Decomposing the distributional impact of EU-wide carbon taxation - Comparing the role of energy expenditure, asset ownership and carbon intensity across six EU countries.

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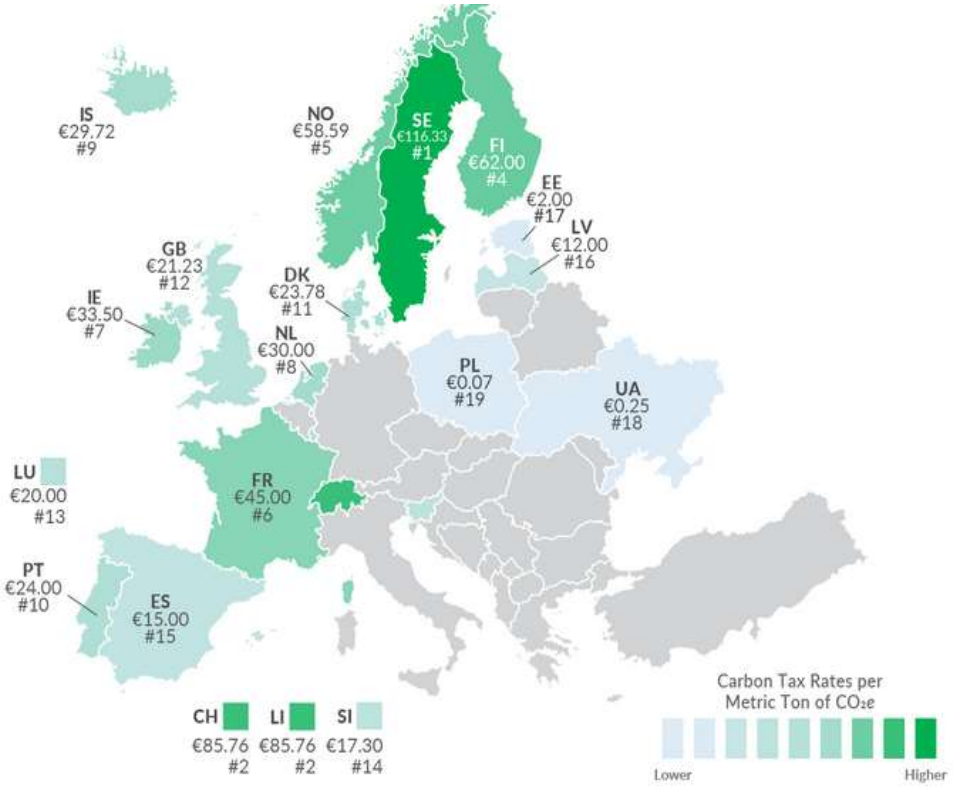
Context: Carbon Pricing

- Carbon pricing is central to EU climate policy – increasing the cost of pollution and effectively of fossil fuels
- Ambitious climate policy - ”Fit for 55 package”
  1) Extends carbon pricing to transportation and residentia sector – ETS2
  2) Carbon Border Adjustment Mechanism
- Revenue recycling can address distributional concerns
  - Member states will submit Social Climate Plans
  - Revenue recycling does not address horizontal inequalities (Cornin et al, 2019)
- What drives the unequal impact of carbon taxation?



https://taxfoundation.org/carbon-taxes-in-europe-2021/

Literature: Distributional Impacts of carbon taxation

- Common conjecture: carbon taxation is regressive in industrialised countries (Klenert and Mettauch, 2016)
  - Research studies suggest that impact can be progressive (Feindt et al; 2021)
- Energy carrier subject to the tax matters (Feindt et al; 2021; Dorband et al, 2019; Fuel and Thomas, 2015)
  - Electricity and home fuel taxation is regressive (Fuel and Thomas, 2015)
  - Motor fuel taxation is progressive (Sterner,2012), though impacts differ across countries (Klenert and Mattauch, 2016)
- Taxation of direct and indirect emissions can be more progressive (Ohlendorf et al, 2020)
- Revenue recycling can make carbon taxing progressive (Klenert et al, 2018)
  - Impact depends on the revenue recycling mechanism
  - Horizontal inequalities remain (Cornin et al, 2019).

LITERATURE: CARBON FOOTPRINT AND CARBON TAX INCIDENCE

- Heterogeneous across income levels and population groups
  - Consumption pattern and asset ownership (Büchs and Schnepf, 2011; Farrell, 2017)
  - Income, education, household size, location (Lévay et al, 2021; Ivanova and Büchs, 2020; Farrell, 2017)
- Heterogeneous across countries
  - Large cross-country differences, larger impacts in Eastern European countries (Feindt et al, 2021)
  - Motor fuel taxation is less regressive in poorer countries (Sterner, 2012; Dorband et al, 2019)
  - Differences in energy mix, infrastructure and climate (Ivanova and Büchs, 2020; Feindt et al, 2021)

LITERATURE: DECOMPOSING THE CARBON TAX INCIDENCE AND BURDEN

- Few studies decompose **the inequality in carbon tax incidence or burden** across households
  - In Ireland, Farrell (2019) quantifies the contribution of *socioeconomic and demographic characteristics* to **inequality the carbon tax incidence**, differentiating between electricity, motor fuel and other fuel-related carbon tax payments.
    - Location, education, number of children and dwelling characteristics matter.
  - In the EU, Feindt et al (2021) decompose the inequality in the **average carbon tax burden** across countries, differentiating between consumption categories, looking at budget shares and carbon intensity.
    - Largest contribution to EU-wide regressivity of the carbon tax is due to differences of budget shares in housing sector (incl. heating & electricity)
- No studies decompose the **impact of the carbon tax on disposable income inequality** within countries and compare across countries
  - Within countries, important to identify the most effective policy lever in equalizing the carbon tax burden.
  - Across countries, important for policy learning.

