Background Report for the Economic Policy Council on Carbon Pricing in Finland

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1.1 Carbon pricing: theoretical framework

Climate change is a global externality problem. Emitting greenhouse gases (GHGs) imposes significant costs on society ranging from local reductions in air quality to the global existential threat of climate change. However, these social costs of polluting are not faced by individual firms or consumers, and consequently do not factor into the decisions to pollute. This creates a classic market failure that warrants government intervention. The widely accepted solution is a carbon price, a form of Pigouvian taxation, equal to the marginal social damage from emitting GHGs. This internalises the negative externalities by equating the marginal private cost of polluting with the marginal social cost. There is a consensus among economists that a uniform carbon price is the most cost-effective way to reduce GHG emissions. It equalises the marginal abatement costs across fuels and sectors and incentivises the least expensive emissions reductions to occur first.

Traditionally, the consensus among economists has been that carbon pricing should be consistent with the social cost of carbon (SCC), i.e. the cost to society of emitting a tonne of CO_2 emissions. However, in reality the social cost of carbon is difficult to calculate and needs to be chosen from a broad range of estimates (Köppl and Schratzenstaller 2021). Consequently, there have been calls for replacing the SCC as the benchmark carbon price with one that is consistent with a specific climate policy goal. In the U.S. context, this approach has been advocated by Nicholas Stern and Joseph Stiglitz, who argue that existing estimates of SCC are biased downwards, because they fail to consider many vitally important costs associated with climate change (2017).

However, the target-based carbon price benchmark has faced serious criticism by economists, including Aldy et al. (2021), who highlight that it is based on climate policies that are fundamentally political, not scientific, and therefore subject to arbitrary change. Therefore, they argue, that the SCC provides a more scientific and objective way for evaluating policies, and efforts should be placed into developing better estimates of the SCC than advocating alternative approaches.

There are two commonly used options for pricing carbon. The first is a carbon tax, where the price of emissions is set, but the emissions reductions are determined by the market. The second option is an emissions trading system (ETS), where the emissions reductions are set in advance, but the price of emitting is determined by the market. In practice, this is achieved by releasing tradeable allowances, each of which allows the owner to emit a certain amount, and the sum of all allowances equals the total emissions. This kind of emissions trading system is also called cap-and-trade. A carbon tax provides certainty on the price level but not the emissions reductions, and conversely an ETS provides certainty on the emissions reductions but not the price level.

According to economic theory, if the carbon price is set exactly equal to the marginal social damage, carbon taxes and emissions trading are equivalent. However, this is no longer the case when there is uncertainty. As demonstrated by Weitzman (1974), the choice between price and quantity instruments under uncertainty depends on the steepness of the marginal abatement cost curve and marginal benefit functions. Figure 1 provides an illustration where there is uncertainty about marginal costs (MC), and the actual marginal costs turn out to be higher than expected. In this situation, a tax results in sub-optimally low abatement (i.e. sub-optimally high emissions), because the tax is lower than the actual marginal cost. Conversely, a quantity-instrument results in sub-optimally high levels of abatement because the abatement level is set based on the lower marginal cost curve.

Panel (a) depicts a situation where the marginal benefit (MB) curve is relatively flat compared to the marginal cost curve (with abatement policies, this is the more realistic scenario). This implies that the marginal benefit of abatement remains relatively constant even for a large change in the quantity of emissions, but the marginal cost of reducing emissions rises quickly. Therefore, implementing a quantity instrument that allows the price to vary creates a larger efficiency loss, E_Q, than a price instrument which allows the abatement quantity to vary and creates the efficiency loss, E_P. Therefore, a price instrument is preferred. Conversely, panel (b) demonstrates that when the marginal abatement curve is steeper than the marginal cost curve, the efficiency loss from letting the quantity vary is greater than that from letting the price vary, and a quantity instrument is preferred.

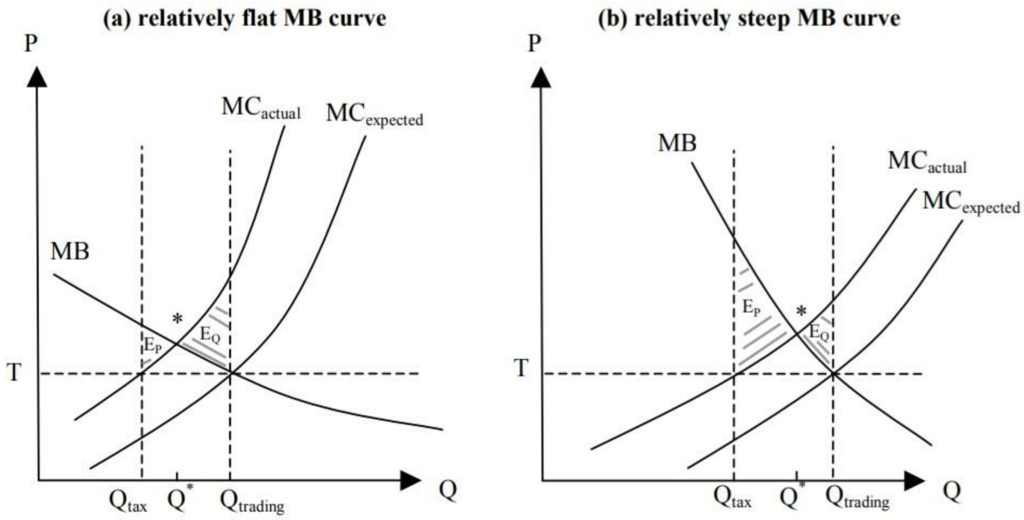

Figure 1: Efficiency losses from price- and quantity instruments under uncertainty. Source: Hepburn (2006) p. 232. Note: The y-axis depicts the price of abatement, and the x-axis depicts the quantity of emissions abated.

In practice, carbon taxes have the advantage of involving lower administrative costs as they can utilise existing tax authorities and systems. They also involve less price volatility, which can be particularly valuable for creating a market that is conducive to the large-scale investments in R&D and cleaner technologies required for effective mitigation (Eerola et al. 2021). However, setting a tax rate that is sufficiently high to match the social costs of carbon may prove politically challenging. An ETS, on the other hand, is a more complex system where details, including the ability to transfer allowances between trading phases, can affect emissions reductions. However, the allowance price adapts to technological development without separate administrative decisions (Eerola et al. 2021).

Both forms of carbon pricing are in place in Finland. 43% of economy-wide emissions in Finland are covered by the EU ETS (Parry and Wingender 2021). For most of the remaining sectors, carbon and energy taxes constitute the main policy instrument.

1.2 The EU Emissions Trading System (EU ETS)

1.2.1 General information

The EU ETS was set up in 2005. It operates in all EU countries plus Iceland, Liechtenstein and Norway, and it covers power stations and other combustion plants with thermal rated input greater than 20 megawatts, as well as airlines operating between countries that are part of the ETS. The EU ETS mainly covers carbon dioxide emissions (CO_2), but also includes nitrous oxide (N_2O) from production of nitric, adipic and glyoxylic acids and glyoxal, and perfluorocarbons (PFCs) from the production of aluminium.

The EU ETS operates in trading phases, with each new trading phase involving revisions to the system (summarized in table 1). The EU ETS is now in its fourth trading phase (2021-2030). Key revisions introduced in this phase include increasing the pace of annual cap reduction to 2.2% as of 2021 and reinforcing the Market Stability Reserve, a mechanism to reduce the surplus of emission allowances in the market.

Table 1: EU ETS Trading Phases. Source: Koljonen et al. (2019), p. 38, (Original in Finnish). Note: CCS stands for carbon capture and storage.

	Trading phase 1 (2005-2007)	**Trading phase 2 (2008-2012)**	**Trading phase 3 (2013-2020)**	**Trading phase 4 (2021-2030)**
Objective	Trial period	-8% vs. 2005	-21% vs. 2005	-43% vs. 2005
Countries	EU-25	EU-27, Norway, Iceland, Liechtenstein	Same as phase 2 + Croatia	Same as phase 3
Gases	CO_2	CO_2, N_20	CO_2, N_20, PFC	CO_2, N_20, PFC
Emissions cap	2078 Mt/year national caps	2083 Mt/year national caps	2084 Mt/year, -1.74%/year EU-wide cap	1739 Mt/year, -2.2%/year EU-wide cap
Cost compensation	Possible	Possible	Possible	Possible
Initial allowance allocation	Free allocation	Free allocation	40%–60% auctioned. Free allocation based on benchmarking. Market stability reserve.	57% auctioned. Free allocation based on benchmarking. Market Stability Reserve and cancellation of allowances 2023.
Key sectors	Power (< 20 MW, steel, mineral and forest industries, glass and cement manufacturing	Same as phase 1 + airlines and nitric acid.	Same as phase 2 + CCS installations, petrochemicals, aluminium, plaster.	Same as phase 3.

1.2.2 Price development and allowance revenues

Emissions have declined under the EU ETS. However, the EU ETS has been criticized for not having created a strong and predictable price signal to incentivize decarbonisation. The key reason for the low price has been the oversupply of allowances in relation to demand. However, since 2017 the price has risen dramatically, as demonstrated by figure 2, which has been attributed to the introduction of the Market Stability Reserve. (Koljonen et al. 2019.)

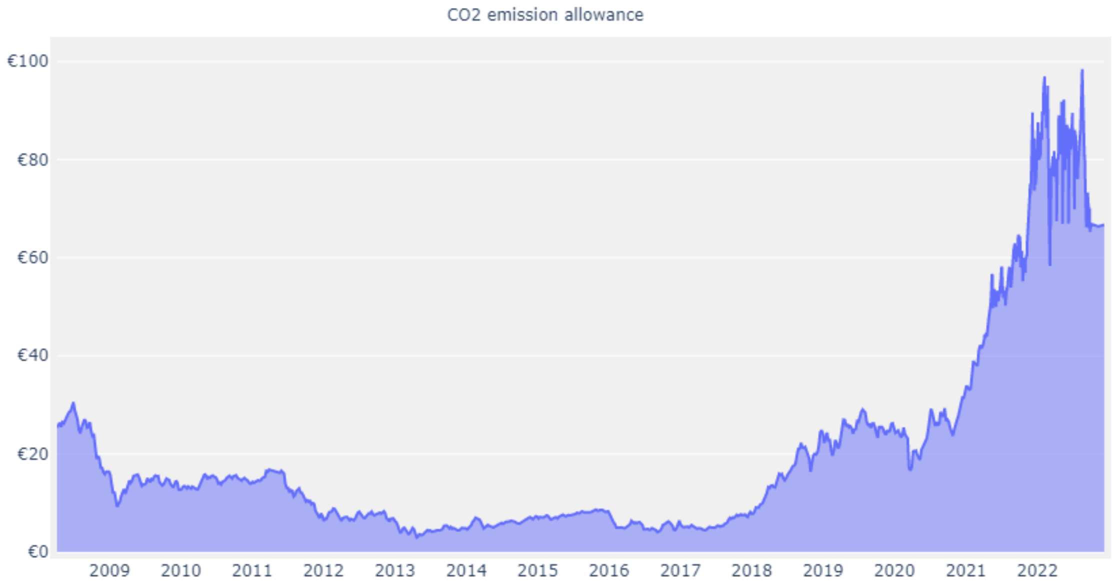

Figure 2: CO_2 emission allowance, Source: Sandbag Carbon Price Viewer, Accessed 09/11/22.

The most notable feature affecting the price signal is the free allocation of allowances to energy intensive industries. During the first two trading phases, nearly all allowances were freely allocated to test how an ETS worked in practice, and to allow regulated installations to familiarise themselves with the trading and compliance practices. Free allowances were mainly handed out through grandfathering, meaning that installations received allowances equal to their historical emissions. Starting from the third phase, auctioning has become the default method for allowance allocation, especially in the power sector. However, an exception was made for energy-intensive, trade exposed, industries at risk of carbon leakage (e.g. iron/steel, cement, chemicals, refineries, pulp/paper), which are still granted free allowances. Free allowances are distributed based on a fixed benchmarking approach where the 10% most efficient installations in each sector determine the number of allowances other installations receive. (Pellerin-Carlin et al. 2022.)

Free allowances amount to subsidies worth billions of euros to the industrial sector. According to Pellerin-Carlin et al. (2022), the industrial sector has received free allowances worth over 138 billion euros since 2005, and the number of allowances has significantly exceeded the sector's emissions. While it is likely that a share of these allowances has been sold on the market since then, the overallocated allowances since 2008 would, in theory, be worth over €90bn at a market price of €85/tCO_2 (Pellerin-Carlin et al. 2022).

During the period 2016-2020, aid was also available for indirect costs caused by the EU ETS, although it was not implemented by all countries. The aid was taken up in some form or another by the UK, Germany, the Netherlands, Belgium, Norway, Spain, Greece and Slovakia (HE 147/2016). The aid was meant to compensate specific industries and firms threatened by carbon leakage for the higher electricity prices caused by the EU ETS. The aid level was determined based on historical electricity use in the reference period.

Under the current system, 43% of the emissions cap can be distributed to industry each year, and the remainder are sold or auctioned by the European Commission or Member States (Sandbag 2022a). The revenues from auctioned allowances go mainly to Member States' budgets. However, Member States are required to spend at least half of their auction revenues to support GHG emissions reductions, to deploy renewables and carbon capture and storage, and to improve energy efficiency and district heating (European Commission: Questions and Answers - Emissions Trading – Putting a Price on carbon). As the price of allowances has risen, so have the auction revenues.

1.2.3. Finnish EU ETS allowances and revenues

In 2021, installations in Finland received approximately 12.7 million free allowances (Finnish Energy Authority: Emission allowances granted and distributed for the year 2021). The value of these allowances increased sharply with the rising allowance price. Between 4th January 2021 and 31st December 2021, the price rose from approximately 33.9 euros per tCO_2 to 80.9 euros, meaning that the value of these free allowances also rose from approximately 429 million euros to 1.02 billion[2].

In July 2022, the aid for indirect costs caused by the EU ETS was replaced in Finland with the aid for the electrification of energy-intensive industries. The main difference is that this introduced an upper limit on the aid. Recipients are compensated for 25% of indirect costs but the total annual costs of the aid scheme cannot exceed 150 million euros. At least half of the granted aid must be used for development activities promoting carbon neutrality. Aid is available to operators during 2022-2026. (Finnish Energy Authority: Aid for Industrial Electrification.)

In 2021, Finland received approx. 400 million euros in EU ETS revenues (see figure 3). It should be noted, however, that this was still less than the value of freely allocated allowances in Finland in 2021. The revenues from the EU ETS are expected to decrease in the future as installations reduce their emissions and demand fewer allowances.

[2] Based on calculations using information on free allowances from the Finnish Energy Authority and the price of EU ETS allowances from the Sandbag Carbon Price Viewer.

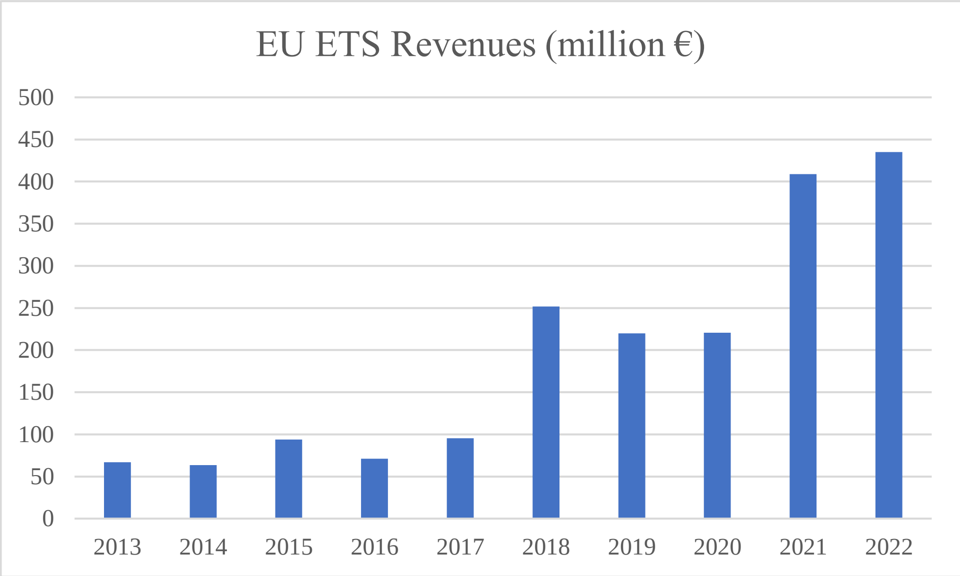

Figure 3: EU ETS Revenues by 3.11.2022. Source: Finnish Energy Authority.

1.2.4 Expected future developments of the EU ETS

In July 2021, the European Commission adopted a package of proposals to make the EU's policies fit for reducing GHG emissions by at least 55% by 2030 compared to 1990 levels. As part of this FitFor55 package, the Commission proposed to lower the overall emissions cap even further and increase its annual rate of reduction. The Commission also proposed to phase out free emission allowances for aviation and to include shipping emissions in the EU ETS. To address the lack of emissions reductions in road transport and buildings, a separate new emissions trading system was put forward for fuel distribution for road transport and buildings. The Commission also proposed to increase the size of the Innovation and Modernisation Funds. The former is a funding programme for the demonstration of innovative low-carbon technologies, while the latter is a dedicated funding programme to support the 10 lower-income EU Member States in modernising their energy systems and improving energy efficiency. (European Commission Press Release 14.7.2021.)

The package also proposes the introduction of a carbon border adjustment mechanism (CBAM), which would set a carbon price on imports to prevent carbon leakage. The European Commission's proposal for the CBAM is currently in the final stages of the legislative process. The Commission's proposal for the CBAM would restrict attention only to direct emissions from a handful of industrial sectors, including iron and steel, cement, fertilizers, aluminium and electricity generation (Morgado Simões 2022). In May 2022, the proposal was referred to the European parliament's ENVI committee, who broadened the list to include, for example, hydrogen, organic chemicals, and polymers, as well as indirect emissions (Titievskaia et al. 2022). In any case, it seems highly likely that the CBAM will be greatly simplified at the beginning to ease administrative burden, and it will gradually be extended. Kuusi et al. (2020) assess the potential impact of different CBAM scenarios based on econometric gravity modelling of trade and general equilibrium modelling. They conclude that the environmental and economic effects in Finland of this type of simplified CBAM will probably be very small.

In May 2022 the European Commission announced the REPowerEU Plan to help finance investment needed to wean the EU off Russian fossil fuels. One of the budget sources for the plan was €20 billion raised from auctioning EU ETS allowances held in the Market Stability Reserve (Sandbag 2022b). While the exact effect is hard to predict, as the number of allowances needed to raise the €20 billion depends on the price each allowance is sold for, Sandbag estimates that it could result in a substantial number of additional allowances in circulation, which would depress the allowance price.

