon taxes in Latin America and the Caribbean. *Nature Sustainability* , 941–948. https://doi.org/10.1038/s41893-019-0385-0.
Wang, Q., Hubacek, K., Feng, K., Wei, Y.-M., & Liang, Q.-M. (2016). Distributional effects of carbon taxation. *Applied Energy, 184*, 1123-1131. doi:10.1016/j.apenergy.2016.06.083
Werner, S. (2017). International review of district heating and cooling. *Energy, 137*, 617-631.
World Bank. (2019). Using Carbon Tax Revenues. *Technical Note, 16*.

8. Appendix

A.1. Data adjustments

To make the simulations more realistic and relevant in the context of a high-inflation environment, we adjust the historical expenditure and income data underpinning the analysis. Currently available HBS data are from 2015; more recent data have recently become available but they relate to the COVID period and are therefore not representative of key consumption patterns. We make adjustments to bring population totals and structure up to a more recent period and, crucially, to account for price and income changes.

2020 is the most recent year for which population totals are available and we use this information to account for changes as shown in Table 2. Even though the 2015-2020 time interval is short, population changes for some age groups were substantial in Lithuania, due to ageing and (historical and current) migration patterns. Lithuania has fewer than 3 million residents, its population is decreasing and projected to decline by 200,000 by 2030 (OECD, 2021). Historically, migration remained outward, with young people, in particular, leaving Lithuania. This trend has reversed recently, with net positive migration flows since 2019 (OECD, 2021). From 2015 to 2020, most working age groups declined while older age cohorts aged (60+) expanded, with greater relative increases for older groups. To approximate 2022 population totals, we subsequently apply twice the average annual growth rate over the 2015-2020 period. The resulting factors are used to reweigh observations in the micro-data depending on their age group.

Total inflation over the 2015-22 period was 54%, with 2021-2022 accounting for more than half (32 percentage points) of this change. Food, drink and tobacco, fuels, restaurants and transport increased at a higher rate than the mean. The impact is comparatively small; price increase observed over the 2021-

2022 period were more than ten times as high as the increase that would result from a carbon tax of EUR 60/tonne, using July 2022 price levels as reference.

Nominal incomes grew faster than prices between 2015 and 2020 (by 60%, a real increase of almost 40%). We uprate all disposable incomes by a uniform factor reflecting this average change. In reality, some of the change in disposable income will have been due to market income changes among workers, some due to employment changes and some due to changes in policy, notably those that impact on pensions and other government transfers. Although it is possible to approximately account for this granularity, it is beyond the scope of this paper. It is preferable to await new data rather than attempting to undertake complex, cumbersome and potentially in-transparent adjustments of the rich income distributions captured in the data.

Table 1. Population change Lithuania - 2020

	2015	2020	Change
0 – 4	150984	145590	0.964
5-9	139381	144512	1.037
10-14	134240	132642	0.988
15 – 19	166270	130926	0.787
20 – 24	201515	154360	0.766
25 – 29	195615	185376	0.948
30 – 34	178111	187446	1.052
35 – 39	176352	171793	0.974
40 - 44	197732	174252	0.881
45 - 49	207820	195470	0.941
50 - 54	225192	201308	0.894
55 - 59	213239	217731	1.021
60 - 64	170639	196708	1.153
65 - 69	145259	154540	1.064
70 - 74	131531	126480	0.962
75 - 79	120539	110410	0.916
80 - 84	85932	90739	1.056
85 - 89	47321	51559	1.090
90 - 94	14902	18624	1.250
95 - 99	1978	3364	1.701
100 +	358	639	1.250
Total	**2904910**	**2793986**	**0.962**

Table 2. Overview of existing distributional studies using microsimulation: Scope and modelling choices

Author	Country coverage	Scope	Distributional impact	Distributional metric	Taxes considered	Multi-regional IO model	Revenue recycling	Data matching
(Pearson & Smith, 1991)	United Kingdom (some results for EU12)	country	Regressive	Expenditure	Carbon tax	Country IO	(1) Lump-sum; (2) lower income tax	no
(Symons, Speck, & Proops, 2002)	5 EU	country	Mixed	Income	Direct and indirect	no	no	no
(Dorband, Jakob, Kalkuhl, & Steckel, 2019)	87 low and middle-income	country	Progressive	Income	Transportation fuel	yes	no	no
(Vogt-Schilb, et al., 2019)	Latin America & Caribbean	cross-country	Progressive	Expenditure	Direct and indirect	yes	(1) Higher cash-transfers, (2) Higher coverage	no
(Büchs, Ivanova, & Schnepf, 2021)	27 EU	EU-level	Regressive across EU	Income	Direct and indirect	yes	(1) fuel rebates; (2) green vouchers + infrastructure	no
(Feindt, Kornek, Labeaga, Sterner, & Ward, 2021)	23 EU	EU-level, country	Progressive across country/ regressive across EU	Expenditure	Direct and indirect	yes	(1) National / EU lump sum; (2) Targeted to poor	no
(Callan, Lyons, Scott, Tol, & Verde, 2009)	Ireland	country	Regressive	Net cost	Direct and indirect	yes	(1) Social welfare payments, child benefit, (2) tax credit, tax rate decrease	no
(Bourgeois, Giraudet, & Quirion, 2021)	France	country	Regressive	Income	Carbon tax	no	(1) Lump-sum, (2) Subsidies	No, specialized dataset
(Reaños, 2021)	Ireland	country	Regressive	Income	Carbon tax	no	Lump-sum	Yes, Stone Index
(Douenne T. , 2020)	France	country	Regressive	Income and Expenditure	Domestic and Transport fuels	no	(1) Lump-sum, (2) Geographical and Fuel targeted	Statistical matching
(Vandyck, et al., 2021)	11 EU	Cross-country	regressive	Income	Direct and indirect	yes	(1) Lump-sum, (2) Social benefit index, (3) Wage index	EUROMOD-ITT, imputation and statistical matching
(Többen, et al., 2023)	Germany	Country	regressive	Income	Carbon tax	no	(1) Purchasing power target, (2) Energy poverty target, (3) renewable energy levy abolishment	Synthetic dataset using iterative proportional fitting and random forests

A.3. Change in cost of living and prices

Figure 1. Change in the cost of living between 2015 and 2022