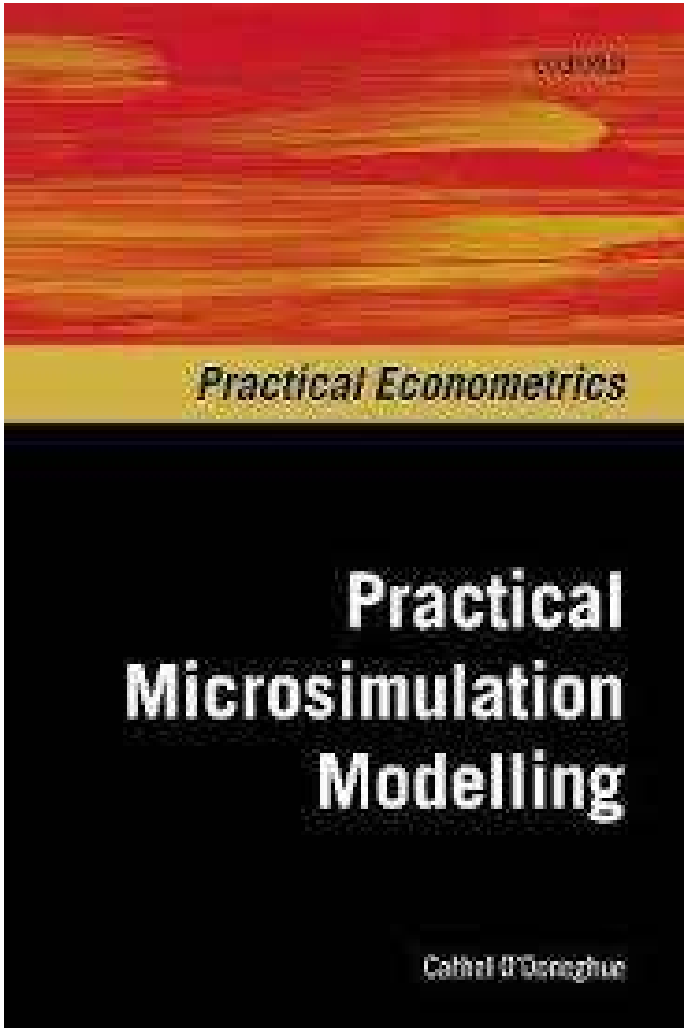
CONTRIBUTION

1. Quantifies the contributions of budget shares, carbon intensity, and asset ownership to the impact of the carbon tax on disposable income inequality
2. High resolution comparative study of six EU-countries
   - Hungary (HU), Lithuania (LT), Portugal (PT), Ireland (IE), Finland (FI), Luxembourg (LU)

Methodology

Method and Data

- Microsimulation modelling
  - Household Budget Survey (HBS) – 2015 & 2020 for LU
  - World Input Output Database Environmental Extension (EE-WIOD) - 2016
- Common €30/TCO_2 tax across six countries
  - Direct and indirect CO_2 emissions – carbon border adjustment mechanism



DECOMPOSING POST-CARBON TAX DISPOSABLE INCOME INEQUALITY

- Decompose the change in Gini due to the carbon tax into direct effects of budget shares of energy commodities (w), carbon intensity per kwh (e) and asset ownership (I) (Biewen and Juhasz, 2012). Energy commodities are home fuel, electricity, motor fuel.
- Generate counterfactuals CO2 emissions for *i* energy commodities:
  - Budget share (w) counterfactual:

$$tCO^{*}_{2hw} = \sum_{i}\left(\frac{y * \bar{w}_i}{p_i} * e_i * I_i\right) \qquad \text{I} = 1 \text{ if w}>0$$

  - Carbon intensity (e) counterfactual:

$$tCO^{*}_{2he} = \sum_{i}\left(\frac{y * w_i}{p_i} * \bar{e}_i * I_i\right) \qquad \text{I} = 1 \text{ if w}>0$$

  - Asset ownership (I) counterfactual:

$$tCO^{*}_{2hI} = \begin{cases} \sum_i((y * w_i/p_i) * e_i) & \forall\ h \in \mathbb{N} \\ \sum_i((y * \bar{w}_i/\bar{p}_i) * \bar{e}_i) & \forall\ h \notin \mathbb{N} \end{cases} \qquad \text{N} = \text{set of households with I} = 1$$

w = budget share
e = tCO2 per kwh
I = ownership of energy-consuming asset
i = energy commodity
y = total expenditure
p = price per kwh
h = household

DECOMPOSING POST-CARBON TAX DISPOSABLE INCOME INEQUALITY

- Counterfactual disposable income after carbon tax:
  - $Yd^{*}_{ct} = Yd_{o} - ((\sum_{i}(tCO^{*}_{2hi}) + \sum_{k}(tCO_{2hk})) * carbon\ price)$
- Change in Gini due to carbon tax:
  - $\mathrm{D}^{ct}(F^{o}, F^{ct}) = G(F^{ct}) - G(F^{o})$
- Change in Gini with budget share counterfactuals:
  - $\mathrm{D}^{w}(F^{ct}, F^{w}) = G^{*}(F^{w}) - G(F^{ct})$
- Change in Gini with carbon intensity counterfactuals:
  - $\mathrm{D}^{e}(F^{ct}, F^{e}) = G^{*}(F^{e}) - G(F^{ct})$
- Change in Gini with carbon tax counterfactuals:
  - $\mathrm{D}^{I}(F^{ct}, F^{I}) = G^{*}(F^{I}) - G(F^{ct})$