1.3 Carbon and energy taxes

Finland was the first country in the world to introduce a tax based on the carbon dioxide component of fossil fuels in 1990 (Alimov et al. 2020). In general, environmental taxes in Finland can be separated into five types (Koljonen et al. 2019):

1) energy taxes (electricity taxes and energy fuel taxes)
2) vehicle-based transport taxes (car taxes, vehicle taxes)
3) taxes on transport fuel
4) emission taxes (mainly waste taxes)
5) resource taxes

1.3.1 Energy taxes

Liquid fossil and bio-derived fuels, electricity, and some other fuels such as peat, natural gas and coal, are subject to energy taxation in Finland. Energy taxes are excise taxes that target the consumption of energy products. The energy taxes on fuels consist of an energy content tax component, a CO_2 tax component, and a security of supply fee. Energy taxes have been largely harmonized in the EU, meaning that EU Directives largely set the key tax structure, including taxable products, minimum tax levels and exemptions. The scope of harmonized energy taxation includes heating fuels, light and heavy fuel oil, coal and natural gas, as well as electricity. (Forsström et al. 2022.)

Peat and pine oil are not subject to the energy content and CO_2 tax components, but to a separate energy tax. Furthermore, peat is only taxable when it is used for heat production in a power plant or thermal centre exceeding 10,000 MWh in a calendar year. An excise duty equivalent to the tax on heavy fuel oil is levied on pine oil used for heating. In combined heat and power (CHP), the energy content tax is reduced by 7.63 euros per megawatt hour. (Forsström et al. 2022.)

The electricity tax applies to the final product. The fuels used in electricity production are exempt from the tax in accordance with the current energy tax directive (Forsström et al. 2022). Electricity taxation does not depend on the energy- or CO_2-content of the fuels used in production (Finnish Ministry of Finance (MoF) 2020). The electricity tax is divided into two classes. The tax rate is considerably lower in class II at 0.05 cents per kWh compared to 2.24 cents in class I (an additional security of supply fee of 0.013 cents per kWh is charged in both classes). The lower tax class II includes most notably industry and professional greenhouses, while the majority of activities are in class I (Finnish Tax Authority 29.3.22).

1.3.2 Road transport taxation

There are three main forms of tax for road transport: car tax, vehicle tax and fuel taxes. Cars are also subject to the value added tax of 24%, which is fully recoverable if the car is used exclusively for business purposes. There is also benefit-in-kind taxation which incorporates the replacement price of the vehicle, a fixed fee, and deductions for battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), with separate rates depending on whether the car is a limited or unlimited benefit (Transport and Environment 2022).

Car (acquisition) tax

The car tax is a one-off tax that is payable by the vehicle owner when a vehicle is registered or taken into use for the first time in Finland. The tax applies to passenger cars, vans, small buses, motorcycles, and three- or four-wheeled motor vehicles. Since 2008, the car tax on passenger cars and vans has been linked to the vehicle-specific CO_2 emissions. The amount of the tax is based on the value of the vehicle, and the rate is based on the vehicle's CO_2 emissions. If the emissions information is not available, the tax rate is based on estimated CO_2 emissions calculated based on the vehicle's total mass and fuel type. The car tax on other taxable vehicles is not directly related to their CO_2 emissions. (MoF 2021.)

Vehicle tax

The vehicle tax consists of a basic tax, which is paid for all passenger cars and vans, and a tax on driving power, which is paid for passenger cars that use fuels other than petrol. The vehicle tax is a daily tax that is paid in advance, usually for a tax period of 12 months. The tax is paid for the period of ownership or possession of the vehicle. The primary purpose for the basic tax is to generate revenue for the government. However, since 2010, the tax rate has been based on the vehicle-specific CO_2 emissions for vehicles taken into use from 2000 onwards. The tax increases from approximately €53 to €650 as the CO_2 emissions rise from 0 g/km to 400 g/km or more. The tax on driving power is used to offset the different operating costs to motorists caused by differing fuel taxes. For example, the tax compensates for the fact that diesel taxes are lower than petrol taxes. (MoF 2021.)

Excise taxes on fuel

Fuel excise duty consists of an energy content tax and a carbon dioxide tax. The energy content tax is based on the energy content of the fuel and should therefore be higher for diesel than petrol. However, a rebate has been set on diesel and its substitute fuels to support truck transport, and thereby the export industry, bus transport and other commercial transport, which all tend to use diesel (MoF 2021). In practice, this means the energy content tax of diesel oil is reduced by a fixed amount of 25.95 cents per litre, which means a tax expenditure of approximately 0.0072 euros per megajoule for diesel oil and its replacement fuels. The carbon dioxide tax is based on the average lifecycle GHG emissions of the fuel. The calculation is based on 77 euros per tonne of CO_2 and an emissions factor specific to each fossil fuel product (MoF 2020). The total excise fuel tax on petrol is currently approximately 76 cents per litre, while it is approximately 59 cents for diesel (Finnish Tax Authority: Tax Rates on Liquid Fuels 1.1-31.12.22).

The preferential tax treatment of diesel is not specific to Finland. We see from figure 4 that the vast majority of European countries apply a higher fuel excise duty on petrol. We also see from the figure below that Finland has one of the highest excise duty rates on both petrol and diesel. Meanwhile, some countries, such as Bulgaria and Hungary, levy excise duties that are below the legal minimums of 0.359 euros/litre for petrol and 0.33 euros/litre for diesel in the European Tax Directive (Transport and Environment 2022).

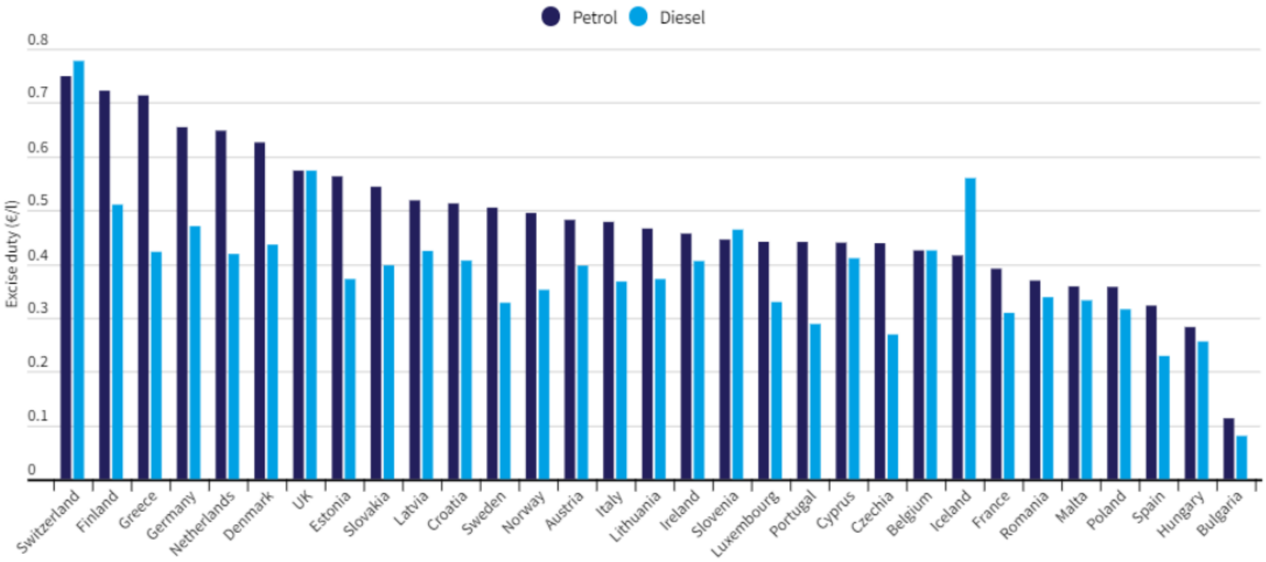

Figure 4: Petrol and diesel excise duties (Note: Calculations exclude VAT). Source: Transport and Environment (2022), p. 45.

With the exception of petrol and diesel oil and their replacement biofuels, there is no separate tax level in Finland for other fuels when used as transport fuels. Thus, for example, natural gas and liquefied petroleum gas used as transport fuel are taxed at a, significantly lower, heating fuel tax level than other transport fuels. The same applies to electricity used in transport, which is taxed according to the rate in electricity tax class I. (MoF 2020.)

1.3.3 Emissions and resource taxes

Resource taxes refer to the compensation paid to society for the use of non-renewable resources (Eerola et al. 2021). Meanwhile, waste tax is paid for waste delivered to the landfill and it is meant to increase the utilisation of waste and decrease the disposal of waste in landfills (Finnish Tax Authority: Waste Tax). These are a very small class of taxes in Finland compared to energy taxes and transport taxes.

1.3.4 Tax expenditures

The environmental taxes in Finland include notable tax expenditures. In the case of energy taxes, tax expenditures amount to approximately half of total revenue accumulation from the taxes (Koljonen et al. 2019). Tax expenditures are exceptions made to the basic structure of taxation, the so-called tax system norm. They are used to support a certain industry or group of taxpayers. In practice, tax expenditures are tax exemptions, tax reductions, lower tax rates, and other comparable means.

Quantifying a tax expenditure requires some kind of baseline to which the favourable tax treatment can be compared. In most cases, a natural baseline is the tax treatment of other firms. However, this requires a definition of the relevant industry, which can be subjective and difficult to determine, as firms compete for customers across industries. Another way of defining tax expenditures is by making comparisons to the recommendations of optimal tax theory. The Finnish Research Division on Business Subsidies quantifies the current business subsidies in Finland in their 2022 report. Some of the main business subsidies affecting energy and transport taxes from this list are provided in tables 3 and 4 in the Appendix.

Some of the most notable tax expenditures in energy taxation are tax refunds to energy-intensive firms and agricultural practitioners. In total, the companies entitled to tax refunds have received approximately 70 percent of the energy taxes they paid as tax refunds (Koljonen et al. 2019). The refund is paid only on the portion exceeding 50,000 euros, meaning that it mostly applies to large firms (Laukkanen and Maliranta 2019). These refunds will be phased out for energy-intensive firms during 2021-2024 (HE 167/2020). However, the energy tax refunds remain in place for agricultural practitioners.

In the transport sector, the most significant tax expenditure is the lowered tax on diesel, which is below the excise tax on petrol. Although diesel vehicles have tended to have higher fuel efficiency than their petrol counterparts, diesel vehicles emit about 16 percent more CO_2 emissions per unit of fuel use (Parry and Wingender 2021). The tax on driving power is used to balance the difference between the effective carbon tax paid on petrol and diesel passenger cars and to ensure a tax-neutral system. However, it only applies to passenger cars.

Non-environmental taxes also include environmentally harmful features. For example, the income tax includes a tax deduction for commuting expenses, which was temporarily raised in July 2022 following the increases in energy prices. The deduction was raised by 5 cents/km compared to 2021 and the maximum deduction was raised from 7000 to 8400 euros (MoF Press Release 17.3.22). The changes are applied retroactively starting from the beginning of 2022.

Another environmentally harmful feature of the tax system is the current method of determining the level of tax-free mileage compensation. The tax-free mileage allowance significantly exceeds variable costs and consequently encourages the transfer of salary and capital allowances to the form of tax-free allowances, which incentivises driving. Determining the level of tax-free mileage allowances based solely on variable costs would eliminate this incentive problem. (MoF 2021.)

1.3.5 Tax revenues

Worldwide, energy taxes are the largest source of environmental tax revenue. Among OECD countries, energy taxes raise an average of 1.1% of GDP. The most important source of energy tax revenues in both OECD and non-OECD countries is transport fuels – petrol and diesel – which together account for more than 50% of energy tax revenues (Matheson 2021). The same trend is visible in Finland. During 2016-2018, a total of 6.8 billion euros was collected in environmental taxes. Out of this, 30% were from energy taxes, 36% from excise fuel taxes, 32% from car and vehicle taxes, and only approx. 1% were from emissions and resource taxes (Koljonen et al. 2019).

Figure 5 summarises the developments in energy tax revenues in Finland between 2002 and 2021. In 2021, net energy tax revenues were approximately 4.3 billion euros in nominal terms, and the trend has been relatively constant, albeit slightly decreasing, since 2016. Meanwhile, the ratio of energy tax revenue to GDP has been clearly declining from 2% in 2016 to 1.7% in 2021. Nominal energy tax revenues have been positively affected by increases in nominal tax levels on transport and heating fuels and electricity during the 2010s. However, this increase has been balanced by a declining tax base and the substitution to more lightly taxed energy products (MoF 2020.)

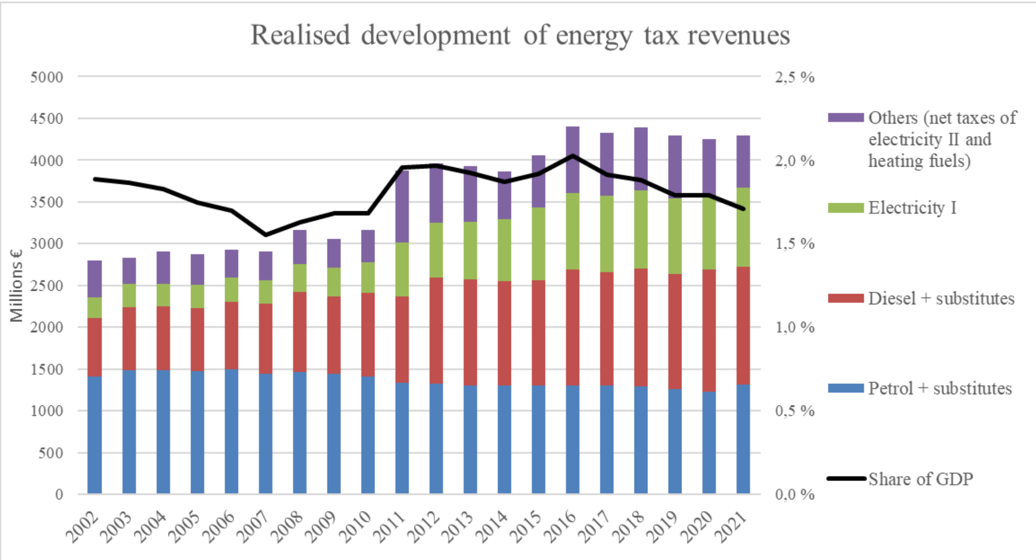

Figure 5: Realised development of energy tax revenues. Source: MoF 9.9.2022. Note: The y-axis on the left-hand side denotes revenues in millions and the y-axis on the right-hand side denotes share of GDP.

The MoF (2020) forecasts that with the 2020 legislation with no new tax changes, revenues from energy taxes will decline by about 0.1 billion euros between 2019 and 2024 and by about 0.6 billion by 2030. The tax revenues from petrol, diesel and their substitute biofuels are projected to decrease by approximately 450 million euros, and energy tax revenues from heating fuels by about 200 million euros by 2030. Meanwhile, revenues from electricity taxation class 1 are projected to increase by approximately 40 million euros. However, these forecasts are subject to uncertainties, notably concerning the rate of electrification of the transport sector and the rate at which energy efficiency improves. (MoF 2020.) There have also been tax changes (discussed in the next section) since 2020 that could affect at least short-term predictions.

Transport has long been a significant source of revenue for the government. However, the share of tax revenues from transport has already been gradually declining during the 2000s. The MoF (2021) forecasts that by 2025, tax revenues from transport will decrease by 0.8 billion euros in real terms. The greatest decline will be felt in car tax revenues due to the increase in the share of EVs and the increasing fuel-efficiency of other vehicles. Revenues from vehicle taxes will decline due to reductions in official CO_2 emissions and the basic tax.

Revenues from taxes on driving power are expected to remain largely unchanged. Overall transport sector tax revenues are reduced by the electrification of transport, the improvement of energy efficiency and the increase in the share of more lightly taxed biofuels due to the distribution obligation. In the long-term, a carbon-based tax will no longer provide an opportunity to maintain the current fiscal role of transport taxation (MoF 2020.)

1.3.6 Reforms to energy taxation

The Ministry of Finance appointed a working group for the period between November 2019 and September 2020 to assess needs for reforming the energy taxation system in Finland. Following the analysis by the working group, the energy content tax on heating and machine fuels, including peat, was increased from the beginning of 2021 by €2.7/MWh. Furthermore, the refunds for energy-intensive firms are gradually phased out during 2021-2024. However, the refunds for agriculture will continue. From 2022, the electricity used by heat pumps, electric boilers and geothermal heating plants' circulating water pumps was moved to the lower electricity tax category II. The range of data centres belonging to the lower electricity tax class II was also expanded to even smaller data centres. A price floor was also introduced to the taxation of fuel peat. At the same time, the scope of tax-free use of fuel peat was expanded for the years 2022-2029. Biogas was included in the scope of energy taxation in 2022. (Forsström 2022.)

There are also expected future changes to energy taxation at the EU level. The EU FitFor55 package proposes a longer-term revision of the Energy Taxation Directive. According to the proposal, the electricity tax would be allowed to have only one class, and the electricity tax level would set at the minimum for fuel taxes. Energy taxation would include all fuels, including bio-based ones. Fuels would be divided into three tax level categories based on environmental criteria. In each category, fuels would be taxed consistently according to their energy content. (Forsström 2022.)

The Finnish Government has also taken action to alleviate hardship from rising energy prices during 2021 and 2022. From the beginning of 2021, the electricity tax for industrial users, data centres and agriculture was reduced to the minimum rate allowed by the EU. The position of consumers on the electricity market has also been improved by intervening in energy transmission prices. The amount of transmission fees that can be charged to customers in 2022 is approximately €370 million less than in 2020. The tax deduction on commuting expenses was also raised temporarily. (Finnish Government Press Release 18.2.2022.)

In September 2022, the government also announced two VAT reductions. Firstly, the VAT on electricity sales will be reduced from 24% to 10% for the period 1.12.2022 – 30.4.2023. Secondly, passenger transport services are temporarily exempted from VAT for the period 1.1–30.4.2023. (Finnish Tax Authority 31.10.22.)

The government also introduced a temporary household tax deduction to compensate households with high electricity bills during the period 1.1.–30.4.2023. The costs arising from the electricity consumption of a permanent residence would be entitled to a household tax deduction in the case that the amount paid exceeds 2,000 euros during the period in question but is less than 6,000 euros. A household can deduct up to 60% of the eligible amount, but the maximum is €2400 (Finnish Government Press Release 26.9.22). A temporary electricity subsidy was also introduced for households that have high electricity bills but who cannot receive the full tax deduction due to low income (Palomaa 2022).

In December 2022, the government announced new measures that are being prepared to support households facing high electricity bills. Firstly, the government intends to offer retroactive, one-off compensation to electricity users. In practice, the government would pay the compensation to electricity companies, who would forward this compensation onto household electricity bills. The government aims to bring the proposal to the parliament in early January. Secondly, the government plans to support households by guaranteeing flexibility in the payment of electricity bills. In practice, this means that electricity bills could be at least partially paid later than otherwise. Lastly, there are discussions of setting a price ceiling for electricity. However, the preparations for a price ceiling would take time and the price ceiling is not expected to take effect before spring 2023. (Palomaa 2022.)

1.4 Other climate policy instruments

In addition to carbon pricing, Finland also has a number of other financial incentive programmes and command-and-control climate policies in place. Some of the main policies are discussed below, but the list is not exhaustive.

