The Distributional Effects of Carbon Pricing Across Countries

Mathilde Le Moigne Simon Lepot Marcos Ritel Dora Simon

University of Zurich, Kuehne Logistics University, University of Stavanger

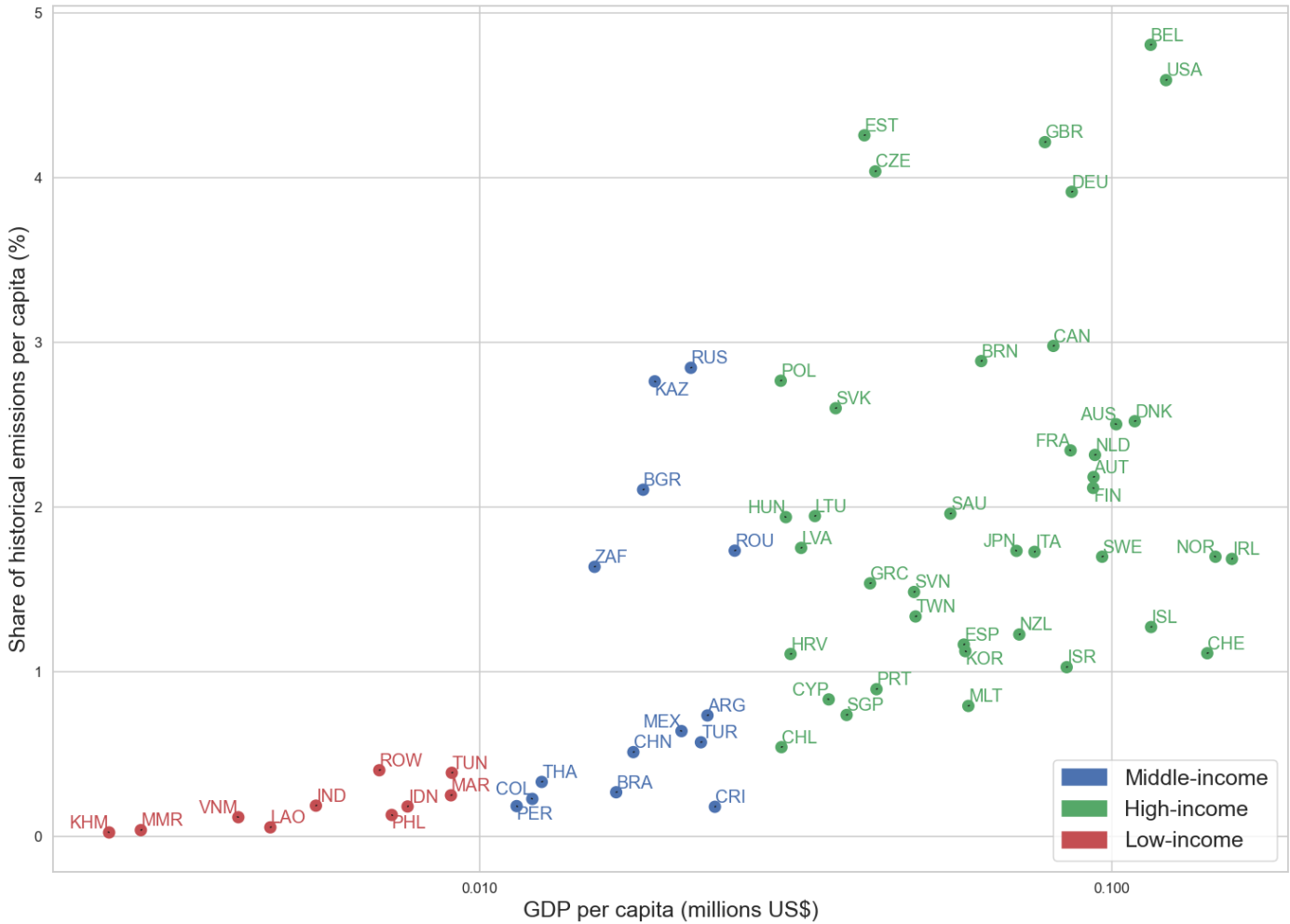
November 2025

Motivation

Climate change will disproportionately impact low- and middle-income countries (Carleton et al. 2022)

Motivation

Low- and medium-income countries contributed the least to climate change



Common But Differentiated Responsibilities (CBDR)

Low and middle income countries have pushed for decades for differentiated contributions in the fight against climate change

- CBDR has been established at the 1992 Earth Summit
- It is a leading principle of climate talks like the Conference of the Parties (COP)
- The Paris Agreement is built around the principle of CBDR
- High-income countries have generally supported CBDR in the context of climate finance

Research Question

What are the distributional effects of climate action across countries?