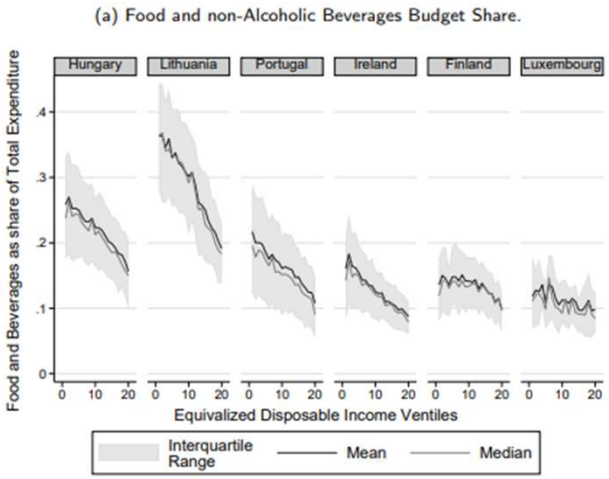
Yd = disposable income
ct = carbon tax
o = pre-carbon tax
i = energy commodity
k = non-energy commodity
D = Change in Gini index
G = Gini index
F = distribution of disposable income

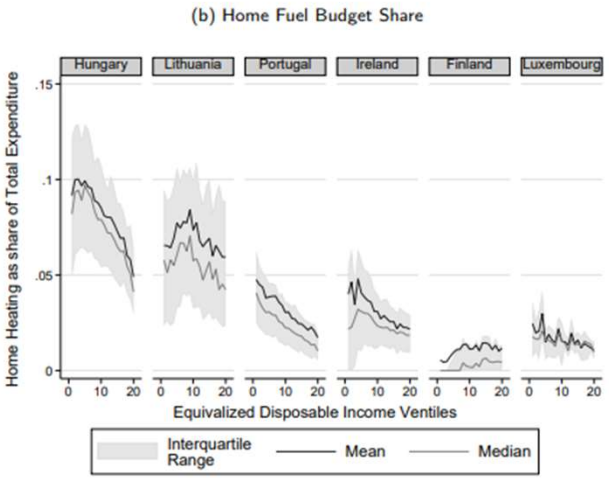
- Composition of the change in Gini due to carbon tax
  - $\mathrm{D}^{ct}(F^{o}, F^{ct}) = \underbrace{\mathrm{D}^{w}(F^{ct}, F^{w}) + \mathrm{D}^{e}(F^{ct}, F^{e}) + \mathrm{D}^{I}(F^{ct}, F^{I})}_{\textit{Direct effects}} + \underbrace{R(\mathrm{D}^{ct}(F^{o}, F^{ct}) - \mathrm{D}^{w}(F^{ct}, F^{w}) - \mathrm{D}^{e}(F^{ct}, F^{e}) - \mathrm{D}^{I}(F^{ct}, F^{I}))}_{\textit{Interaction and other effects}}$

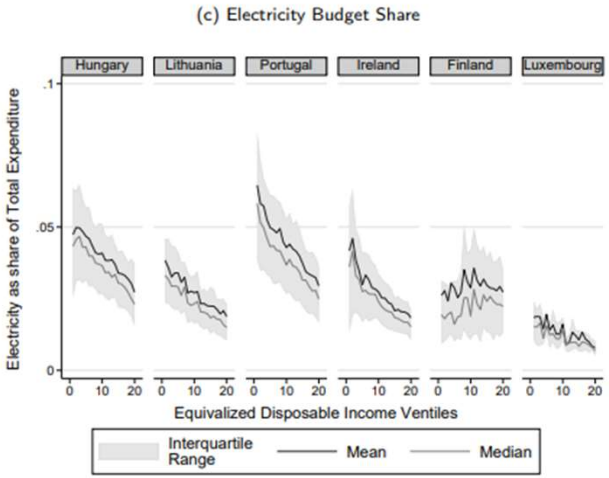
Decomposing the distributional impact of EU-carbon taxation

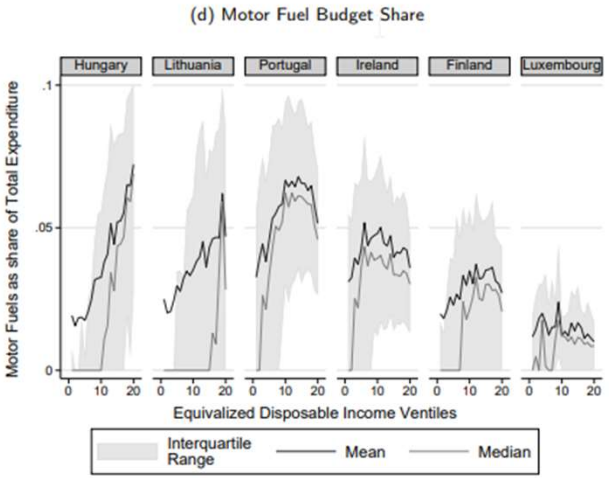
ENERGY EXPENDITURE

- Necessities
  - Food
  - Home fuel
  - Electricity
- Luxury good
  - Motor fuel
- Across countries:
  - Food and Energy fuel is higher in poorer countries
  - Electricity is higher in Portugal, Ireland and Finland
  - Finland is an outlier