1.4.1 Buildings

In 2022, the tax credit for household expenses (*kotitalousvähennys*) was increased temporarily for the period 2022-2027 for households that replace oil heating with a more climate-friendly form of energy. The higher tax credit covers 60% of renovation labour costs up to a maximum of 3,500 euros (Finnish Tax Administration Release 2021). Owners of detached houses that are used year-round are eligible for a subsidy for oil heating replacement from the Centre for Economic Development, Transport and Environment. In addition to these measures targeting oil heating replacement, there are subsidies for energy efficiency renovations in general. The Housing Finance and Development Centre of Finland (ARA), offers two different subsidies: The first is a repair subsidy, which is targeted at low-income elderly or disabled individuals. While the subsidy is meant for renovations that improve the owner's possibility of living at home, it also covers any energy efficiency measures undertaken as part of the renovation. The second is an energy subsidy, which covers 21 different energy efficiency measures plus design costs.

The Government Programme also sets the target of phasing out fossil fuel oil in heating by the beginning of the 2030s. Oil heating will no longer be used in properties owned by central and local governments after 2024. A quota obligation has been introduced for light fuel oil used for heating. The obligation for bio liquids will be a 10% share in 2028. There are also a range of informational policies, including consumer energy advice, energy certificates and labelling, and campaigns on energy efficiency. (Finland's Integrated Energy and Climate Plan 2019.)

1.4.2. Transport

The main non-tax measure in the transport sector is the quota obligation for biofuels. Fuel distributors are required to supply a statutory share in the form of biofuels each year. This share was planned to be raised to 30% by 2029, with a separate obligation for advanced biofuels rising gradually to 10% by 2030 (MoF 2021). However, following the sharp increase in energy prices, the obligation is reduced by 7.5 percentage points in both 2022 and 2023, meaning the obligation is 12% in 2022. This would be compensated by raising the obligation for 2024-2029 and setting the obligation at 34 percent for 2030. (Finnish Ministry of Economic Affairs and Employment Press Release 8.7.2022.)

Other notable measures include subsidies for EV charging infrastructure and support for buying fully electric cars (€2,000), as well as support for gas or ethanol conversions of old cars (€1,000 for gas and €200 for ethanol conversions). There was also a vehicle scrappage fee system in place during 1.12.2020–31.1.2021. Furthermore, the government program outlined an annual support of 20 million euros for public transport climate measures. In 2021, Traficom granted 15.5 million euros in grants to climate measures in public transport. The implementation of the National Walking and Cycling Promotion Program is also underway. 6.5 million euros has been allocated for 2022 for support to municipalities to improve conditions for walking and cycling. Rail transport is also implemented through purchase agreements. For the year 2021, the Ministry of Transport and Communications and VR, the government-owned railway company, concluded an agreement with the help of 22 million euros granted by the government. (Finnish Ministry of the Environment 2022.)

1.4.3 Agriculture

The current measures in the agricultural sector are mainly related to the implementation of the EU's Common Agricultural Policy (CAP). It involves rural development measures to address specific challenges facing rural areas, market measures to address difficult market situations, and direct payments to provide income support for farmers (European Court of Auditors 2021). However, climate policy efforts in the agricultural sector do not appear to have been effective. Agriculture is the only sector in Finland in which emissions have remained approximately unchanged for years and, for example, the Finnish Climate Change Panel (2022) estimates that with current policy measures, future emissions reductions will also be modest.

A special report by the European Court of Auditors (2021) examines whether the CAP supported climate mitigation practices with a potential to reduce GHG emissions from agriculture in the 2014-2020 period. They find that despite the fact that over 100 billion euros – more than a quarter of the total CAP budget – was attributed to mitigating and adapting to climate change, it had little impact on agricultural emissions. The audit reveals that most of the CAP's mitigation measures have low potential to mitigate climate change. For example, the CAP does not seek to limit livestock numbers, despite the fact that livestock emissions represent around half of emissions from agriculture. The CAP also provides minimal support for effective mitigation practices related to chemical fertiliser use, including forage legumes, variable nitrogen technology, or nitrification inhibitors[3], and offers only limited protection for carbon stored in grassland. (European Court of Auditors 2021.)

The polluter-pays principle, i.e. the practice that those who pollute should bear the costs of pollution, is generally not applied in the agricultural sector. Agriculture is not regulated by the EU ETS, and in Finland agriculture receives energy tax refunds. Meanwhile, some of the existing policies create environmentally undesirable incentives. For example, there are currently subsidies that support clearance of peat land for farming (Parry and Wingender 2021).

1.4.4 Energy production and industry

The EU ETS is the main policy instrument in energy generation and industry. However, renewable energy and energy efficiency is promoted also through national measures, which affects these sectors. In 2019, Finland passed legislation to phase out the use of coal in energy production by 2029. Investment support amounting to 90 million euros for energy projects replacing coal is available during 2020-2025. (Finnish Ministry of the Environment 2022.)

Finland has also committed to a target of having 51% of its gross final energy consumption met with renewables by 2030. Policies to achieve the target included a sliding feed-in tariff system for the production of electricity from renewable energy sources, which was phased out. In May 2018, a new premium system was introduced, which is based on a competitive tendering process (Integrated Energy and Climate Plan 2019). However, the auction for renewable energy consisted of only one round, and the resulting premium was low. All the accepted tenders came from wind power plants (The Finnish Energy Authority 27.3.2019).

Renewable energy is also promoted through, for example, the Energy Aid Scheme, an investment subsidy. Aid is primarily targeted at the commercialisation of new technologies and the non-ETS sector, including plants producing advanced biofuels for transport, and non-ETS installations' electricity and heat production. Aid is paid up to 30% for mature technologies and up to 40% for new technology projects. However, aid levels are typically much lower, especially for mature technologies. The objective is that aid for different technologies will be phased out as a technology develops, costs are reduced, and competitiveness improves. The typical annual budget has been €30–40 million and this trend is expected to continue in future. (Integrated Energy and Climate Plan 2019.)

Finland also has a separate energy efficiency target based on the EU's Energy Efficiency Directive. The 2030 target is for final energy consumption to not exceed 290 TWh. Meeting this target is supported, for example, with energy advisory services and information services targeted at consumers. Energy savings and energy efficiency have been promoted through Voluntary Energy Efficiency Agreements drawn up between the Government and industrial/

[3] Forage legumes, such as clover and alfalfa, can be used in grassland and lower fertilizer use due to their ability to fix nitrogen from the air. Variable-rate nitrogen technology is a particular type of precision farming that matches fertilizer applications to crop needs within the same field. Nitrification inhibitors are compounds that slow down the conversion of ammonium to nitrate, which reduces N_2O emissions. (European Court of Auditors 2021.)

municipal associations already since the 1990s. The agreements are intended to guide companies and municipalities towards continuous improvement in energy efficiency. The participants set a quantitative target to improve their energy efficiency and they implement actions in order to reach their targets. (Finland's Integrated Energy and Climate Plan 2019.)

To reduce emissions from machinery, an act to promote the use of biofuels in heating, machinery and stationary engines entered into force on 1 April 2019. The act sets an obligation to supply light fuel oil with bio-liquid so that the share of biofuels will increase from 3% in 2021 to 10% in 2028 (Finnish Environment Ministry 2022).

2. Analysis of carbon pricing and energy taxation

2.1 Effectiveness of carbon pricing instruments

While there exist numerous papers on carbon pricing, only a small number of papers are ex-post empirical studies assessing the effectiveness of carbon pricing. The reason for this is the difficulty of isolating the effects of a carbon tax or ETS from those of other climate instruments or exogenous economic conditions. However, there exist some systematic reviews that focus only on ex-post quantitative evaluations of carbon pricing. Martin et al. (2016) review the literature on the impacts of the EU ETS on regulated firms in the industrial and power sectors, while Haites (2018) and Green (2021) review studies on both carbon taxes and ETSs worldwide. These reviews conclude that the effects of carbon pricing instruments have been modest. However, this is likely to be caused by the fact that almost all existing policies impose carbon prices that are inefficiently low. Furthermore, many of the studies included in these reviews rely on, for example, fixed-effects regression models, and cannot provide a causal effect of carbon pricing.

However, there are some exceptions that use more sophisticated econometric methods. For example, Andersson (2019) studies the effects of a carbon tax and VAT on transport fuel on transport sector emissions in Sweden during 1970-2011 using a synthetic control method. Andersson finds that after implementation of a carbon tax and VAT on transport fuels, CO_2 emissions from transport declined almost 11 percent in an average year, with 6 percent attributable to the carbon tax alone.

Another method used for studying the effectiveness of carbon pricing is difference-in-differences (DiD). For example, Dechleprêtre et al. (2018) study the effects of the EU ETS on CO_2 emissions and find that it reduced emissions by 6% during 2005-2007, and 15% during 2008-2012. Using DiD, Petrick and Wagner (2014) and Wagner et al. (2014) find no effect of the EU ETS on emissions during Phase I but estimate that it reduced emissions by 25–28% in Germany and by 13.5–19.8% in France during Phase II. DiD has also been used to study carbon taxes. Lin and Li (2011) study the effects of carbon taxes in selected countries during 1990-2008. They find that the Finnish carbon tax caused a 1.7% reduction in the growth rate of CO_2 emissions per capita, but carbon taxes had no statistically significant effect on emissions in Denmark, Sweden and the Netherlands.

2.2 Factors limiting the effectiveness of carbon pricing

The variation in findings from the studies discussed above highlights that low carbon prices and other policy features can significantly influence the effectiveness of carbon pricing. These factors are now discussed in turn.

2.2.1 Low price level

As discussed earlier, there is an ongoing debate about the appropriate benchmark for carbon pricing. One approach is to estimate the social costs that result from each tonne of CO_2 released into the atmosphere. Under this approach, it is economical to cut emissions as long as the investment needed to reduce emissions is lower than the costs of emissions to society. These social cost estimates vary widely, as they rely on different assumptions. The German Environmental Protection Agency estimates the social damage to be €180 per tonne released in 2016, while an earlier literature review by Alberici et al. (2014) suggests a low-end estimate of climate costs of €30 at that time. (OECD 2021.)

Another approach estimates what level of carbon pricing would produce an emission reduction path in line with a certain goal. For example, the High-Level Commission on Carbon Prices (2017), led by Nicholas Stern and Joseph Stiglitz, estimates that the price should be 50-100 USD/tCO_2 by 2030, in order to achieve the emission reductions in accordance with the Paris Agreement.

Figure 6 depicts the actual effective carbon rates for EU Member States. These effective carbon rates are the sum of fuel excise taxes, carbon taxes and emissions trading systems that put a price on carbon emissions. However, it should be noted that fuel excise taxes, which are usually not motivated by climate objectives, dominate effective carbon rates (OECD 2021). The rates are reported in terms of the carbon content of the fuels to which they apply. The following observations can be made based on the table: Firstly, we see that a significant share of countries have effective carbon rates that are far lower than any of the benchmark carbon rates. Secondly, Finland has the highest effective carbon rates for most fuels, followed by Sweden, France and Denmark. Thirdly, the differences in effective rates are larger across EU Member States than within Finland. It seems that Finland does significantly better than other countries in terms of effective carbon price levels. However, many other EU countries' carbon prices are almost certainly too low to achieve climate targets, but they simultaneously constrain Finland's ability to raise its own carbon rates unilaterally for fears of adverse impacts on international competitiveness.

Sector	Fuel	Min.	AT	BE	BG	HR	CY	CZ	DK*	EE	FI*	FR*	DE*	EL	HU	IE*
Transport	Diesel	110,8	133	201	111	139	134	143	144	125	240	244	183	138	114	166
	Petrol	158,9	213	231	160	231	190	221	279	249	373	347	315	310	164	266
	LPG	40,4	84	301	56	4	40	49	173	62	153	85	113	139	93	63
Residential heating	Diesel	7,5	35	6	9	20	27	9	120	134	142	101	47	147	122	42
	Heavy Fuel Oil	4,8	19	5	8	7	5	6	122	18	141	89	30	12	7	31
	LPG	13,3	14	6	0	4	0	0	103	18	144	112	45	19	93	25
	Natural Gas	5,3	30	8	0	5	46	6	159	19	155	86	52	5	0	0
	Coke and coal	3,2	18	4	3	3	3	3	104	10	120	88	28	3	0	0

Sector	Fuel	Min.	IT	LV	LT	LU	MT	NL	PL	PT*	RO	SK	SI*	ES	SE
Transport	Diesel	110,8	207	139	125	119	138	169	113	172	115	132	146	127	219
	Petrol	158,9	322	225	206	209	216	354	170	295	165	246	201	223	288
	LPG	40,4	87	92	98	33	13	113	62	105	44	59	65	19	115
Residential heating	Diesel	7,5	145	20	8	4	62	181	19	139	123	141	84	35	144
	Heavy Fuel Oil	4,8	20	5	5	5	12	12	5	33	5	37	29	5	134
	LPG	13,3	61	0	0	3	13	113	4	105	39	0	24	5	142
	Natural Gas	5,3	21	8	5	19	15	208	5	29	6	7	33	12	147
	Coke and coal	3,2	5	8	3	11	3	5	3	23	3	3	25	7	113

*Figures for countries with a * include national CO_2 taxation. Calculations based on the "Taxes in Europe Database"[139]*

Figure 6: Effective Carbon Rates 2020. Source: "Effective 2020 carbon price by EU Member States", p. 135.

2.2.2 Overlapping policies

While the average effective carbon rate in Finland is relatively high, it varies substantially across sectors and firms. However, according to economic theory, in order for carbon pricing to be the most cost-effective, it must be uniform. This allows for the least expensive abatement to occur first.

In some cases, overlapping policy instruments are used to target the same emissions. For example, the carbon tax component of energy taxes overlaps with the EU ETS to some extent, as operators pay for allowances under the EU ETS and also the energy tax. The main argument against overlapping emissions trading and carbon taxation is the "waterbed effect". If Finnish firms face a high carbon tax, they will be incentivized to reduce their emissions. Consequently, the demand for allowances is reduced, which suppresses the allowance price. This reduces the incentive for other countries to mitigate climate change.

This problem has been addressed with the introduction of the Market Stability Reserve which removes excess allowances from the market. However, the effectiveness of this solution depends on the rate at which allowances are removed. However, even with the Market Stability Reserve, overlapping policies can increase the cost of abatement. For example, Magnusson (2017), estimates with a model calibrated to EU countries' energy sectors, that the EU's requirements for renewable energy production doubled the cost of abatement. (Koljonen et al. 2019.)

There are some justifications for sectoral policies including local externalities. For example, transport generates local environmental problems through particulate emissions, as well as congestion, noise, and other externalities, which can justify a higher carbon price. Furthermore, the EU ETS allowance price was very low for a prolonged period of time and was estimated to be below the carbon price needed to reach the targets set in the Paris

Agreement in 2015. In light of these factors, additional national measures may be justified. However, in general, avoiding overlapping instruments would lower the cost of abatement.

2.2.3 Exemptions from carbon pricing

A more common inconsistency in carbon pricing is that many firms and fuels face lower carbon rates or are completely exempted from carbon pricing. In the case of the EU ETS, a significant proportion of non-electricity emission allowances will continue to be freely allocated to operators. The free allocation of allowances essentially amounts to handing out scarcity rents to firms (Fullerton 2011).

Similarly, carbon and energy taxes in Finland include notable tax expenditures. One key feature that has traditionally undermined energy taxation in Finland is the energy tax refunds. While these will be phased out for energy-intensive firms during 2021-2024, they will still continue for agriculture.

Other key features undermining the cost-effectiveness of energy taxation are the lowered energy-content component tax for CHP and, to some extent, the exceptions on the taxation of peat. From a climate policy perspective, the tax expenditure is not justified since the climate impacts of peat match those of coal. The situation is further complicated by the fact that small installations are not included in the EU ETS and the smallest installations have been exempted from the energy taxation of peat. (Eerola et al. 2021.)

Free allowances not only reduce the auction revenues that would otherwise benefit public finances, they also undermine the price signal of the ETS. Dechezleprêtre et al. (2018) find that installations receiving free allowances did not, on average, reduce their emissions, which hinders the emissions-reduction potential of the ETS. Furthermore, if only specific sectors or firms are eligible for the reduced taxes or free EU ETS allowances, this provides them with a financial advantage, which can be interpreted as business support. However, as noted by Laukkanen and Maliranta (2019), the business support element of free allowances is ambiguous, since the ETS only includes relatively large installations, meaning that without free allocation, it involves differential treatment of installations in the same industry.

The exceptions to the carbon price have been justified on the basis of competitiveness arguments that forcing installations to pay the full carbon price would result in carbon leakage. Carbon leakage can be the result of either domestic firms transferring their production abroad to avoid the increase in production input prices, or it can be due to domestic firms losing market shares to foreign competitors from countries with less ambitious climate policies (Eerola et al. 2021). The transfer to production abroad would not only have economic effects, but potentially also environmentally harmful effects if new factories and other buildings are built abroad, resulting in substantial embodied emissions.

Empirical studies do not, however, provide evidence of an obvious carbon leakage threat. In the case of energy refunds, Harju et al. (2016) and Laukkanen et al. (2019) have analysed the effects of the refunds on firms' competitiveness. Both arrive at the conclusion that the refunds had little effect on firms' performance. Furthermore, taxes are refunded only to relatively large firms. This means that the final carbon price differs depending on firm size, which undermines cost-effectiveness. Dechezleprêtre et al. (2018) find in their study comparing installations around eligibility thresholds, that the ETS does not impose any negative economic effects on regulated firms and, in fact, seems to have even improved the turnover of firms. This would be consistent with the so-called Porter hypothesis, according to which environmental regulation can have a positive influence on growth and competitiveness, because firms develop new innovative technologies and products as a result of regulation (Köppl and Schratzenstaller 2021).

One argument for exemptions from carbon pricing is that they make carbon pricing more politically acceptable, and without them, it might become more challenging to raise the carbon prices in the future. However, there is little empirical evidence to support this claim. Furthermore, as noted by the Finnish Research Division on Business Subsidies (2022), once tax expenditures are introduced, they have a tendency to remain permanent features of the tax system. It should also be noted that even if exemptions from carbon pricing are temporary, it does not mean they are without, potentially long-term, consequences. Hawkins-Pierot and Wagner (2022) use US Census microdata and quasi-experimental variation in energy prices to show that the initial electricity prices that manufacturing plants pay in their first year of operations are important determinants of long-term energy intensity. The authors argue that is a consequence of "lock-in" that limits plants' ability to re-optimise energy-inefficient production technologies chosen based on past market conditions. Therefore, they note, ignoring the dynamic effects of current energy prices on energy use tomorrow underestimates the benefits of carbon pricing today.

Overall, the discussed exemptions do not follow the principles of good public policy. They result in the differing treatment of firms based on their size. There is also limited evidence that they improve the competitiveness of firms, which is the main argument used to justify them. It should be kept in mind that these empirical studies have focused on periods when the EU ETS allowance price and carbon tax rates have been relatively low, and the results could differ for a higher carbon price. However, the existing literature suggests that the case for free allowances and tax expenditures based on competitiveness concerns is not very strong.