- We explore the case for differentiated contributions in the fight against climate change in the spirit of CBDR
- We use a state-of-the-art quantitative trade model with climate policies

This paper

- We first analyze a benchmark where optimal climate action is induced by a worldwide tax on greenhouse gas emissions, without taking into account the CBDR principle
- Next, we ask whether equity can be achieved by pairing the global carbon tax with transfers. We quantify international transfers
  - to equalize the present costs of global carbon taxation
  - to divide the costs based on accumulated cross-country GHG emissions since the Industrial Revolution
- We analyze some prominent proposals for carbon taxation that rely on heterogeneous pricing

Results

1. A uniform carbon tax strongly exacerbates between-country inequality
    - Emissions decrease by around 52%, while real income decreases on average by 0.6%
    - Low- and middle income countries experience real income losses of up to 7%, while high-income countries often experience a real income gain

Results

1. A uniform carbon tax strongly exacerbates between-country inequality
   - Emissions decrease by around 52%, while real income decreases on average by 0.6%
   - Low- and middle income countries experience real income losses of up to 7%, while high-income countries often experience a real income gain
2. Cross-country transfers of an average of 89-200 USD per person from the Global North to the Global South could remedy this inequality

Results

1. A uniform carbon tax strongly exacerbates between-country inequality
   - Emissions decrease by around 52%, while real income decreases on average by 0.6%
   - Low- and middle income countries experience real income losses of up to 7%, while high-income countries often experience a real income gain
2. Cross-country transfers of an average of 89-200 USD per person from the Global North to the Global South could remedy this inequality
3. Heterogeneous pricing schemes do not lead to fairer outcomes and lower costs

Contribution

We conduct the first comprehensive quantitative analysis of the distributional effects of carbon pricing across countries

- **Distributional effects of climate change and carbon policies** Krusell and Smith (2022), Kotlikoff et al. (2021), Cavalcanti et al. (2020), Finkelstein-Shapiro and Nuguer (2023)
- We analyze the distributional effects across countries

- **Trade policy and GHG emissions** Felder and Rutherford (1993), Hoel (1996), Elliott et al (2010, 2012), Aichele and Felbermayr (2012), Böhringer et al (2016), Kortum and Weisbach (2021), Weisbach et al (2022), Farrokhi and Lashkaripour (2022), Garcia-Lembergman et al. (2025)
- We address an equity dimension often overlooked in broader analyses of trade and the environment

- **Integrated assessment models** Nordhaus (1993, 2018), Weyant (1993), Golosov et al (2014), Boyce (2018), Kotlikoff et al (2022)
- We add an international economics dimension to the benefits and costs of climate policy

Outline

- Model
- Data
- Results
- Robustness

Model: Carbon taxes

- Many-country, many-industry Armington model with input-output linkages
- Emissions stem from fossil-fuel extraction and agriculture (Garcia-Lembergman et al., 2025)
- Notation: i origin, j destination, s' sector produced by i, s sector produced by j
- Countries have access to a carbon tax imposed on final goods and intermediate inputs:

$$
\begin{aligned}
t^{e}_{is'j} &= \frac{t_{is'j}\, e_{is'}}{p_{is'j}}, \\
e_{is'} &= \frac{\mathrm{CO}_{2\,is'}}{q_{is'}}.
\end{aligned}
\tag{1}
$$

- It is levied in the country of final or intermediate consumption and redistributed lump-sum to households either in the country of consumption or production
- This formulation ensures that the carbon tax is equivalent to a per-unit tax on emissions