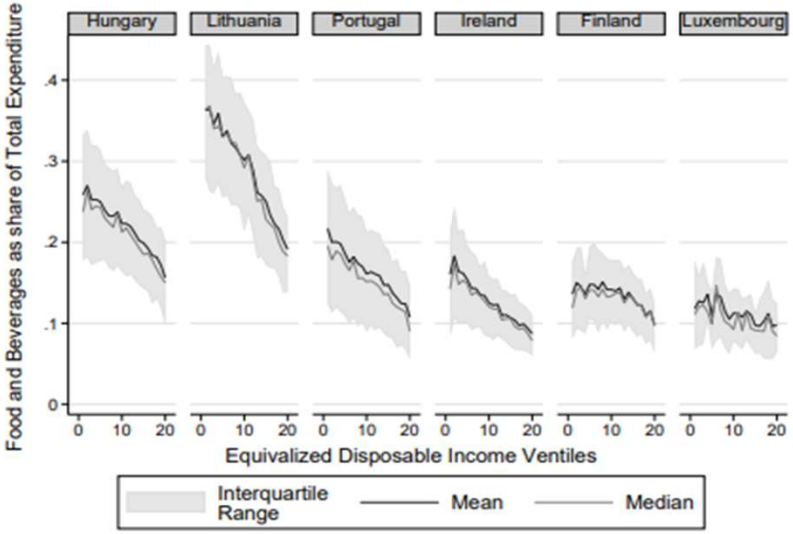




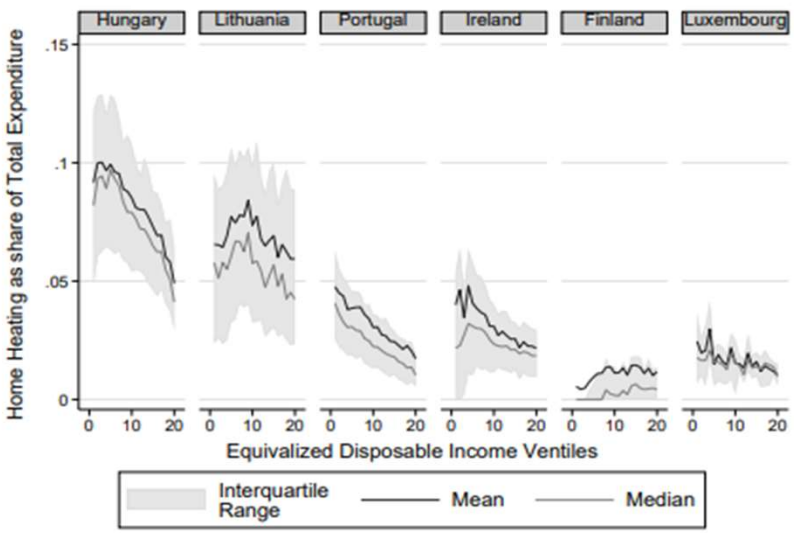




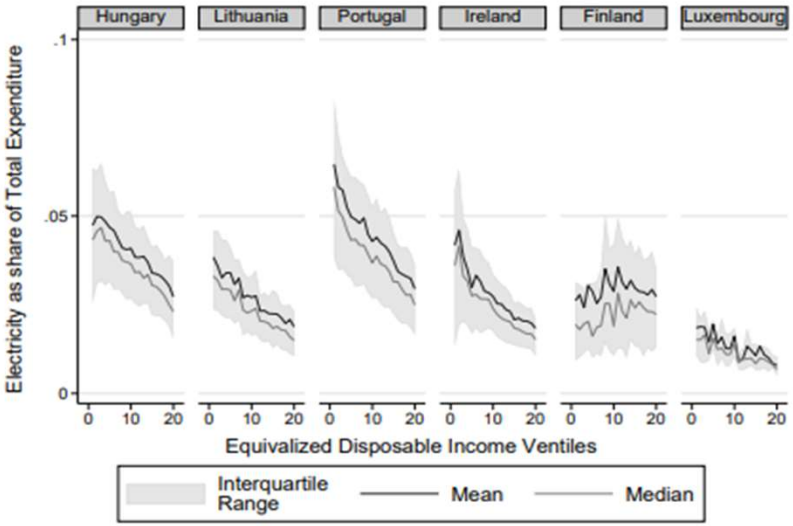
Food and non-alcoholic beverages



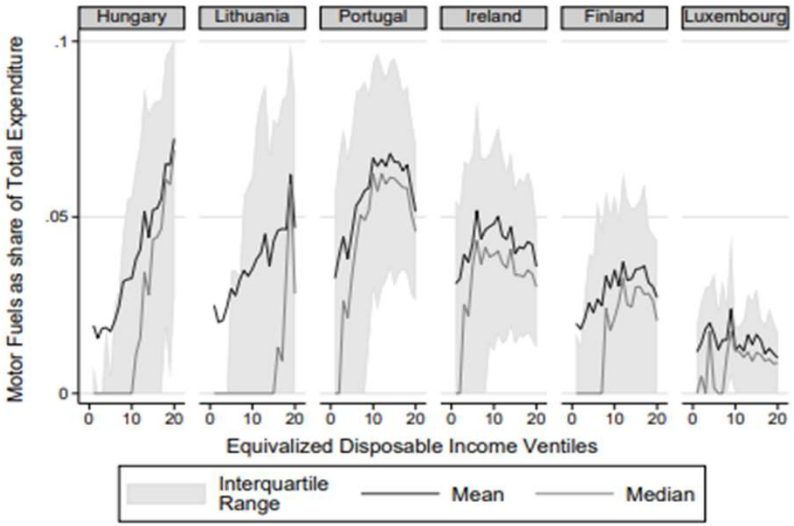
Home fuels



Electricity

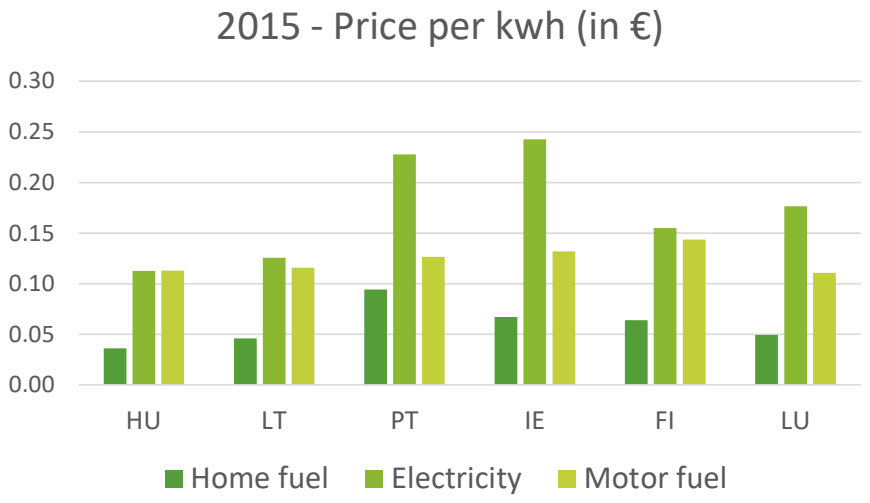


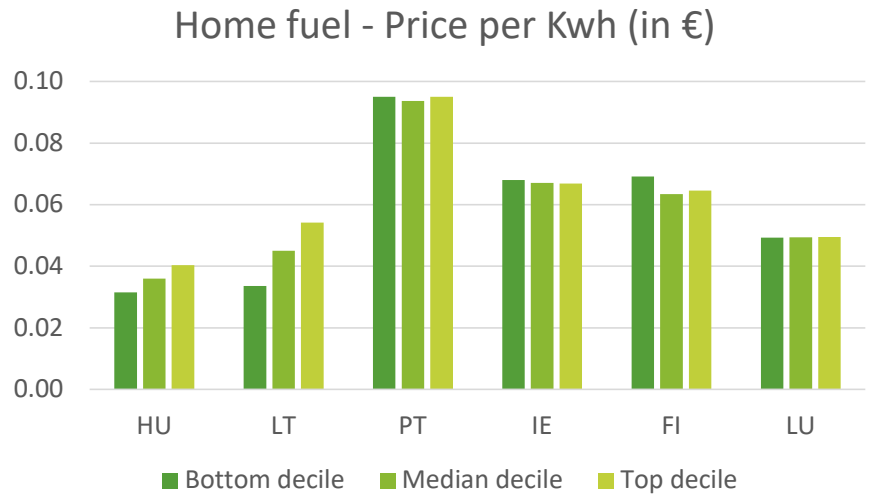