2.3 Developments in tax and allowance revenues

The revenues from carbon pricing instruments depend on the amount and price of emissions. As emissions decrease, the revenue base decreases, which in turn reduces the income from carbon taxation and emissions trading. On the other hand, the price of emissions is expected to rise as the emissions cap is decreased or carbon taxes increased. In general, revenues depend on marginal abatement costs, which in the longer term depend on the development of production technologies and consumer preferences. (Finnish National Audit Office 2020.)

Finnish revenues from both EU ETS allowance auctions and energy and carbon taxes are expected to decline in the future as the economy decarbonises. This has serious budget implications as, for example, energy taxes are the largest class of excise taxes in Finland. While a dramatic decline is not forecasted to occur in the medium term, it still requires preparation in the near future (MoF 2020).

The development of environmental tax revenues is tied to the broader issue of fiscal sustainability. The financial crisis of 2008/2009 and the fiscal implications of COVID-19 made it clear that fiscal sustainability is critical for addressing multiple aspects of the green transition – it influences the ability of the EU and its neighbours to finance investments while maintaining the resilience of the economic system (EEA 2022).

Existing climate measures are also expected to have mixed effects on the economy. The results of the HIISI project, which produced modelling on the effects of Finland's climate measures, suggest that the effects on the national economy arise primarily from additional investments in energy technology, but also from increasing energy efficiency and production processes, as well as the electrification of transport. On the other hand, these expensive investments renew the economy's consumption and production structures, which creates significant efficiency and also new opportunities when the economy becomes electrified and electricity production becomes emission-free. The investments required to limit emissions are forecasted to increase GDP for a large part of the 2020s and 2030s. During the transition, exports and household consumption will decrease compared to the scenario without climate measures. However, new, more productive and energy- and material-efficient technology enables exports to recover and supports overall economic growth in the long-term (Honkatukia 2021).

There are also potential economic policy risks from both mitigation policies and climate change itself. For example, climate policies can change the cyclical dynamics of the economy in the longer term, as the majority of carbon pricing revenues come from energy production and industry, which are sensitive to business cycles. Similarly, the price of EU ETS allowances is counter-cyclical, which acts as an automatic stabiliser, but weakens the public sector's finances in recessions. Mitigation efforts are also expected to result in some fossil fuel-based activities and infrastructure losing their value before the end of their expected economic life, resulting in stranded assets. It is difficult to predict the extent of assets that will lose their value, which makes them a potential source of financial market disruption. However, climate change itself will also cause physical risks that are expected to be wide-ranging and severe. Failure to act can result in significant risks, which warrants taking a climate perspective into account in the longer-term planning of government finances. (National Audit Office 2020.)

Climate change also involves numerous fiscal implications which cannot be easily quantified. For example, mitigation could involve co-benefits to health and productivity (Shang 2021). While this could have a positive impact on public finances, the effect is difficult to predict. Furthermore, as noted by Hassler et al. (2020), indirect effects caused by the impact of climate change on the world around us, including trade, migration, international conflicts, and increased need for international aid could be significant, but are very difficult to assess.

The effects of climate policies on public finances also crucially depend on the chosen measures. If policies are designed cost-effectively, their fiscal implications may be small compared to, for example, spending related to population ageing (National Audit Office 2020). However, both the Finnish National Audit Office (2020) and the Finnish Economic Policy Council (2021) expect that the role of climate policy in government budgeting will have to increase in the future, which will consequently require a reconsideration of the current composition of public expenditure.

In general, governments will have to come to terms with the increasing pressure from decreasing environmental tax revenues and increasing need for mitigation and adaptation investments. However, current business support measures, including reductions and exceptions in energy taxation and the free allocation of EU ETS allowances, mean the government is currently losing out on substantial carbon price revenues. Addressing these exceptions to the carbon price could strengthen the carbon price signal and improve climate policies' cost-effectiveness, while also creating more fiscal space.

2.4 Transport sector carbon pricing

Reducing transport emissions has a crucial role in meeting Finland's climate targets and mitigating climate change. It is also a sector where national carbon pricing is the key mitigation measure. For this reason, it warrants more detailed inspection.

The transport sector in Finland generally has a high carbon price that creates a strong incentive to reduce emissions. Finland has one of the highest total car tax burdens (sum of acquisition taxation, ownership taxation and energy taxation) compared to other European countries. For example, the typical total tax burden[4] for a small petrol car over ten years of private ownership is €8,434 in Finland, while the lowest is €1,512 in Bulgaria. When compared to other Nordic countries, Finland has some of the highest excise fuel duties, but taxes on the acquisition and ownership of cars tend to be lower. For example, in Denmark the majority of taxation is on car purchases and ownership and the overall tax burden on a privately-owned small petrol car in Denmark is double that in Finland at €16,930 (Transport and Environment 2022.)

Analysis of transport sector taxes generally indicates that out of all tax instruments, excise taxes on fuels are the most effective way to mitigate transport emissions, as they create continuous incentives to reduce annual mileage. In their 2021 report, the Danish Chairmanship of the Environmental Economic Council analyses a comprehensive reform of the taxation of private cars in Denmark and concludes that it involves major net benefits. In the proposed reform, the negative externalities from private motoring would be targeted by three modifications to the tax system. Firstly, by introducing road pricing that reflects the costs of traffic, including congestion, accidents, pollution, and other externalities. The taxes would be higher in cities during rush hours, when the externalities from driving are the greatest. Secondly, by reducing car registration and ownership taxes significantly. Thirdly, by targeting fuel taxes at CO_2 emissions.

The Chairmanship quantifies the size and distributional consequences of the reform and find that when fully phased in, the reform is expected to give an annual net benefit of approximately DKK 20 billion (approx. €2.7 billion) in 2030. Furthermore, the public sector would receive additional revenue of almost DKK 15 billion (approx. €2 billion). The Chairmanship recommends that the taxation of cars be reoriented towards road pricing. Their

[4] Based on typical ownership periods and driving distances.

analysis also comes to the conclusion that CO_2 reductions are achieved most cost-effectively by increasing fuel taxes on petrol and diesel, as these taxes are directly targeted at CO_2 emissions. It would also provide a more effective incentive to buy electric cars compared to EV subsidies, as subsidies tend to incentivise more driving.

A working group appointed by the Ministry of Finance between September 2019 and May 2021 investigated the needs for reforming road transport taxation in Finland. The working group estimated that the taxation is functional, but not cost-effective in all respects. This could be improved by shifting the emphasis from the basic tax component of the vehicle tax to fuel taxes and car taxes, and by removing harmful tax expenditures. This would improve the mitigation incentives of transport taxes without tightening transport taxation overall. It could also improve the progressivity of transport taxation because the effect of reducing vehicle taxation is relatively constant across income levels but the effect of the fuel tax increases with income. This is because higher income households drive more on average than lower income households. However, the average changes in tax burden in different income deciles would be very small, no more than €30 per year. (MoF 2021.)

While the Finnish car tax system provides incentives for purchasing lower-emission vehicles, the environmental incentives are somewhat blunted by relating tax rates to vehicle prices. This reduces the tax advantage of EVs as they tend to be more expensive (Parry and Wingender 2021). However, car taxes have an important role, as they are paid when a car is first acquired and can therefore correct for the fact that consumers may not account for the full future fuel costs and other costs when choosing a car. Conversely, the basic tax component of the vehicle tax is generally seen as an inefficient way to mitigate emissions (MoF 2021). Studies using European data have generally found that while annual vehicle taxes can reduce the demand for more emissions-intensive cars and promote the removal of cars subject to higher taxes from the vehicle fleet, these effects tend to be modest and could be achieved more cost-effectively with fuel taxes (Palanne and Sahari 2021). Therefore, readjusting the emphasis between transport sector taxes could have significant benefits.

Road transport taxation in almost all countries includes tax expenditures that reduce the mitigation incentive. The most notable tax expenditure in the transport sector is the lowered excise tax on diesel. The marginal damages from using diesel are greater than those from using petrol, making the lowered tax inefficient (Eerola et al. 2021). Removing the favourable treatment of diesel in excise fuel taxation would improve economic efficiency and generate, albeit moderate and transitional, emissions and fiscal benefits (Parry and Wingender 2021).

2.5 Policy responses to the energy crisis in the electricity sector

Energy prices were rising already during 2021, due to factors including underinvestment in natural gas and clean energy supply, and short-term developments including reductions in natural gas spot delivery by Russia and a strong recovery in demand in the aftermath of the COVID-19 slump (OECD 2022). This situation was drastically exacerbated by Russia’s war in Ukraine, resulting in a significant reduction in consumers’ purchasing power. Finnish households have already seen their electricity bills increase by hundreds, or even thousands, of euros compared to 2021, and the worst is expected to come during the winter when electricity demand is highest. As discussed in section 1.3.6, electricity tax was lowered for a number of sectors and firms already during 2021, and in 2022 the government has introduced a VAT reduction for electricity as well as a household tax deduction to alleviate the pressure on households from rising electricity bills. In December, the government announced new measures that are being prepared, including a retroactive, one-off compensation to electricity users and flexibility in paying electricity bills.

However, there are many reasons to question the effectiveness of electricity tax reductions and deductions. Firstly, consumers could instead be compensated with lump-sum transfers that avoid distortions to relative prices and make consumers better off. Secondly, by making electricity relatively cheaper, tax cuts hinder the incentive to reduce energy consumption. This does not allow demand to adjust to supply constraints, which could exacerbate shortages and sustain future inflation (OECD 2022). A similar critique can also be made against the household tax deduction as it is based on this winter's electricity bills and therefore dampens households' incentives to reduce electricity consumption. Thirdly, these are not targeted instruments. This means they may accrue disproportionately to large electricity consumers, who often have higher incomes (OECD 2022). Furthermore, they are likely to place a larger burden on the government's budget compared to more targeted instruments.

Another measure that has received a lot of attention is the possibility of lowering the price cap on the wholesale electricity market. The current EU-wide cap is €4,000/MWh. The price cap has involved an automatic maximum price adjustment mechanism, in which electricity exchanges are obliged to automatically increase the price ceiling of the daily electricity market whenever the price level reaches 60% of the price ceiling in even one of the bidding areas of the EU's connected electricity markets. In August 2022 this mechanism was triggered when the price of electricity rose to €4,000/MWh in Estonia, Latvia and Lithuania, which would have resulted in the cap rising to €5,000/MWh in September 2022. However, following calls from grid operators to freeze the automatic maximum price adjustment mechanism, the cap was kept at 4,000/MWh (Uusitalo 2022.)

At this time, there are no plans to lower the cap at the EU level. However, the Finnish government is preparing a national price ceiling for electricity. Gerlagh et al. (2022) argue that a lower electricity price cap at the EU-level would correct for the misallocation caused by the fact that short-term demand is sticky in electricity markets. Furthermore, they argue that lowering the cap has significant distributional benefits as a small demand reduction leads to a large price drop. However, lowering the cap at the Finnish level has been criticized for fear that it would result in power cuts, as it does not create an incentive to save electricity at a time when supply is limited (Keski-Heikkilä 2022).

The EU has also introduced a new regulation on an emergency intervention to address high energy prices. It includes measures to reduce electricity demand to help lower the electricity costs for consumers and suggests a temporary revenue cap on electricity producers using technologies with lower costs, such as renewables, nuclear and lignite. The Commission proposes to set the cap for those "inframarginal" producers to €180/MWh. The third measure is a temporary solidarity contribution on excess profits made in the oil, gas, coal and refinery sectors. It would be collected by EU countries on 2022 profits, which are at least 120% of the average profits of the previous 3 years and would be redirected to energy consumers. The regulation was adopted in October 2022. (European Commission: Action and measures on energy prices.)

3. Distributional effects of carbon pricing and compensation policies: Literature review

The distributional effects and perceived fairness of climate measures are important goals not only in themselves, but also because they are closely linked to the acceptability and feasibility of climate actions. People who feel they are adversely affected by climate actions are also more likely to oppose them (Alimov et al. 2020). Therefore, assessing the distributional effects of climate policy measures already in the planning phase is important and requires more research. The issue is also very timely, as the rising costs of living have sparked intense debate about the need to reduce households' tax burdens.

3.1 Carbon tax incidence

Economic tax incidence refers to who truly bears the tax burden, and it often differs from statutory incidence, i.e. who has the legal obligation to pay the tax. Under perfect competition, the economic incidence of the tax depends on the relative demand and supply elasticities for the good, where the more inelastic side of the market bears a greater share of the burden of the policy. An extensive literature has developed, focusing on the incidence of carbon taxes[5], especially the distributional consequences of differing carbon tax burdens across income groups.

Traditionally, the consensus in the literature has been that carbon taxes are regressive, meaning that the carbon tax budget share decreases with income, and therefore the tax places the greatest relative burden on low-income households. The proposed explanation for this is that poorer households spend a larger share of their disposable income to cover their energy needs (Frondel and Schubert 2021). More recent studies, however, have called this "regressivity assumption" into question. A relatively recent literature has emerged that suggests the distributional impacts of energy taxes depends upon the fuels and pollutants that are targeted, the characteristics of the taxed populations and their communities, how household income is measured, and how policy-generated resource rents are distributed (Pizer and Sexton 2019). These studies have consequently tended to highlight assumptions and modelling choices that appear to be key in explaining whether a carbon tax is found to be regressive, progressive or proportional. These assumptions and modelling choices are discussed below.

[5] The literature has tended to study the distributional impacts of carbon taxes rather than emissions trading systems. The two instruments differ in terms of, for example, who receives the revenues from carbon pricing. However, most of the conclusions from the literature are likely to apply regardless of whether carbon pricing takes the form of a tax or an ETS.

3.2 Key factors influencing distributional effects

3.2.1 Measure of income

When calculating the carbon budget shares for households, a measure of income needs to be chosen. There are two main approaches in the literature, which differ in the time dimension over which the ability to pay is assessed. One takes a lifetime ability-to-pay approach and relies on total household consumption expenditure as an indicator. The other follows a short-term financial capacity approach and focuses on annual income. (Jacobs et al. 2021.)

The latter is likely to overestimate regressivity, as annual income is prone to intertemporal fluctuations. For example, some households in the lowest income deciles have low earnings today, but high potential future earnings (e.g. young households), or are retired with low pensions but large savings (Andersson and Atkinson 2020). However, using a lifetime ability-to-pay approach has its own shortcomings, as it relies on assumptions that households base their consumption on a constant fraction of lifetime income rather than current income, and that there is high income mobility (Jacobs et al. 2021).

Hasset et al. (2009) address issues with using current consumption by using an adjusted lifetime measure for consumption, first employed by Bull (1994), that is intended to correct for long-run predictable swings in behaviour. They classify people into subsamples, and for each subsample, the authors calculate a "typical" path of consumption. For any given person in the subsample, the authors know the ratio of their current consumption to the average of their age group, and they compute lifetime consumption by multiplying this ratio with the present value of their typical lifetime path. This is meant to control for predictable lifetime patterns of consumption on incidence calculations. The authors' comparisons of results with different income measures confirm that incidence calculations based on annual income imply much steeper regressivity, because the proportion of energy in total consumption varies significantly over the lifecycle.

3.2.2 Elasticities and market conditions

Due to their nature as Pigouvian taxes, carbon taxes are meant to incentivize substitution away from polluting activities that incur the tax. This substitution consequently affects an individual's tax burden but will differ depending on the nature of the product being taxed. As noted by Andersson and Atkinson (2020), in countries with a relatively low GDP per capita, transport fuel is often a luxury good – having an income elasticity of demand above unity – and a carbon tax on transport fuel would therefore be progressive. Similarly, fuel taxes on aviation are generally considered progressive (Clayes et al. 2018). Conversely, taxes on necessities (income elasticity below unity) are regressive.

Elasticities also determine the extent to which firms can pass on the tax to consumers and can therefore create differences in tax incidence. Markets with a high price elasticity would have to absorb the carbon tax from the direct use of fossil fuels as well as potential price increases from intermediates, which could lead to profit losses. Markets with inelastic demand, on the other hand, could shift the tax burden to downstream sectors and consumers. (Köppl and Schratzenstaller 2021).

Harju et al. (2022) analyse the pass-through of a diesel tax increase to diesel prices using station-level microdata and a difference-in-differences strategy. They find that the economic burden of the diesel carbon tax is somewhat split between the demand and supply sides of the market, though consumers face most of the burden. However, their results also reveal regional differences. The pass-through tended to be higher in areas with lower average incomes and in rural areas, compared to areas with higher average incomes and urban areas.

It should, however, be noted that the relationship between pass-through rates and elasticities may be further complicated by differences in market competitiveness. There exists a theoretical literature which suggests that while in a perfectly competitive market, tax pass-through is determined by the relative elasticities of supply and demand, in an imperfectly competitive market, pass-through is more complex as it depends not only on elasticities but also on the curvature of demand and degree of market power (Weyl and Fabinger 2013). Empirical studies offer some support for this hypothesis. For example, Stolper (2016) finds that greater market power (measured by brand concentration and spatial isolation) is strongly associated with higher pass-through of energy taxes in the Spanish retail automotive fuel market. Similarly, Genakos and Pagliero (2022) study how the pass-through of excise duties by gas stations on small Greek islands vary. They find that pass-through increases from 0.4 in monopoly markets to 1 in markets with four or more competitors.

The existing literature also suggests that elasticities might differ between consumers, which would have distributional implications. Preuss et al. (2022) note that looking at the carbon emissions by households reveals that households differ considerably in their consumption behaviour. For example, the importance of fuel, and many other goods and services, increases with income.

The implications of differing elasticities are not, however, completely clear. Berry (2019) notes that if low-income households reduce their consumption more than high-income households, one might expect the carbon tax to become less regressive. However, this situation could reflect an unwanted restriction in energy consumption. This argument is also made by Tovar et al. (2018), who use a dataset on household expenditures in Germany and an Exact Affine Stone Index (EASI) demand system to analyse the distributional effects of rising energy prices. They find considerable differences in the elasticities of lower income households compared to richer ones, suggesting the former react more strongly to price changes. However, they argue that this should not be falsely interpreted as ex-ante higher flexibility, which makes households less vulnerable. Quite the contrary, the higher price reactivity is to a good part due to economic hardship low-income households face when energy prices increase.

Elasticities may also differ over time. Buchsbaum (2022) studies how income impacts price responsiveness among residential electricity customers by utilising price variation driven by the block pricing rate structure in California. Interestingly, Buchsbaum finds that not only do elasticities differ by income, but that high-income consumers are more responsive in the short-run, while low-income consumers are more responsive in the long-run. Buchsbaum argues that higher income consumers may have more margins to adjust their usage in the short- to medium-run, but prices play a larger role for low-income households in making investments in energy efficiency.

3.2.3 Country- and sector-specific characteristics

Heine and Black (2019) highlight that due to the multitude of factors that affect results, analysis of the distributional effects needs to be tailored to account for country-specific characteristics. For example, a tax on transport fuel is believed to be progressive in lower-income countries because owning a car is less common. However, in high income countries, more people own a car, and transport fuel is considered a necessity. Therefore, a carbon tax is likely to be more regressive in higher income countries.