Motor fuels



ENERGY PRICE

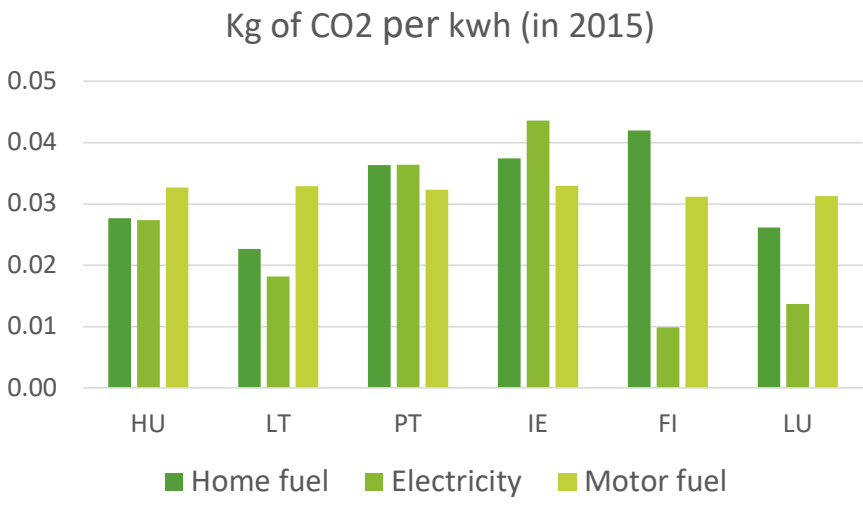
- Home heating is the cheapest fuel everywhere
- Across countries:
  - Variation due to energy mix
  - Largest price differences in electricity
- Across deciles
  - Home fuel price results from the energy mix
  - Poorest have the cheapest energy mix

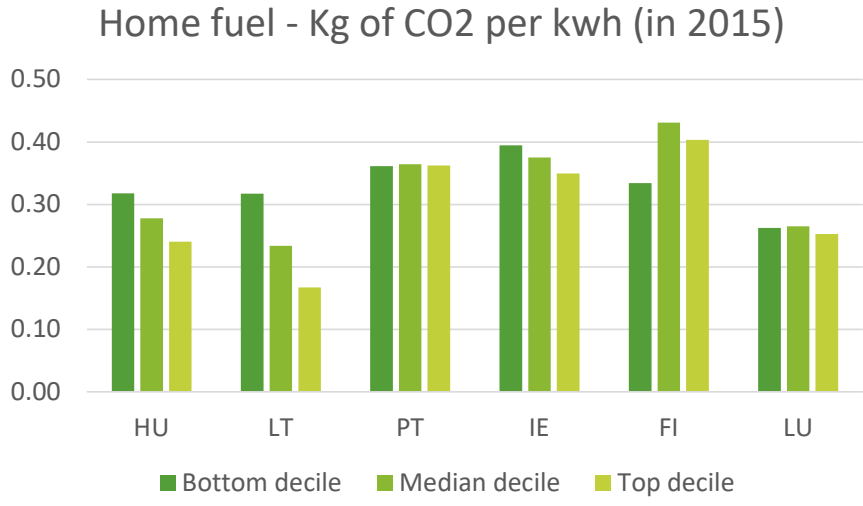




CARBON INTENSITY

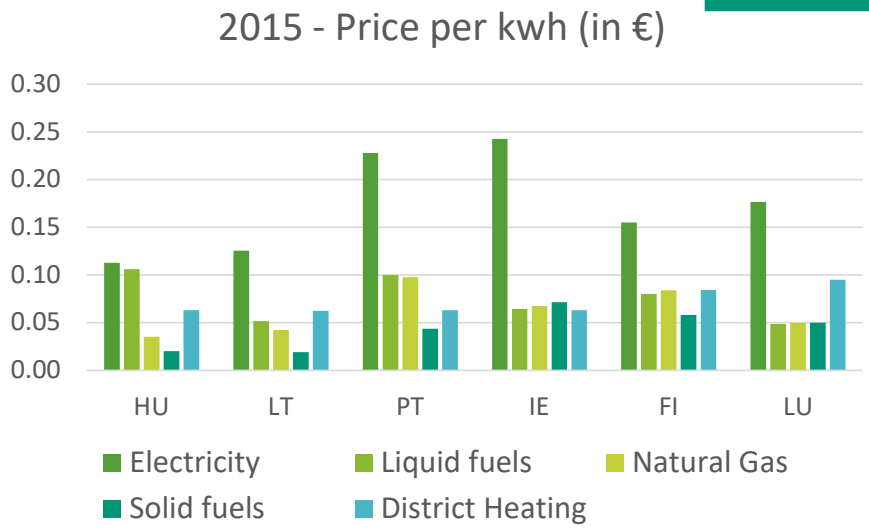
- Home fuel carbon intensity results from the energy mix used
  - More solid fuels in HU, LT, FI and IE
  - HU and LT however also use district heat
- Across countries:
  - Large differences in home fuel and electricity
  - Largest differences in electricity
  - Motor fuel is similar
- Across deciles:
  - Poorest have the most carbon intensive energy mix
  - Inverse of price

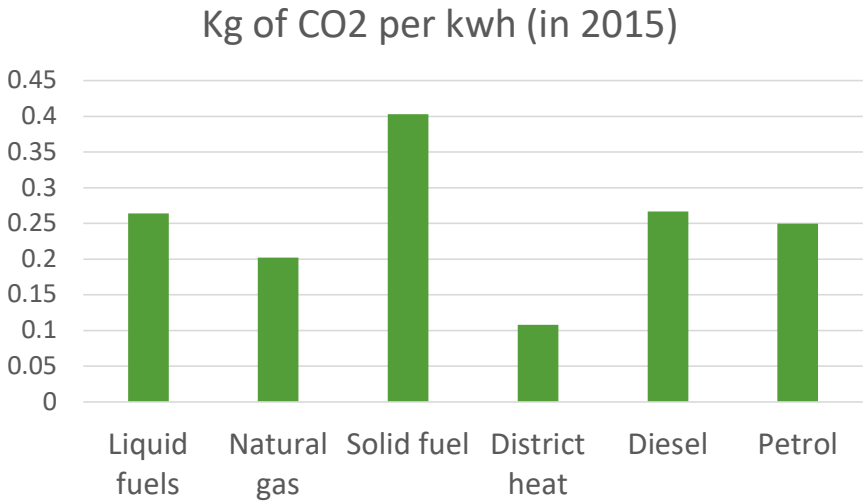




PRICE AND CARBON INTENSITY

- Home fuel price and carbon intensity results from the energy mix used
- Cleaner fuels are more expensive
- Electricity most expensive