Andersson and Atkinson (2020), however, argue that it is actually income inequality of a country that explains differences in regressivity, as opposed to the income level. They study the Swedish carbon tax on transport fuel using time-series data from 1999-2012 on carbon tax expenditure from a large annual household expenditure survey. The authors control for variations in GDP per capita, gasoline price, urbanisation, and unemployment, and they find a strong correlation between income inequality and the regressivity of the carbon tax. While the evidence is descriptive, and focuses on only one country, it suggests that regressivity could be linked to income inequality. This would imply that in countries such as Finland, with relatively equal distribution of income, consumption taxes would be close to proportional in their tax incidence.

Similarly, as elasticities are affected by the availability of close substitutes, country- or city-specific factors, such as the availability of public transport, can affect findings. Based on a meta-analysis of the literature, Ohlendorf et al. (2018) attempt to systematically determine the sources of variation in different studies' findings concerning the regressivity of carbon pricing and fossil fuel subsidy reforms. They apply an ordered probit meta-analysis framework on 53 empirical studies in 39 countries. Ohlendorf et al. (2018) conclude that there is an increased likelihood of progressive distributional outcomes for studies on low-income countries and transport sector policies. The same applies to study designs that consider indirect effects, behavioural adjustment of consumers, or lifetime income proxies.

3.2.4 Indirect effects

In addition to the direct effects of raising the prices of taxed goods, carbon taxes also have indirect effects as they raise the prices of goods that use taxed inputs. Therefore, progressivity will be affected not only by households' consumption of energy and fuels, but also their consumption of other goods and services. Furthermore, carbon taxes affect not only households' consumption, referred to as the *use-side*, but also the income side of consumers' budgets, referred to as the *source-side* (Goulder et al. 2019). Households that rely heavily on income from factors whose prices fall relative to other factor prices will be adversely affected (Rausch et al. 2011).

Whether source-side effects are progressive or regressive is not, however, completely clear. Fullerton (2011) argues that climate policies may increase the demand for capital relative to labour, which depresses the real wage. Since low-income households receive a relatively high share of their income from wages, they may have a higher burden on the source side.

However, Rausch et al. (2011) use US Consumer Expenditure Survey data in a comparative-static general equilibrium framework and find the source-side effects of carbon pricing to be progressive. Goulder et al. (2019) arrive at similar conclusions based on analysis of the impacts of various carbon tax designs on U.S. households using an integrated general equilibrium framework. They further find that the progressive source-side effect offsets the regressive use-side effect, so the overall impacts are either slightly progressive or close to proportional.

As noted by Pizer and Sexton (2019), by ignoring the indirect effects of carbon taxes, assessments can present an incomplete and distorted view of distributional effects. Consequently, studies may arrive at vastly different findings concerning the regressivity of carbon taxes depending on whether they also consider the differing income compositions of households. There are two main approaches for assessing indirect effects. The first method is a relatively simple approach based on input-output tables. For example, Hasset et al. (2009) use input-output tables to describe the flows of products and intermediary goods in the economy. The second is a more complex approach based on modelling the behaviour of energy users and other actors in the economy (Pizer and Sexton 2019).

While more difficult to quantify, carbon taxes also involve nonpecuniary effects. Douenne (2020) argues that restricting attention to monetary effects will lead to an understatement of the welfare impacts on those who reacted more strongly to prices. If some of them are already at the edge of their basic energy needs, their decrease in consumption could have critical welfare implications that will not be captured by the monetary effects (Douenne 2020). Other nonpecuniary effects include health effects. If the health effects of climate change and emissions are distributed unequally, then policies to mitigate those effects also have distributional implications. Globally, it has been argued that the poor live in areas that are more prone to climate-related damage and have higher exposure to air pollution (Shang 2021). Furthermore, the marginal damages from climate change tend to be larger for poorer populations because they have less access to credit and cannot insure themselves or build resiliency against adverse climate events (Shang 2021). In Finland, while it is not clear that lower income households would live in areas more prone to climate damage, there are evident differences in ability to adapt. This is demonstrated by, for example, the uneven access to air conditioning during increasingly frequent heatwaves.

All of the varying channels through which carbon taxes affect households also interact with the progressive income tax schedule in Finland, as any increase in consumer prices only affects the after-tax consumption of households (Parry and Wingender 2021). The effect on the income distribution depends on the progressivity of the effective tax schedule. Preuss et al. (2022) study the distributional effects of carbon pricing in Germany using household expenditure survey data and find that changes in the existing income support system can significantly affect the progressivity of carbon pricing and different revenue-recycling designs. Similarly, Goulder et al. (2019) find that existing inflation-indexed social transfers avoid otherwise regressive overall impacts of the carbon tax by providing additional nominal transfers to compensate for the higher overall consumer prices induced by the tax.

3.3 Revenue recycling

Together with the regressivity assumption, a long-standing assumption in the literature has been that any undesirable distributional impacts can be mitigated by returning tax revenues to households in the form of lump-sum transfers. While more recent literature still highlights the importance of revenue recycling in alleviating distributional effects, it also emphasizes that it is not a silver bullet.

Households are generally compensated in two ways: by changes in existing redistributive instruments (reduction in income tax, social transfers, etc.) or by the introduction of a new instrument (cash transfers, energy cheques, etc.). The first option is simpler to implement and avoids the costs of developing a new instrument. However, not all households fall under the scope of existing instruments. For example, social transfers mostly benefit low-income households, so increasing the levels would reduce regressivity. However, not all households receive social transfers, meaning that some individuals in the lowest income deciles would be left out (Berry 2019.)

Some economists also argue that the choice between using revenues to reduce taxes or returning them in the form of transfers involves an equity-efficiency trade-off. Equal per capita transfers would be more equitable, but less efficient. For example, Goulder (2013) compares different revenue-recycling mechanisms and finds that lump-sum transfers are considerably more expensive than tax cuts. However, lump-sum transfers have the added benefit of being more salient than tax cuts, which could make them politically more desirable (Preuss et al. 2022). Conversely, cuts to existing taxes would be more efficient, but more regressive as they would mostly benefit households with labour income (Rausch et al. 2011). Proponents of tax cuts also tend to raise the hypothesis of a "double dividend". According to the strong version of this hypothesis, using environmental tax revenues to decrease distorting taxes leads to an overall welfare increase, while according to the weak double dividend hypothesis revenue recycling via a reduction of distorting taxes is more efficient than granting lump-sum transfers (Köppl and Schratzenstaller 2021).

However, the double dividend hypothesis has also faced significant criticism. Existing inefficiencies in the tax system could be addressed more directly, without connecting this task to the use of carbon tax revenues. Furthermore, achieving a double dividend may be challenging in practice. Goulder (2013) argues that this is due to two reasons. Firstly, a carbon tax acts as an indirect factor tax as it raises the prices of taxable products and services, and simultaneously reduces real wages and real capital income. This is known as a *tax interaction effect*. Secondly, replacing a broad tax, such as income tax, with a narrow carbon tax substitutes consumption away from carbon-intensive goods and service. While this is good from an environmental point-of-view, it leads to more expensive production as production factors are used less efficiently (Goulder 2013). According to Goulder, a necessary condition for a double dividend is that the existing tax system is inefficient in a way that is unrelated to GHG emissions, and the revenue recycling sufficiently addresses these inefficiencies.

One important issue in revenue recycling is that the compensation should not interfere with the price signal from the carbon tax. Therefore, transfers should not be indexed to the energy expenditure or in any other way that essentially returns the full amount back to all the same individuals who were taxed. One potential solution proposed for this is indexing compensation to decisions that have already been made, as this would not distort future choices (Eerola 2021).

Ohlendorf et al. (2018) point out that revenue-recycling may be necessary even if the tax is progressive, since it may still significantly burden low-income households, and progressive effects do not automatically mean that a carbon pricing scheme would be politically acceptable. Indeed, there is precedent of increases in carbon-based taxation sparking serious backlash, for example in the form of the Yellow Vest protests in France, highlighting the importance of ensuring the acceptance of carbon pricing. Jacobs et al. (2021) also argue that, while from an environmental perspective it appears reasonable that heavy fossil fuel users are penalised, it might be worthwhile to address cases of hardship especially during a transition period. Specific groups of households might not be able to adjust to a less carbon intense behaviour in the short run, nor bear the additional tax burden.

3.4 Horizontal equity

More recent literature has highlighted that the average carbon tax burdens in income deciles hide considerable heterogeneity within. Therefore, attention must be paid not only to vertical equity, i.e. distributional effects across income deciles, but also horizontal equity, i.e. distributional effects within deciles. Tax burdens can vary considerably depending on households' consumption preferences and choices concerning, for example, where they live and how they commute.

Sources of horizontal variation identified in the literature include household size, regional structure of the place of residence, homeownership status, climate, electricity-generating infrastructure, home size and vintage, vehicle miles travelled, and the energy efficiency of durable goods (Cronin et al. 2019, Preuss et al. 2022). Preuss et al. (2022) note that based on the literature, particularly high-emission factors include disposable income, oil or gas heating, long-distance commuting and single-person households.

Horizontal equity also raises serious challenges for revenue-recycling. Even if vertical redistributions could be addressed with revenue recycling, horizontal redistributions are more problematic due to heterogeneity of income sources and expenditures. Douenne (2020) combines the French transport survey and the consumer expenditure survey to micro-simulate fiscal policies between 2016 and 2018. Douenne estimates the behavioural response to energy prices and simulates at the household level the fiscal incidence of an increase in energy taxes rebated using lump-sum transfers. The results show that tax incidence is very heterogenous. This poses a great challenge to revenue-recycling. No redistributive instrument can accurately and efficiently target those most affected because tax incidence depends on imperfectly observable, and highly manipulable, characteristics, including vehicle fuel-efficiency, housing choices, and preferences for energy consumption (Douenne 2020).

Using a microsimulation model built on a representative sample of the French population from 2012, Berry (2019) simulates the effects of taxes levied on households' consumption of energy for housing and transport. Based on a comparison of different revenue-recycling options, Berry finds that while the inequities of a carbon tax could be offset at a reasonable cost relative to total carbon tax revenues, the benefits of finely adjusting cash transfers may be somewhat limited. Those most burdened by the tax cannot be identified by one single characteristic, and fine-tuning can involve significant administrative costs. Sometimes this fine-tuning is not only costly, but impossible if the factors explaining tax burdens are unobservable. Berry finds that adjusting the transfer to income level is the most efficient design tested, while adjusting the transfer to household composition is on average slightly more expensive. Adjusting for residential location or climate zone does not significantly change the results. However, the study only considers the direct effects of the tax, and the results relate to a counterfactual scenario for 2012 before the implementation of the carbon tax.

Cronin et al. (2019) estimate the distributional effects of three revenue-recycling mechanisms using the U.S. Treasury Distribution Model and find that within each income decile there is large variation in energy demand, and horizontal redistributions exceed vertical redistributions. Cronin et al. worryingly find that transfers may not only fail to address distributional effects, but they may in fact even widen horizontal redistribution. They find that family size, and thus per capita rebates, vary within all deciles, but this variation is larger as a percentage of consumption for those in low consumption deciles. Similarly, transfer receipts are a large fraction of income for the average family in poor deciles, but some families in those deciles receive a small transfer, or no transfer at all. Thus, a uniform increase in all existing transfers overcompensates some poor families for their carbon tax burden and provides no compensation to other poor families (Cronin et al. 2019). Cronin et al. therefore emphasise that any package of reforms is likely to create winners and losers within each income group. However, their analysis does not consider factors including the efficiency effects of a carbon tax, the distribution of carbon policy benefits, or changes in factor prices.

Edenhofer et al. (2021) arrive at similar conclusions based on an assessment of the inequality effects of a carbon price on transport and heating fuels introduced in Germany in 2021. They find that there is a trade-off between horizontal and vertical inequality reduction with compensation measures. They suggest, as a practical solution, combining equal-per-capita payments with hardship compensation, for example, for oil heaters and long-distance commuters. This, they find, produces the least variability in tax burdens across the different household types, while simultaneously compensating poorer households.

The compensation of horizontal effects also includes more philosophical considerations about the appropriateness of compensation. Economic theory does not provide obvious answers to why, and in what way, the tax treatment of households should depend on their consumption preferences and choices (Eerola 2021). For example, if a household decides to live far away from their workplace and the services they require, they know they are committing to longer commuting distances which involve emissions and other negative externalities. It seems problematic to then compensate households for these choices. However, these decisions are sometimes the product of budget or credit constraints or other factors that constrain the household into making suboptimal decisions, further complicating the debate about compensation. For example, Clayes et al. (2018) argue that low-income households face budget constraints that lead them to prefer different consumption baskets than high income households, and they face borrowing constraints that prevent them from procuring more efficient durables. This is a topic that warrants further research.

3.5 Distributional effects of carbon pricing in Finland

Parry and Wingender (2021) estimate both the direct and indirect effects of Finnish carbon pricing. Direct effects are estimated using Eurostat tables on the structure of consumption expenditure for 48 aggregated categories of goods and services by income quintile for 2015 and assuming these budget shares apply for 2030. This assumption is problematic, but necessary due to data limitations. The indirect effects are estimated using supply-use tables for Finland for 2016 to calculate how sectoral prices change in response to higher domestic energy input prices, assuming these price impacts would be the same in 2030. The sectoral price changes are then matched to the household consumption tables.

Parry and Wingender assume increases in energy production costs are fully and immediately passed forward onto the domestic prices of goods and services, and the prices of non-energy intermediate and final imports stay constant when domestic energy prices increase. They also calculate the pass back of higher domestic energy input costs for exporting firms by sector using the same supply-use table. The associated sectoral wage changes multiplied by the share of output that is exported is then matched to household survey data to calculate the impacts on different household income groups. Finally, they analyse the interaction effect with income taxation in Finland.

Parry and Wingender estimate that prior to revenue recycling, a carbon tax of €125 per ton of CO_2 in 2030 imposes an average burden on households (relative to business-as-usual) of 0.9 percent of consumption and follows a U-shaped pattern (see Figure 7). The main channel contributing to lower real incomes is higher prices for electricity and district heating, lower wages and higher prices for other goods and services. The progressive income tax schedule also means that households in the lowest quintile face price increases on a larger share of their pre-tax budget compared to other households, since they pay lower taxes on average. At the other end of the income scale, households in the top 20 percent see a similar erosion in purchasing power, with almost half of the incidence driven by lower wages. Middle income households see the largest incidence impact mainly from lower wages and higher prices for electricity and heating. The authors argue that transferring the proceeds of the carbon tax along with a modest top up from general funds would fully offset the carbon tax burden at a fairly modest fiscal cost.

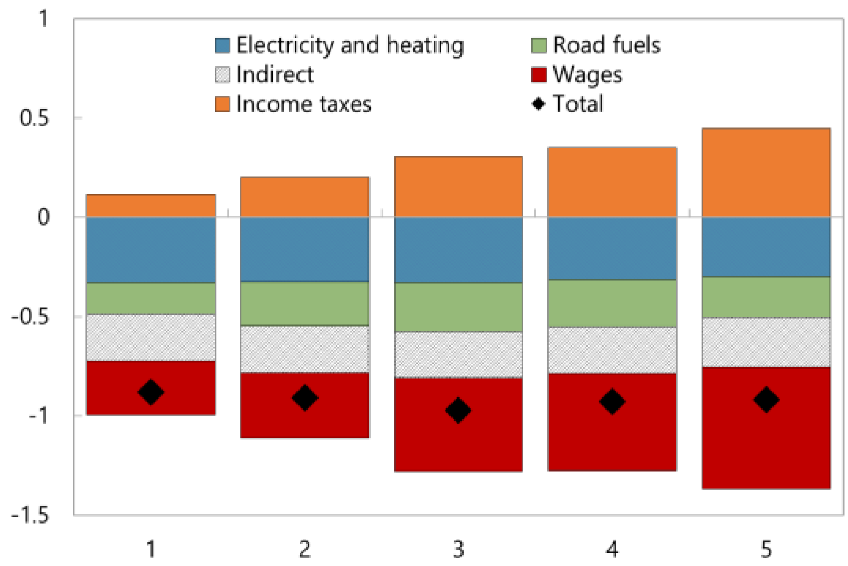

Figure 7: Carbon Tax Burden by Source (Percent of Total Household Consumption, by Income Quintile). Source: Parry and Wingender (2021) p. 26.

Palanne and Sahari (2021) examine the distributional effects of transport sector taxes in their report on the Finnish vehicle stock. They use Finnish Transport Safety Agency TRAFI data from 2016 on the passenger car fleet and annual inspections, which includes kilometres driven, the vehicle's fuel type and CO_2 emissions per km. The car owner could be matched to registry data from Statistics Finland providing the annual income of the owner and their residence region. Palanne and Sahari examine how carbon emissions and excise fuel tax budget shares vary by income group and region.

They find that lower income households are significantly less likely to own cars and they drive far fewer kilometres annually than higher income households. Consequently, average tax burdens increase with income, and the fuel cost share of household budget is highest for households in the 6th and 7th income deciles. They also find that households in less densely populated rural areas are more likely to own cars and drive more than those in inner city areas, and that variety in fuel cost shares is actually greater between regions than between income groups.

Alimov et al. (2020) study the distributional effects of climate measures in Finland using a dynamic general equilibrium model complemented with a microsimulation module for households. The baseline scenario consists of all current climate measures, and it is compared to scenarios with potential additional measures. The analysis is based on the assumption that households representing ten different income deciles provide an accurate representation of the population. The analysis studies the distributional effects of both the measures themselves and cases where the revenues are recycled by reducing income taxation margins or corporation tax. The effects of lump-sum transfer are also studied in one scenario.

Alimov et al. find that without compensation, the additional measures in several cases lead to a more even distribution of income compared to the baseline. When revenue-recycling is taken into account, the effects are unevenly distributed between households. The effects of the reduction in income taxation are primarily aimed at middle-income households, while the compensation made through the corporate tax targets the highest income decile. Lump-sum transfers reduce income differences the most, which is in line with findings from previous research.

Ari et al. (2022) illustrate the effects of the recent surge in international fossil fuel prices on households across European countries. Using the IMF's Climate Policy Assessment Tool, they compare household energy cost burdens with the projected energy prices for 2022, with a baseline derived from future prices as of January 2021. The model assumes a uniform price elasticity of demand of 0.5 and estimates the burden on consumer budgets for households in different consumption quintiles.

Ari et. al. note that in all European countries, poorer households spend more on electricity as a share of total consumption than richer households. Therefore, the direct impact of higher electricity prices is regressive. Poorer households also spend, on average, more on natural gas relative to total consumption in most countries. Conversely, spending on transport fuels as a share of consumption is relatively flat across consumption quintiles. Ari et al. estimate that the increase in fossil fuel prices raises European households' cost of living in 2022 by approximately 7 percent of total household consumption. However, Finland fares comparatively better in comparison to other countries, because households in Finland spend a smaller share of their total consumption on energy products. Figure 8 below compares the impact of higher energy prices on the 1st and 5th consumption quintiles. We see that the higher energy prices tend to be regressive across European countries, but the burden differs very little in Finland between the two quintiles.