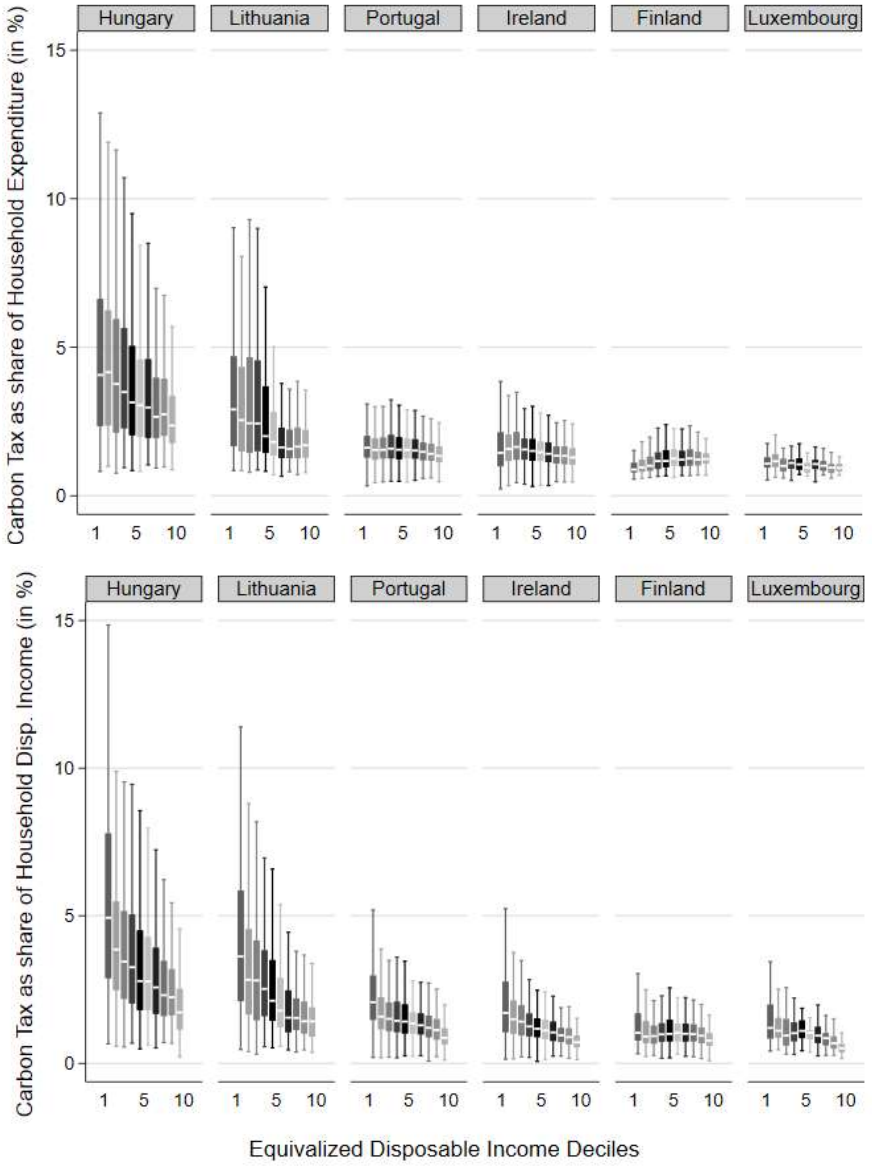




CARBON TAX BURDEN

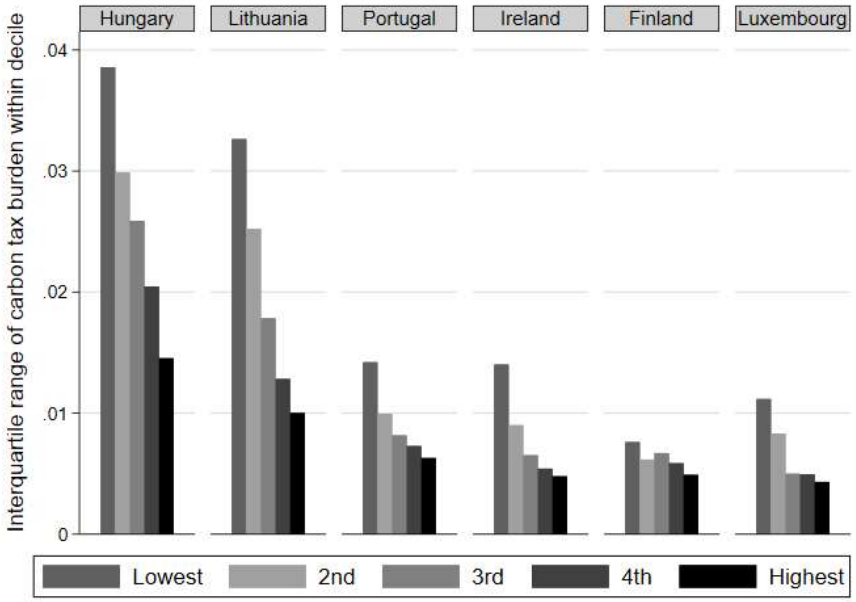
- Top Figure. Relative to expenditure
  - Carbon intensity of the consumption basket
- Bottom Figure. Relative to disposable income
  - Carbon tax relative to household resources

- Carbon Tax is regressive in all countries
  - But least in Finland
- Impacts are significantly larger in poorer countries



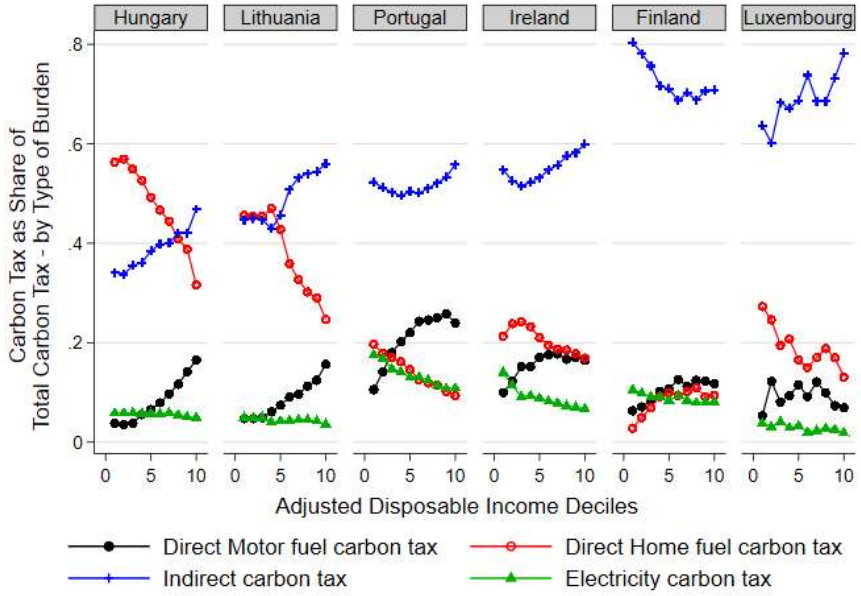
Carbon tax burden: Horizontal Inequality

- Horizontal inequality defined by the interquartile range within each income group.
- Difference in impact within income groups
- Impact is substantially more heterogeneous among the poor
- Horizontal inequality is much larger in poorer countries



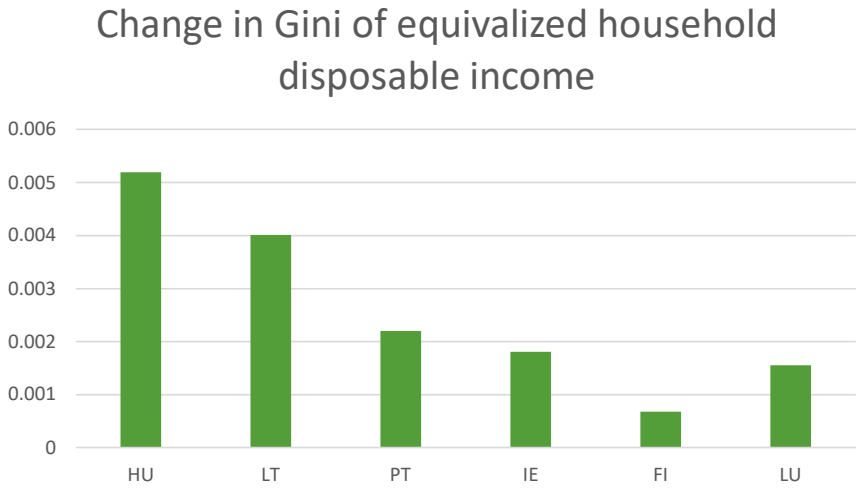
Decomposing the Carbon tax burden

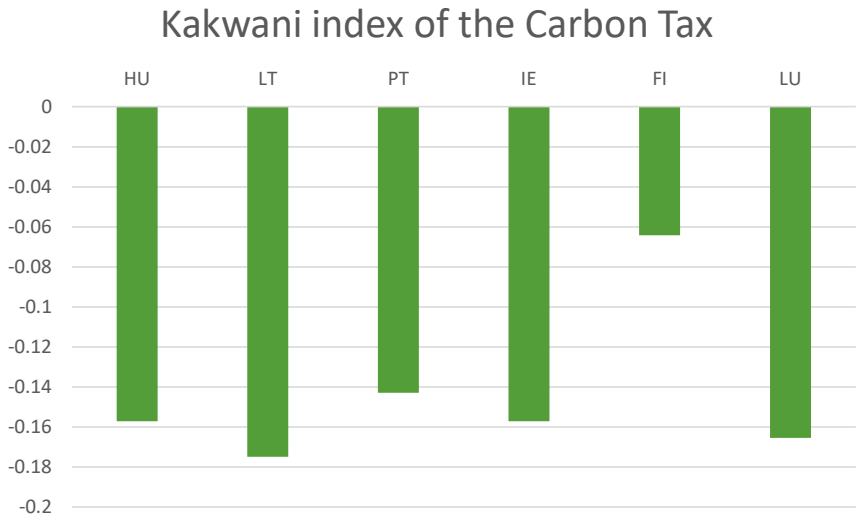
- Largest component.
  - Home fuel in poorer countries
  - Indirect emissions in richer countries
- Finland follows unexpected pattern
  - Motor fuel follows an inverted-U across countries, it becomes a necessity in wealthier countries
- Taxing indirect emissions (CBAM) equalizes the tax burden across countries and across households
- EU-ETS2 is regressive, particularly in richer countries



CARBON TAX AND INEQUALITY

- Increase in inequality due to the carbon tax is larger in poorer countries
  - And falls with increasing average income
  - But is lowest for Finland
- Regressivity of the carbon tax is approximately equal across countries
  - Except in Finland, where it is substantially lower

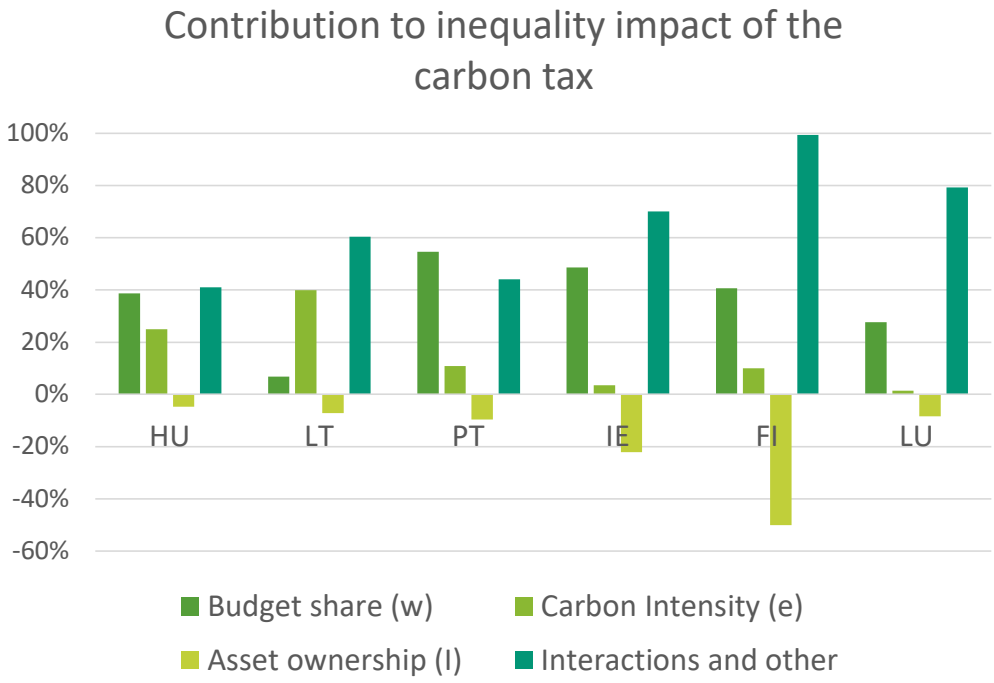




DECOMPOSING POST-CARBON TAX DISPOSABLE INCOME INEQUALITY

- Contributions of energy Budget Shares (w), carbon intensity (e) and asset ownership (I)

- Largest contribution due to Budget share (w), except in LT
- Contribution of Carbon Intensity is largest in LT, HU and PT
- Interactions and impact of indirect emissions and differences in savings rates grows with countries wealth.



CONCLUSION

- Common EU carbon tax puts highest burden on households in poorer countries.
  - Energy Expenditure patterns and income levels matter.
- Composition of the carbon tax burden differs across countries
  - Differences in wealth across countries matter
- Larger impact on inequality in poorer countries, similar regressivity across countries.
  - Larger budget shares and carbon intensive fuel consumption among the poor.
- The drivers of the carbon tax impact on disposable income inequality differs across countries
  - Most effective policy lever to reduce unequal impact will differ across countries.
- ETS2 is regressive in and across countries. CBAM is progressive within and across countries.

Thank you

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Environmentally Extended Multi-regional input-output model

- Multi-Regional Input-Output model
  - Captures linkages between different sectors and allows to trace emissions embedded into the production process.
- Word Input-Output Database (WIOD)
  - 56 industries and 44 countries, including the rest of the world (Timmer et al, 2015)
  - Environmental Extension: CO_2 emissions (Genty et al., 2012; Arto et al, 2020)
- Leontief Technology matrix
  - Inputs from one sector in one country to other sector in same/other country.
- Matched WIOD sectors to HBS consumption categories
  - Translating goods by expenditure purpose into industry outputs using a bridging matrix by Cai and Vandyck (2020).
  - COICOP -> CPA -> NACE rév. 2
- Calculate price changes for each expenditure group assuming 100% pass-through