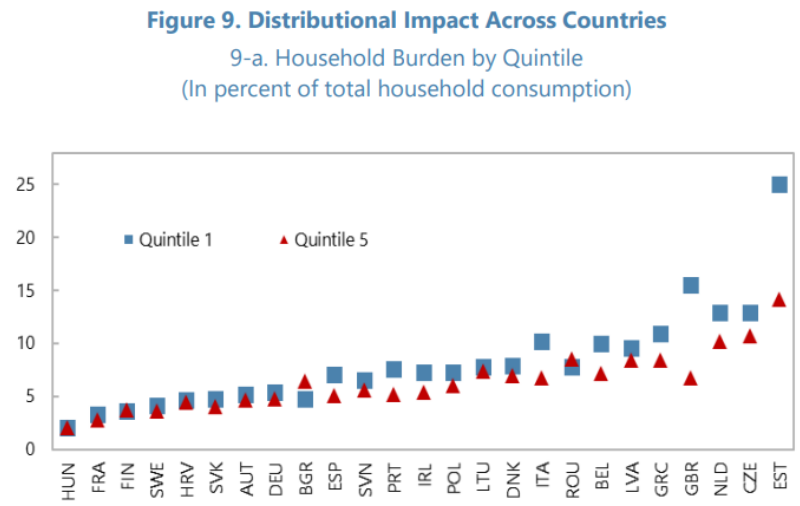

Figure 8: Distributional Impact of Higher Energy Prices Across Countries. Source: Ari et al. (2022), p. 15.

4. Empirical analysis for transport sector

4.1 Data and empirical strategy

Empirical analysis was conducted to analyse the distributional effects of excise fuel taxes on passenger car transport in Finland. The analysis was conducted by Kimmo Palanne, and it builds on work by Palanne and Sahari (2021). The analysis utilises three sources of data. Firstly, the Finnish Transport Safety Agency TRAFI's data on the Finnish car fleet on 31.12.2016 is used to determine vehicle owners. Secondly, TRAFI's data on vehicle inspections is used to estimate each car's annual distance driven in kilometres. Each car's fuel consumption and fuel costs for 2016 were calculated using information on each car's fuel consumption (litres/100 km) and average fuel prices in 2016. Thirdly, using Statistics Finland's FOLK-dataset, it was possible to assign car owners to households[6] and calculate each household's total fuel costs and their ratio to household disposable income.

In 2016, a total of €1295 million petrol excise taxes and €1362 million diesel excise taxes were collected[7]. The petrol tax was 68.13 cents/litre, out of which the carbon tax component was 16.25 cents/litre, and the diesel tax was 50.61 cents/litre, out of which the carbon tax component was 18.61 cents/litre. Therefore, the estimated revenue from the carbon tax components was 809.7 million euros[8]. The analysis evaluates the distributional impacts of different compensation mechanisms that return this revenue to the 2 654 611 households that existed in Finland on 31.12.2016. The scenarios are:

1. **No compensation**
2. **Equal sized compensation**: The revenue is distributed equally among all households in Finland, meaning that each household receives approximately €305.
3. **Compensation based on household size**:
   3.1. Transfer based on absolute household size, i.e. a lump-sum transfer for each individual. Each person receives approx. €150 per person.
   3.2. Weighted transfer using OECD equivalence scale: The first adult in the household has weight 1, other adults have weight 0.5, and children have weight 0.3. Therefore, the first adult receives approx. €210, other adults €105, and children €63.
4. **Earned income tax reduction**: This means a reduction in state income tax[9]. The reduction is calculated such that the reduction in tax is the same, in percentage units,

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[6] The unit of observation consists of all the individuals permanently living in the same apartment, meaning it includes also non-family members. However, only approximately 4 percent of these units include non-family members.

[7] The analysis is based on returning total CO_2 tax revenues, meaning it also includes revenues from non-passenger cars. This may result in slightly higher compensation amounts but is a reasonable simplification for this type of illustrative example.

[8] 16.25/68.13*1295 m€ + 18.61/50.61*1362 m €=809.7m€

[9] A reduction to municipal tax was not considered, because these tax rates are set individually by each municipality. Therefore, it seems more feasible that a nationwide compensation mechanism would take the form of a state income tax reduction than a municipal tax reduction. However, it should be noted that many in the lowest income deciles do not pay

for each individual, and the lost tax revenue corresponds to the revenue from the CO_2 tax. This means that each individual receives a 1.13% reduction in their state income tax. However, the reduction is at most equal to the actual tax percentage.

The analysis examines both the effects on all households and the effects on only car-owning households. For analysis examining the distribution based on, for example, household socioeconomic status, the households were categorised based on a reference person (in practice, the household member with the highest income).

4.2 Results

4.2.1 Household fuel expenditure

Figure 9 below demonstrates that fuel expenditure as a share of income is relatively constant across all households and is the highest for households in the 6th-7th income deciles. This is partly explained by the fact that there are fewer car-owning households in lower income deciles. However, when we focus only on car-owning households, we see that the distribution is regressive, i.e. the share of fuel expenditure decreases with income. Households in the 1st income decile who own cars spend over 10% of their income on fuel, while those in the 10th decile spend less than 3% of theirs. This highlights that the different shares of car-owners in different income deciles dramatically affect the distribution.

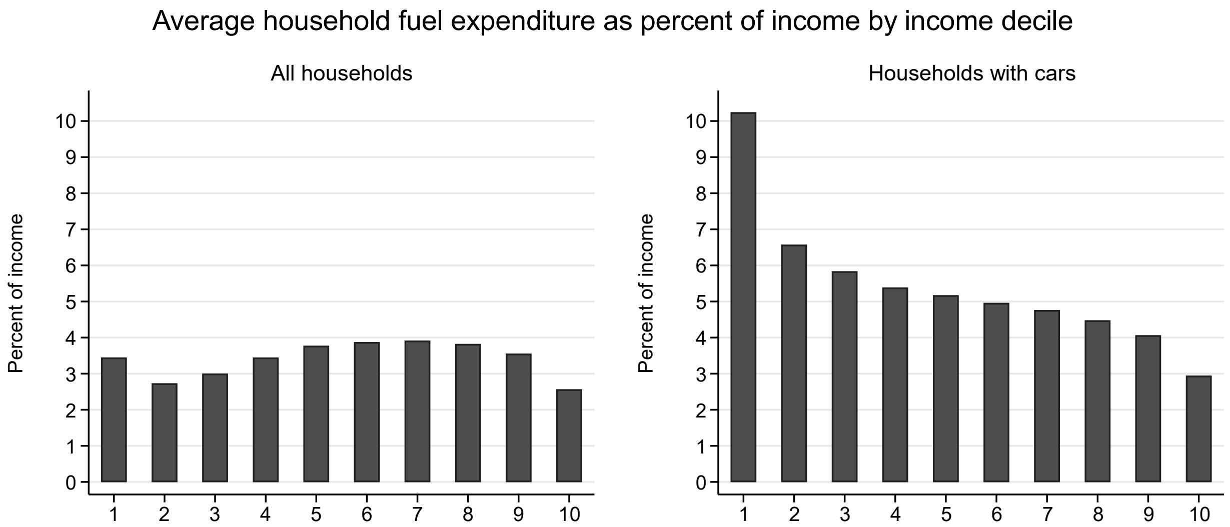

Figure 9: Average household fuel expenditure as a percent of income by income decile.

For all households, the average fuel costs in 2016 were €1344 (median €964), and for just car-owning households they were €1961 (median €1605). Unsurprisingly, when we look at all households, average fuel expenditure in absolute terms increases with income (see figure 19 in appendix). The average and median fuel costs as a share of household disposable income (henceforth just referred to as income) are provided in table 2. We see that with revenue-recycling, the average tax burden falls considerably when looking at all households, because

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state income tax, meaning that they receive no compensation through this compensation mechanism.

there are households that do not own cars and the transfer generates a negative tax burden for them. When looking only at car-owning households, revenue-recycling still reduces the average tax burden, but the effect is naturally smaller.

Table 2: Average and median fuel costs as a share of household disposable income.

	All households		Car-owning households	
	Average	Median	Average	Median
No revenue-recycling	3.41 %	2.46 %	4.97 %	3.99 %
Lump-sum transfer	1.22 %	1.68 %	3.91 %	3.17 %
Weighted transfers based on household size	1.60 %	1.68 %	3.97 %	3.16 %
Transfer based on absolute household size	1.85 %	1.67 %	4.02 %	3.15 %

4.2.2 Distributional effects of compensation

Figure 10 below demonstrates the average size of different compensation measured in euros by income decile. We see from the figure that the income tax reduction stand out from the other measures as the tax reduction in euros increases substantially with income. Furthermore, many in the lowest income deciles receive nothing because they do not pay state income tax. Direct compensation mechanisms that are tied to household size, on the other hand, result in an average compensation that is roughly constant in euros throughout the distribution. Furthermore, the different direct compensation mechanisms do not differ substantially among themselves. Their main difference is that the more strongly the compensation is tied to household size, the more households in higher income deciles benefit, because they tend to be larger. Conversely, households in lower income deciles benefit more than high income households from equal-sized compensation[10].

[10] The effects of returning the tax revenues only to the three lowest income deciles was also examined, and the results were very predictable. The share of fuel costs for compensated households falls significantly and the situation does not change for anyone else. Consequently, average fuel cost shares fall significantly in groups that have more low-income individuals, such as single person households, young households, students, unemployed or those out of the workforce.

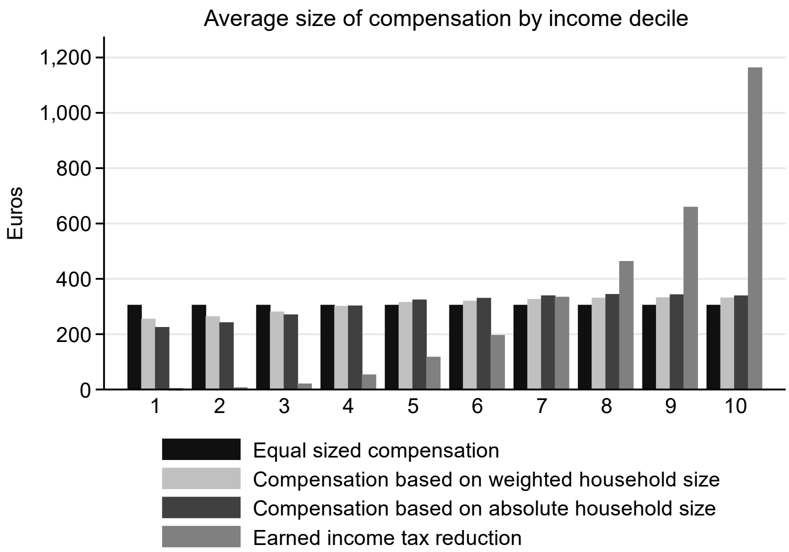

Figure 10: Average size of compensation by income decile.

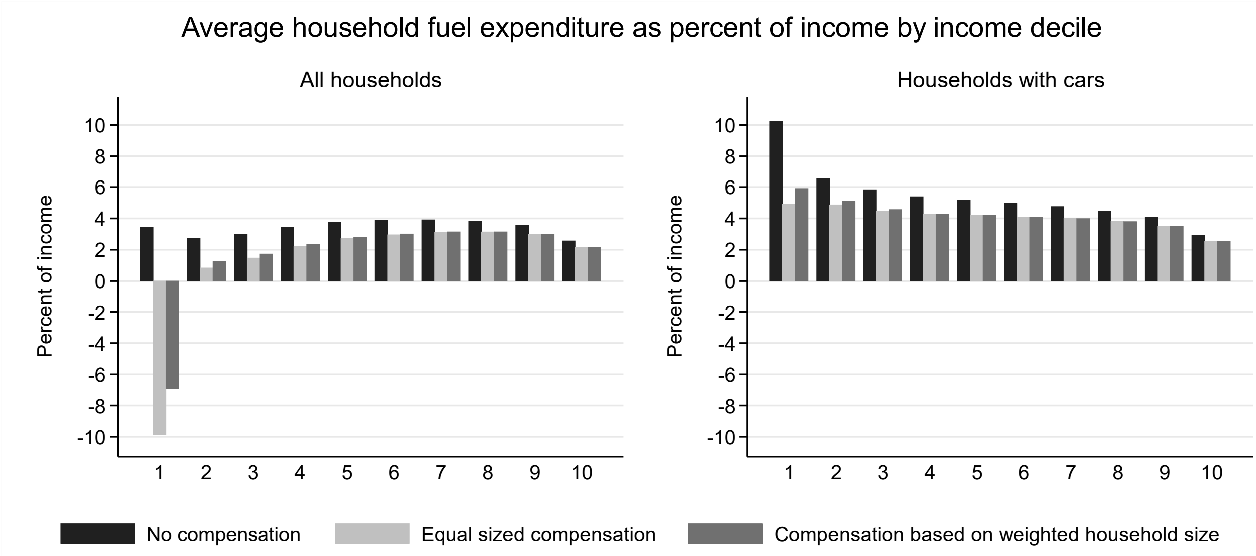

Figure 11: Average household fuel expenditure as a percent of income by income decile.

Figure 11 compares the distribution of fuel expenditure without compensation to equal-sized compensation and compensation based on weighted household size. Due to the lower share of households that own cars in the first income decile, the direct compensation measures result in the lowest income households on average receiving a transfer that exceeds their fuel costs. This effect naturally disappears when looking only at car-owning households. However, compensation still considerably reduces average fuel expenditure for the lowest income decile. The distribution for households with cars remains slightly regressive even with compensation but, especially with lump-sum transfers, approaches proportionality. Differences between lump-sum transfers and transfers proportional to household size are very small for most of the income deciles. The greatest differences are in the lowest deciles, as households with lower income tend to be smaller and therefore benefit more from equal-sized compensation.

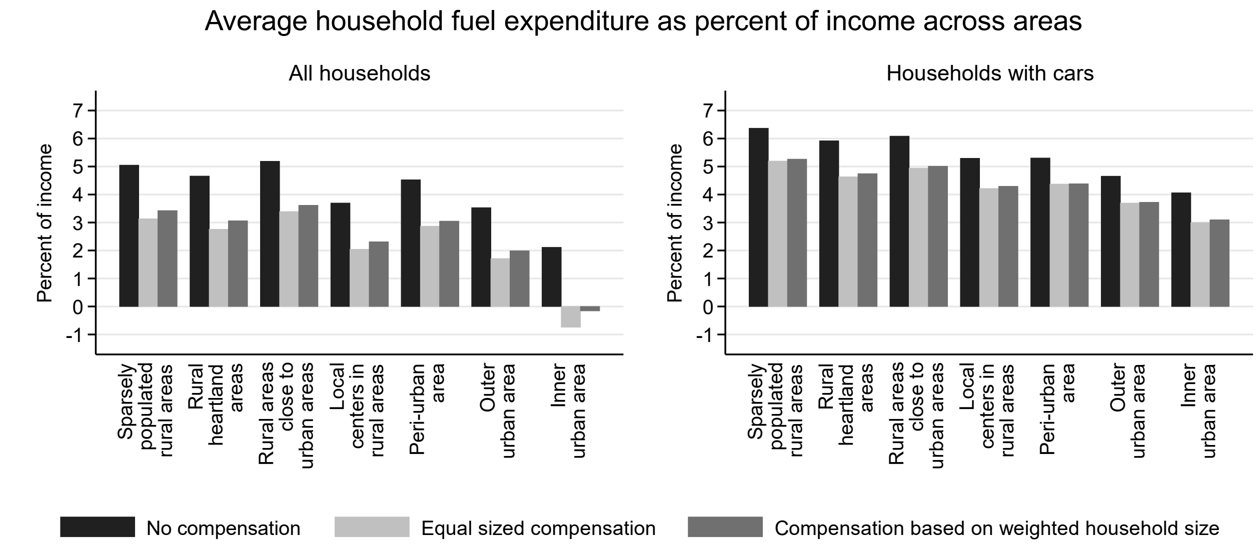

Figure 12: Average household fuel expenditure as a percent of income across areas.

Moving on to look at the regional distribution (figure 12), we see the largest differences in fuel expenditure shares between inner urban areas and other areas. This is consistent with inner urban areas having better public transport connections and shorter travel distances. Compensation on average considerably reduces fuel cost shares for all households. It also results in net-positive transfers to households in inner urban areas due to the lower share of car-owners. However, it does not appear to alter the distribution of cost shares. Again, the differences between the two compensation mechanisms are small.

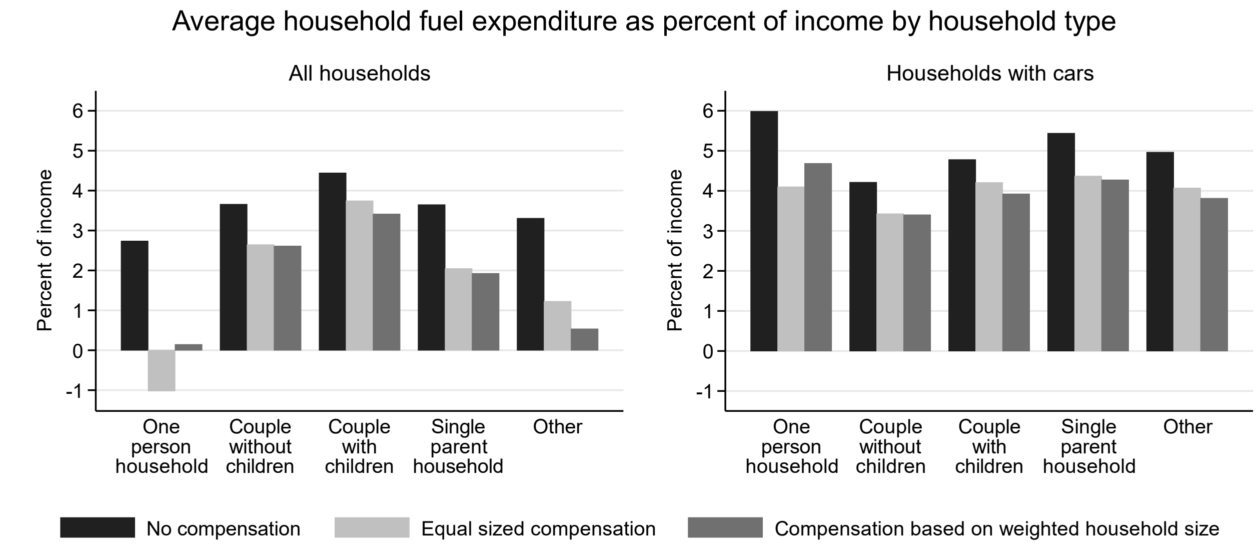

Figure 13: Average household fuel expenditure as a percent of income by household type.

When looking at household types (figure 13), we see that the distribution differs quite considerably depending on whether the focus is on all households or just car-owning households. This is due to differences in the share of car-owners in each group. In particular, one-person households and single-parent households are less likely to own cars, meaning that when we look at all households, they have the lowest fuel cost shares on average. However, those one-person households that do own cars have the highest average burdens. The two compensation measures reduce average fuel expenditure shares for everyone and reduce the differences between household types.

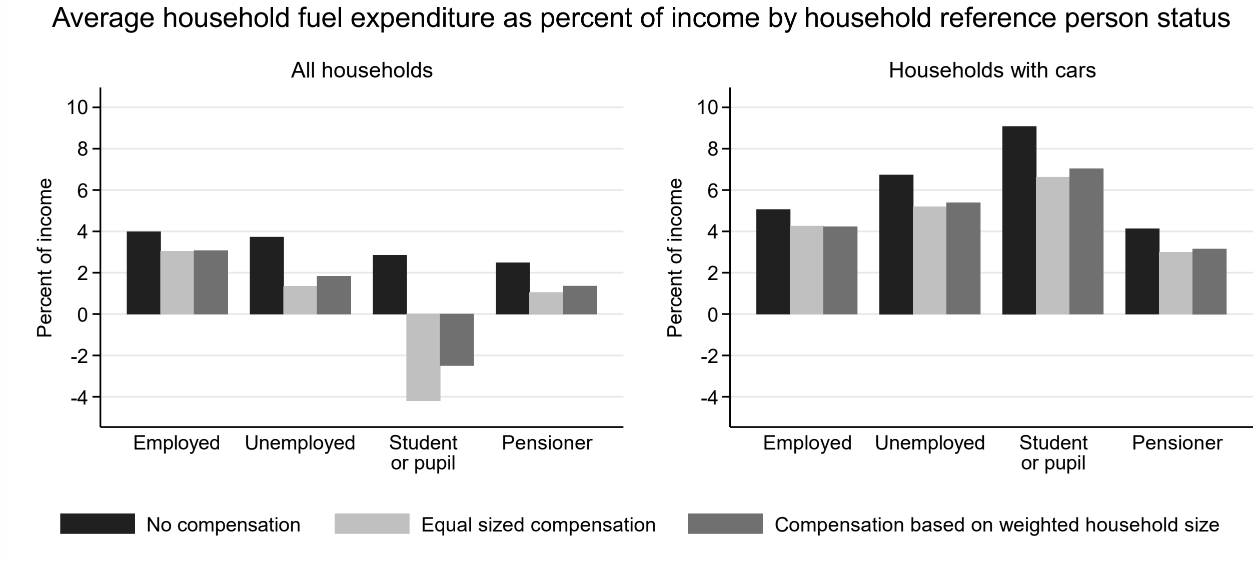

Figure 14: Average household fuel expenditure as a percent of income by household reference person status.

Figure 14 plots average fuel expenditure shares based on the occupation of the reference member in the household. Again, differences between the results for all households and for car-owning households appears to be driven by difference in the shares of car-owners. While car-owning students and unemployed households[11] have the highest average burdens, students and the unemployed in general own fewer cars and drive less, and therefore have similar fuel cost shares as other groups when we look at all households. With compensation, a large share of students consequently have negative fuel expenses since they do not own cars.[12]

4.2.3 Vulnerable groups

Three factors emerged as being significantly correlated with driving, and therefore fuel expenditure:

1. Employment
2. Living outside inner urban areas
3. Having children

Figures 21 and 22 in the Appendix visualise how average fuel expenditure varies when holding these factors constant. While these factors are linked to potential vulnerability to rising fuel prices or taxes, on their own they are not enough to classify potentially vulnerable

[11] It should be noted that because the occupation is determined by the household's reference person, usually the highest earner, the unemployed category mostly consists of households where both members are unemployed.

[12] Figure 20 in the Appendix presents the distribution by reference person age, and the results are similar to those discussed so far.

households. In addition to high fuel expenditure, attention must also be paid to the necessity of driving for the household and the household's income. Since there is no way to identify these characteristics for all households, we choose observable characteristics that appear to predict higher fuel expenditure burdens and are consistent with earlier literature (see e.g. Preuss 2021). The chosen characteristics are low income, belonging to a one-person or single-parent household, and being in the labour force outside an inner urban area. The last group was chosen, because being employed or searching for a job is expected to increase the need to commute. Outside of inner urban areas, these commutes are more likely to be driven, and therefore these groups are likely to need a car the most.

Figure 15 demonstrates that some of these groups are large. We also see that only 2.9% belong in all vulnerability groups. However, if we constrain ourselves to two factors, these shares are much larger. For example, 16.1% of the population are one-person or single-parent households and have low income, while 13.9% are one-person or single-parent households who are in the labour force and live outside inner urban areas.

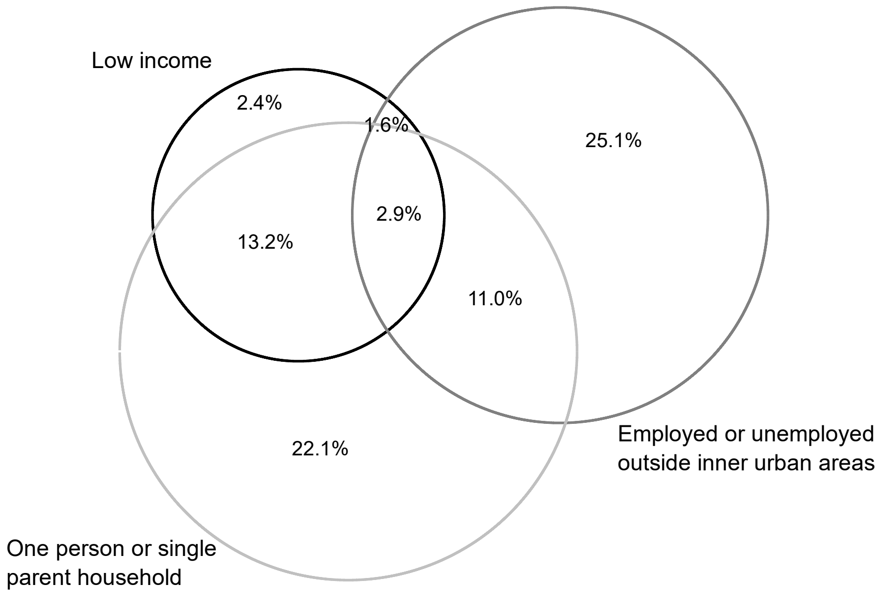

Figure 15: Overlap in vulnerable groups.

4.2.4 Fuel price scenarios

Figure 16 provides an estimate of what fuel expenditure shares could potentially look like with the average fuel prices[13] of 2022. The calculations are based on the assumption that the fuel consumption of all cars (litres/100 km) has decreased by 2 percent (This corresponds to the average decrease in fuel consumption between 2016 and 2020). Furthermore, household disposable income is assumed to have increased by 4% (This corresponds to the median increase from 2016 to 2019). Between 2016 and 2022, the price for petrol increased by 60% and for gasoline by 82%.

[13] Average prices from January to August.

The first two bars in each figure demonstrate average fuel expenditure shares for 2016 and 2022 assuming that fuel demand has not changed as a result of the price increase. In the third bar, it is assumed that the price elasticity of fuel demand is -0.3, so the demand for petrol decreased by approximately 18% and for diesel by about 24.6%.

The figure demonstrates that while we expect higher fuel prices to have increased fuel expenditure shares throughout the distribution compared to the 2016 scenario, the shape of the distribution is expected to remain largely the same, even with a demand response.

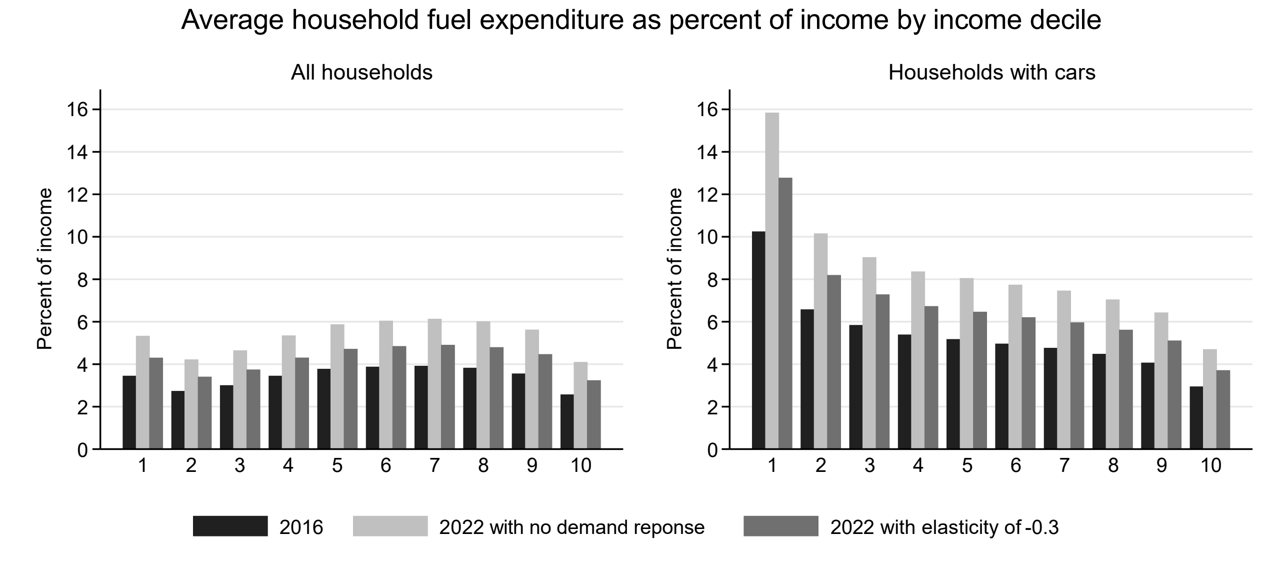

Figure 16: Average household fuel expenditure as a percent of income by income decile.

Figure 17 presents a situation where the CO_2 tax on petrol and diesel is eliminated in 2022, which reduces their prices and increases their demand. For simplicity, the tax reduction is assumed to pass through completely to prices (pass-through rate 100%), meaning that the price of petrol is reduced by 21.49 cents/litre and the price of diesel by 24.56 cents/litre[14].

The increase in fuel consumption depends on the price elasticity of fuel demand. Four different price elasticity scenarios are considered:

1. Elasticity equal to -0.3 for everyone
2. Elasticity equal to -0.9 for everyone
3. Elasticity increasing in income from -0.1 in the 1st income decile to -0.4 in the 10th
4. Elasticity decreasing in income from -0.4 in the 1st income decile to -0.1 in the 10th

The price elasticity values were determined based on a review of the existing literature. Price elasticities of fuel consumption are estimated to be between -0.1 and -0.3 in the short-term, and between -0.6 and -1 in the long-term (See e.g. Sterner 2012, IMF 2019, or Palanne and Sahari 2021 for a review of the literature on price elasticities). There are far fewer papers estimating tax elasticities of fuel consumption. However, tax elasticities are generally believed to be even three times greater than price elasticities (Andersson 2019). Therefore, while the

[14] These are the CO_2 taxes on petrol and diesel in 2022.

scenario with an elasticity of -0.9 may seem extreme, it can be considered as representative of a long-term elasticity that also accounts for the possibility that tax elasticities can be much larger than price elasticities.

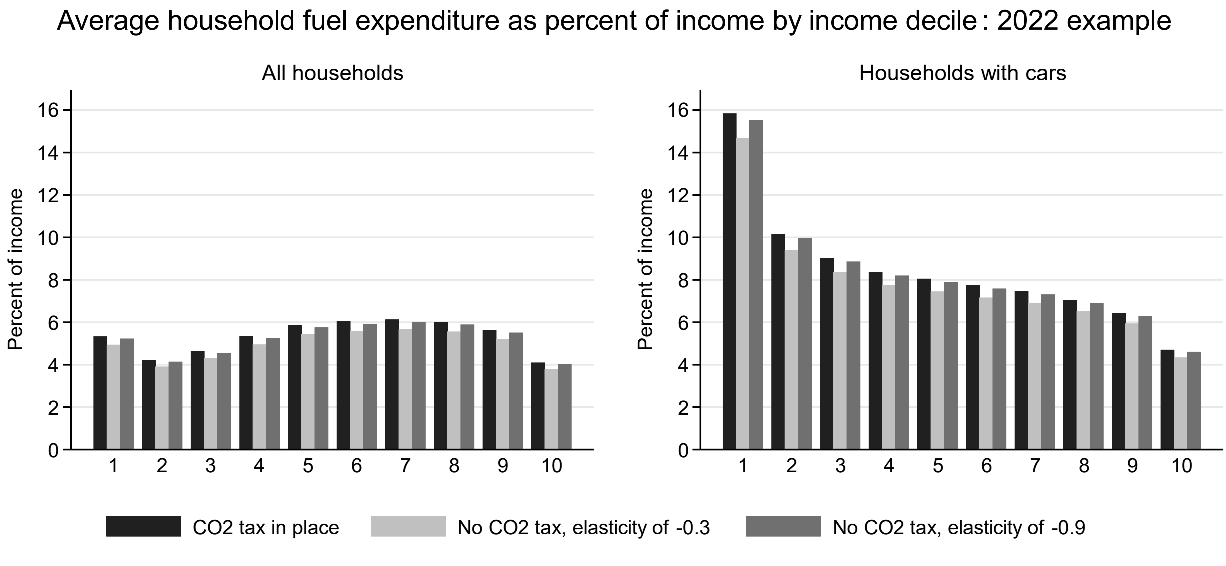

Figure 17: Average household fuel expenditure as a percent of income by income decile: 2022 example.

We see from the figure above that if price elasticity is towards the higher end, -0.9, then the elimination of the CO_2 tax leaves fuel expenditure shares almost unchanged, because consumers increase their fuel consumption. Even in the case where the price elasticity is lower, -0.3, the reduction in fuel expenditure following the elimination of the tax is marginal. Figure 23 in the Appendix demonstrates the situation where the price elasticity is either increasing or decreasing in income and we see that this has very little effect on the results and does not change the progressivity of the distribution.

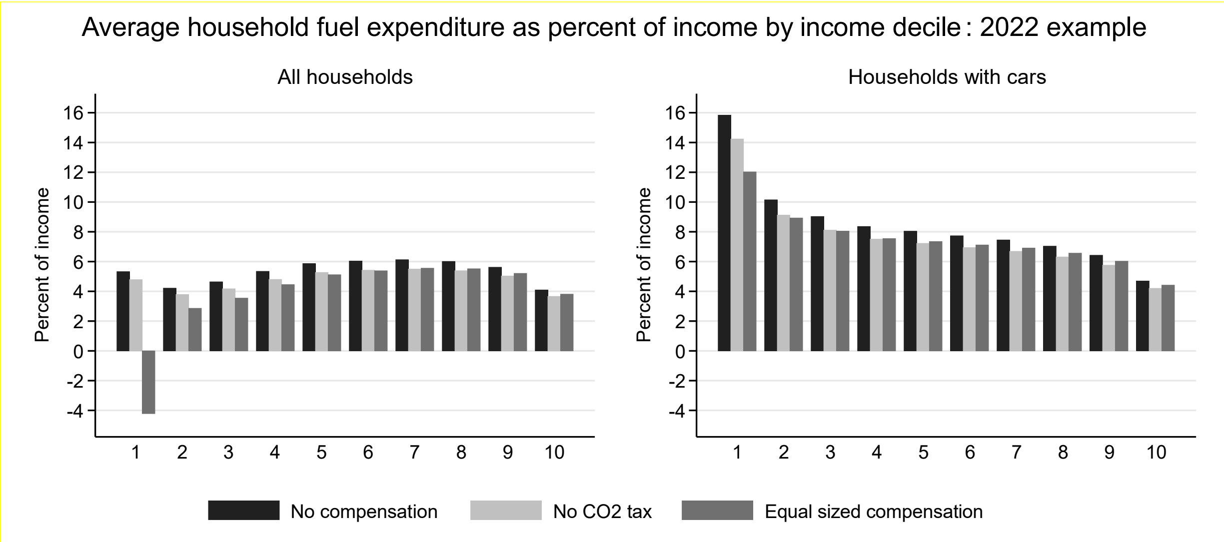

Figure 18: Average household fuel expenditure as percent of income by income decile: 2022 example.

Figure 18 above compares the situation with no compensation to equal-sized compensation and to the elimination of the CO_2 tax assuming no demand response. The equal-sized compensation is calculated by multiplying the total diesel and petrol consumption of household passenger cars with the 2022 tax rates and dividing this amount (603 million euros) among households, resulting in a lump-sum of 227 euros per household. This ensures the compensation measure is comparable to the removal of the CO_2 tax. It should be noted that this approach differs from that in the previous figures, where the equal-sized compensation is calculated by dividing the total CO_2 tax revenues[15] among households. Therefore, the compensation amount in this figure it not directly comparable to that in previous figures. From figure 18 we see that equal-sized compensation considerably reduces the burden on households in the lowest income deciles and results in a more proportional distribution compared to the elimination of the CO_2 tax.

4.3 Discussion

Based on the empirical analysis, we can make some conclusions about the distributional effects of fuel taxation.

Firstly, we see that vertical equity of fuel taxation appears markedly different depending on whether we examine all households or only car-owning households. For all households, average fuel expenditure as a share of income is relatively low throughout the income distribution, and slightly increasing between the 2nd and 7th income deciles. However, when we focus on just car-owners, the distribution is clearly decreasing in income, implying more regressive effects.

This difference is driven by the fact that certain household types have lower average fuel expenditures because they drive less, or not at all. Notable examples are those in the lowest income deciles, those living in inner urban areas, one-person and single-parent households, students and the unemployed. However, if a household falls into one of these categories and does own a car, their average fuel expenditure as a share of income tends to be much higher than average. This raises an interesting phenomenon of selection into car ownership, for which the equity implications are not obvious. The higher average fuel expenditure burden seems more acceptable if, for example, a student with high expected future earnings owns a car without strictly needing one. In comparison, if a single-parent, who works part-time, has to drive their children to school, the higher fuel expenditure burden seems considerably less reasonable. Naturally, there are exceptions to these generalisations. This is just to illustrate that judgements about the equity of different distributional burdens will depend on the necessity of driving for the household and whether the household's low income is transitory.

Indeed, Rausch et al. (2011) note that when ranking households by their annual income, a difficulty in interpreting the results is that many households in the lowest income groups are not poor in any traditional sense that should raise welfare concerns. The group usually includes households that are facing transitory negative income shocks or who are making human capital investments (Rausch et al. 2011). However, this generalization cannot be made to all households in this group, and the challenge is in identifying those most in need.

[15] Total CO_2 tax revenues also include revenues from non-passenger cars.

Secondly, when we look at different compensation measures, it appears that direct compensation in the form of transfers to households is considerably more equitable than tax reductions. In the case of income tax reductions, higher income households receive considerably higher compensation in euros, because they pay more income tax, compared to lower income households. Furthermore, the income tax reduction leaves a share of households in the lowest income decile without any compensation as they do not currently pay any state income tax.

The removal of the CO_2 tax also benefits higher income households more than lower income households because the tax reduction makes driving less expensive and higher income households tend to drive more. Furthermore, the reduction of the CO_2 tax would probably create more environmentally harmful incentives as it makes driving relatively cheaper and may therefore increase driving. Naturally, lump-sum transfers could also potentially increase driving as part or all of the transfer could be used for driving expenses. However, since the lump-sum transfer can also be used for something else and does not change relative prices, it is not expected to increase driving as much at the CO_2 tax removal.

Thirdly, based on a comparison of direct compensation measures, lump-sum transfers may be preferable to transfers proportional to household size. The difference between the two is very small and the former appears to be more effective at reducing vertical distributional effects (distributional effects across income deciles). Furthermore, while not modelled here, lump-sum transfers are also likely to involve lower administrative costs. The results also suggest that if the aim is to improve progressivity, lump-sum transfers should be determined at the household level rather than the individual level, to account for economies of scale.

The empirical analysis on the distributional effects of carbon pricing in Finland had to be constrained to the transport sector due to a lack of available data to study the distributional effects of electricity taxation. The main microsimulation model SISU includes data from consumption surveys on household consumption behaviour, which allows for some analysis of the distributional effects of energy and carbon taxes. However, the consumption survey is from 2016 and the model in general has not been updated in recent years. SISU is also a static model, which does not allow for the modelling of behavioural responses to taxes.

Some tentative conclusions about the distributional effects of electricity taxation can be made based on the literature and generalisations from the empirical analysis. While the regressivity of fuel taxes can be mitigated by the fact that not all households in the lowest income deciles own a car, electricity is used by all households. In general, the literature suggests that carbon pricing in the transport sector may be more progressive than in the electricity sector (see e.g. Ohlendorf et al. 2018). Some households in the lowest income deciles may be partly shielded by the fact that they are more likely to rent apartments in blocks of flats that don't tend to have electric heating and may have their electricity bills included in their rent. However, at the same time, in all European countries, poorer households tend to spend more on electricity as share of total consumption (Ari et al. 2022). Furthermore, low income households may not be able to adjust as their electricity demand as quickly as households with higher income (Buchsbaum 2022).

Due the ongoing energy crisis, the public discussion has largely centred around how to compensate households for high electricity bills this winter. Identifying those most in need can be challenging, because consumers can be in very different positions concerning their vulnerability to electricity price increases depending on, for example, whether they have electric heating and whether they have fixed- or variable rate electricity plans. However, one parallel between fuel expenditure and electricity is that both tend to increase in absolute terms with income. In other words, households with higher income tend to drive more and consume more electricity (Palanne and Sahari 2021, OECD 2022). Therefore, any tax reductions are likely to disproportionately benefit higher income households. Lump-sum transfers are likely to be more equitable.

5. Appendix

Tax expenditures (millions €)	2021	2022	”Tax system norm”	Notes about data
Deduction for commuting expenses	-	-		Tax expenditure has not been assessed.
Lowered excise fuel tax on diesel (minus driving power tax correction)	331	340	Tax level for diesel according to energy tax model for transport fuels.	Up-to-date information from tax return data.
Tax support for paraffinic diesel oil.	75	35	Tax level for diesel according to energy tax model for transport fuels (accounting for clean vehicle directive) minus tax expenditure for diesel. The support ends in 2023.	Up-to-date information from tax return data.
Lowered tax rate for light fuel oil used in machinery.	478	472	Tax level for diesel according to energy tax model for transport fuels (diesel tax plus diesel tax expenditure).	No accurate or up-to-date information. Based on modelling instead of statistics (VTT-TYKO).
Lowered tax rate on electricity used in transport.	8	14	Tax level for electricity according to the energy tax model for transport fuels. This theoretical level has not been defined.	No accurate or up-to-date information. Based on modelling instead of statistics (VTT-ALIISA)
Lowered tax rate on natural gas used in transport.	14	15	Tax level for natural gas according to the energy tax model for transport fuels	No accurate or up-to-date information. Based on modelling instead of statistics (VTT-ALIISA)
Tax-free electricity for rail traffic.	19	19	Electricity tax class I	No accurate or up-to-date information. Latest estimates are from 2 years ago.
Light fuel oil used in railway diesel engines	16	16	Tax level for diesel according to energy tax model for transport fuels.	No accurate or up-to-date information. Latest estimates are from 2 years ago.

Tax exemption for wood-based fuels	303	303	Tax level for wood-based fuels according to the energy tax model for heating fuels	No accurate or up-to-date information. Latest estimates are from 2 years ago.
Tax exemption for biogas	4	4	The tax level for biogas in traffic according to the energy tax model for transport fuels and the tax level according to the energy tax model for heating fuels for the use of heating and machinery.	No accurate or up-to-date information. For heating, latest estimates are from 2 years ago. For transport, estimates based on modelling (VTT-ALIISA).
Tax support for waste incineration	63	63	Tax level for waste according to the energy tax model for heating fuels.	No accurate or up-to-date information. No precise information on the characteristics of the waste in order to determine the exact standard tax level.
Reduction of energy content tax for combined electricity and heat production (CHP)	136	130	The tax level according to the heating fuel energy tax model for each fuel used in CHP.	With the exception of peat, up-to-date information from tax return data.
Lower electricity tax rate for industry and greenhouses (Tax class II)	803	831	Tax class I	Up-to-date information from tax return data.
Tax refund for energy-intensive firms (classified in the report as direct subsidies)	225	58	Tax refund amount	Up-to-date information from tax refund data. The tax refund is phased-out by 2025.
Lowered tax rate on peat.	127	122	Tax level for peat according to the energy tax model for heating fuels.	No accurate or up-to-date information regarding CHP use. Latest estimates from 2 years ago.
Tax exemption for small-scale use of peat (less than 5,000 megawatt hours).	18	25	Tax level for peat according to the energy tax model for heating fuels.	No accurate or up-to-date information. The latest estimates are from 2 years ago, including rough assumptions. The tax support will be extended in 2022.

Energy tax refunds to agriculture (classified in the report as direct subsidies)	35	48	Tax refund amount	Up-to-date information from tax refund data. Tax support increased in 2021 with tax increases.
Exemption from car tax for emergency vehicles, ambulances, accessible taxis, etc.	92	92	Car tax determined based on the price of the vehicle and CO2 emissions	Estimate of vehicle numbers based on latest car fleet data.
Car tax relief for taxis	2	1	Car tax determined based on the price of the vehicle and CO2 emissions	Up-to-date information on tax refunds. The tax expenditure will be phased out during the years 2018-2022.
Exemption of museum vehicles, emergency vehicles, ambulances, buses from vehicle tax	3	3	Vehicle tax determined based on the vehicle's CO2 emissions or mass	Up-to-date information on the number of vehicles, based on which the amount of tax support can be estimated.
Exemption from vehicle tax for vehicles using wood and peat-based fuel	0,5	0,5	Vehicle tax determined based on the vehicle's CO2 emissions or mass	Up-to-date information on the number of vehicles, based on which the amount of tax support can be estimated

Table 3: Tax Expenditures. Source: Finnish Research Division on Business Subsidies Report 2022.

Direct subsidies (millions €)	**2021 budget**
Energy tax refunds to energy-intensive firms	225
Energy tax refunds to agricultural practitioners	35
Aid for indirect costs from the EU ETS	106,3
Aid for the electrification of energy-intensive industries 2022-2026	-
Transition period support for energy peat 2022	30,6

Table 4: Direct Subsidies. Source: Finnish Research Division on Business Subsidies Report 2022.

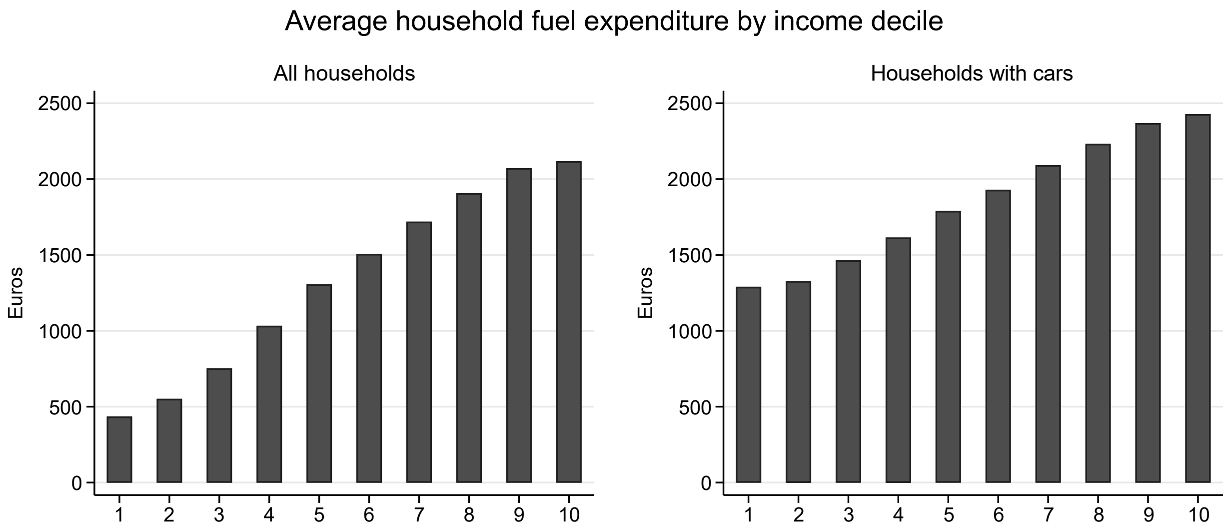

Figure 19: Average household fuel expenditure by income decile.

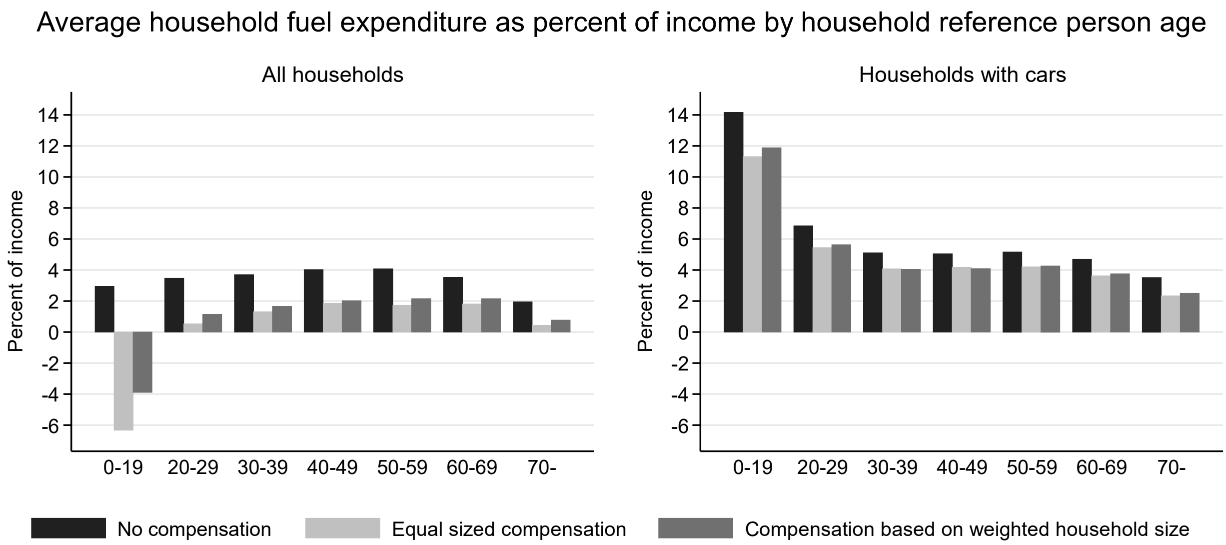

Figure 20: Average household fuel expenditure as percent of income by household reference person age.

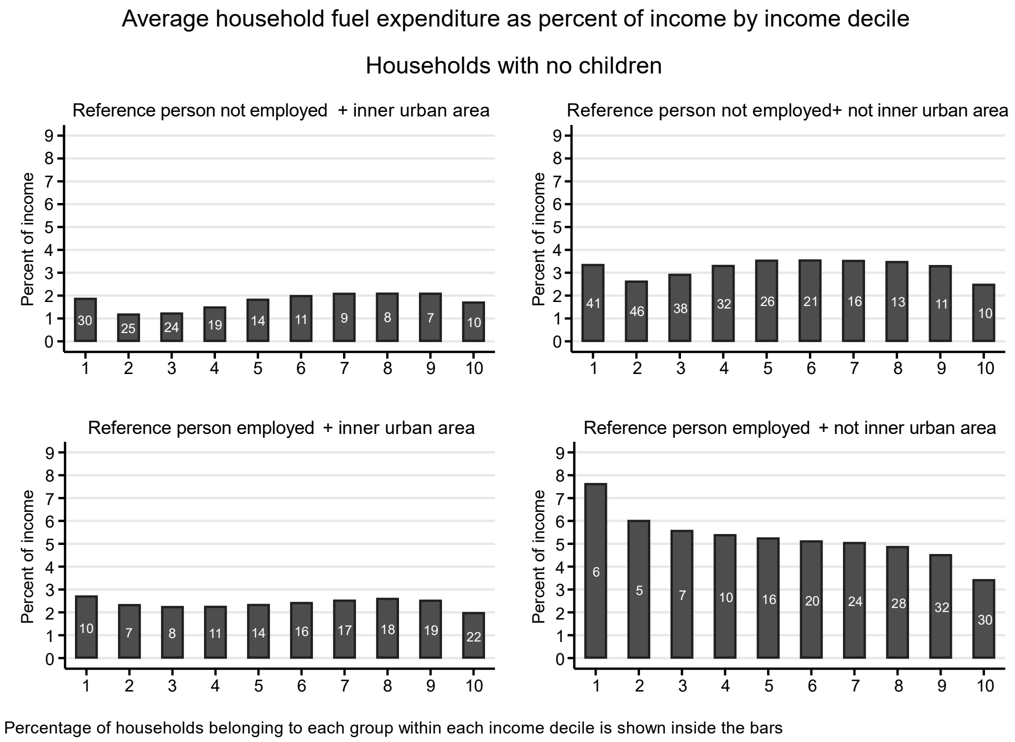

Figure 21: Average household fuel expenditure as percent of income by income decile: Households with no children.

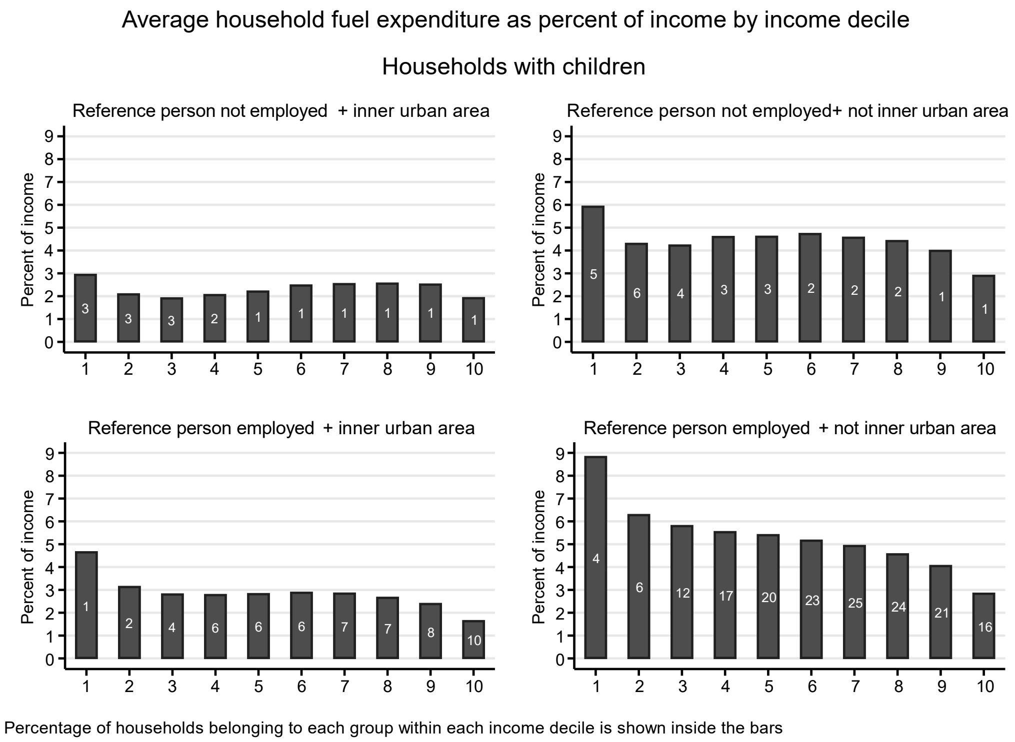

Figure 22: Average household fuel expenditure as percent of income by income decile: Households with children.

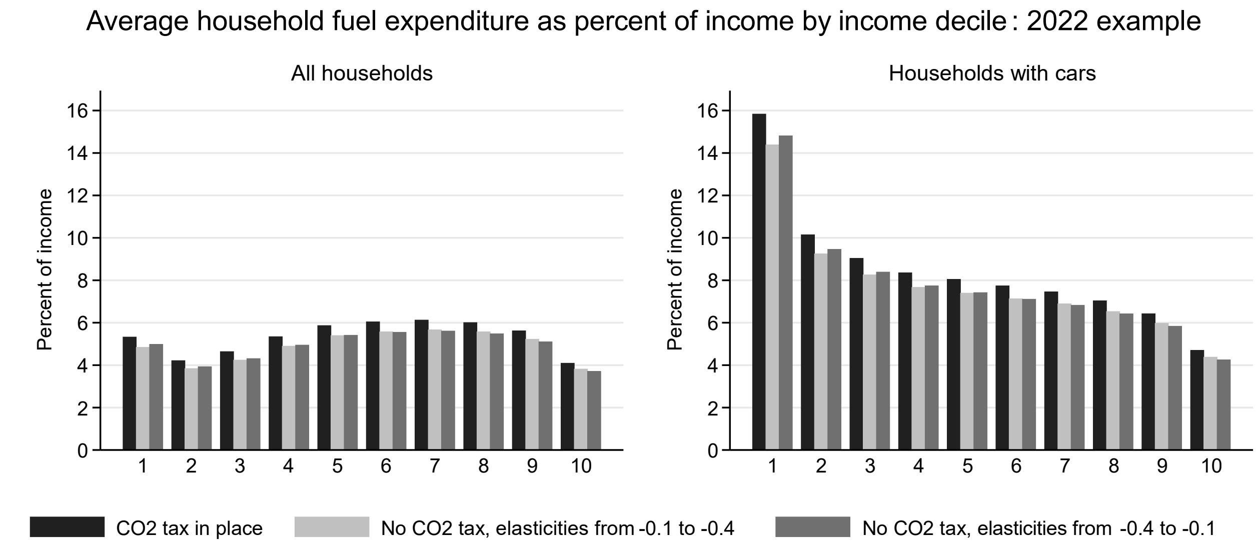

Figure 23: Average household fuel expenditure as percent of income by income decile: 2022 example.

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