Total emissions intensities

Model: Households

- Consumers have Cobb-Douglas-CES preferences over varieties differentiated by country of origin

$$U_j = \left[\prod_{s'} U_{s'j}^{\beta_{s'j}} \right]$$

$$U_{s'j} = \left(\sum_i a_{is'}^{1/\sigma_{s'}} \, q_{is'j}^{(\sigma_{s'}-1)/\sigma_{s'}} \right)^{\sigma_{s'}/(\sigma_{s'}-1)}$$

- The carbon tax makes browner varieties more expensive

$$q_{is'j} = a_{is'} \left[p_{is'} \tau_{is'j} (1 + t^e_{is'j}) \right]^{-\sigma_{s'}} I_{s'j} \; P^{c}_{s'j}{}^{(\sigma_{s'}-1)} \tag{2}$$

- Market clearing for consumer tax

$$I_j = \sum_s w_j L_{js} + \sum_s \gamma_{j,Ms} Y_{j,s} + \sum_{i,s'} p_{is'j} q_{is'j} t^e_{is'j} + \sum_{i,s',s} p_{is'j} m_{is'js} t^e_{is'j} + D_j \tag{3}$$

- Market clearing for producer tax

$$I_j = \sum_s w_j L_{js} + \sum_s \gamma_{j,Ms} Y_{j,s} + \sum_{i,s'} p_{js'i} q_{js'i} t^e_{js'i} + \sum_{i,s',s} p_{js'i} m_{js'is} t^e_{js'i} + D_j \tag{4}$$

Model: Firms - Non-Mining Goods

- Firms produce these varieties from labor and intermediates using Cobb-Douglas-CES technologies

$$q_{js} = A_{js}\left(\frac{L_{js}}{\gamma_{j,Ls}}\right)^{\gamma_{j,Ls}} \prod_{s'}\left(\frac{m_{s'js}}{\gamma_{s'js}}\right)^{\gamma_{s'js}}$$

$$m_{s'js} = \left(\sum_{i} b_{is's}^{(1/\eta_{s's})}\, m_{is'js}^{(\eta_{s's}-1)/\eta_{s's}}\right)^{\eta_{s's}/(\eta_{s's}-1)}$$

- The carbon tax makes browner varieties more expensive thus inducing greener production choices

$$m_{is'js} = b_{is's}\left[p_{is'}\tau_{is'j}(1+t^{e}_{is'j})\right]^{-\eta_{s's}} E_{s'js}\; \overset{\pi}{P}_{s'js}^{(\eta_{s's}-1)} \tag{5}$$

Model: Firms - Mining Goods

- Extraction of fossil fuels in sector s (coal, gas, oil) requires a fixed natural resource M_{js}

$$q_{j,s} = \left(M_{js}\right)^{\gamma_{j,Ms}} \left(\frac{L_{js}}{\gamma_{j,Ls}}\right)^{\gamma_{j,Ls}} \prod_{s'} \left(\frac{m_{s'js}}{\gamma_{s'js}}\right)^{\gamma_{s'js}},$$

- Solving the cost-minimization problem yields the following upward-sloping supply curve:

$$Y_{js} = p_{js} q_{js} = M_{js} p_{js}^{\frac{1}{\gamma_{j,Ms}}} w_j^{-\frac{\gamma_{j,Ls}}{\gamma_{j,Ms}}} \prod_k \left(P_{kjs}^{\pi}\right)^{-\frac{\gamma_{kjs}}{\gamma_{j,Ms}}}, s \in \mathcal{S}^M \tag{6}$$

Counterfactuals

- As is now standard in the literature, we compute counterfactuals using 'exact hat algebra' (Dekle et al, 2007)
- This involves writing the equilibrium conditions in changes and expressing their coefficients in terms of trade shares
- This eliminates the need to estimate the preference shifters, productivity shifters, and iceberg trade costs.
- It ensures that the model perfectly matches the global pattern of production and trade in the baseline.
- We estimate the elasticities of substitution using the standard methodology of Caliendo and Parro (2015)

Climate damages

$$U_j^* = \left[\prod_{s'} {U_{s'j}}^{\beta_{s'j}}\right]\left[\frac{1}{1+\delta_j(CO_2 - CO_2^B)}\right]$$

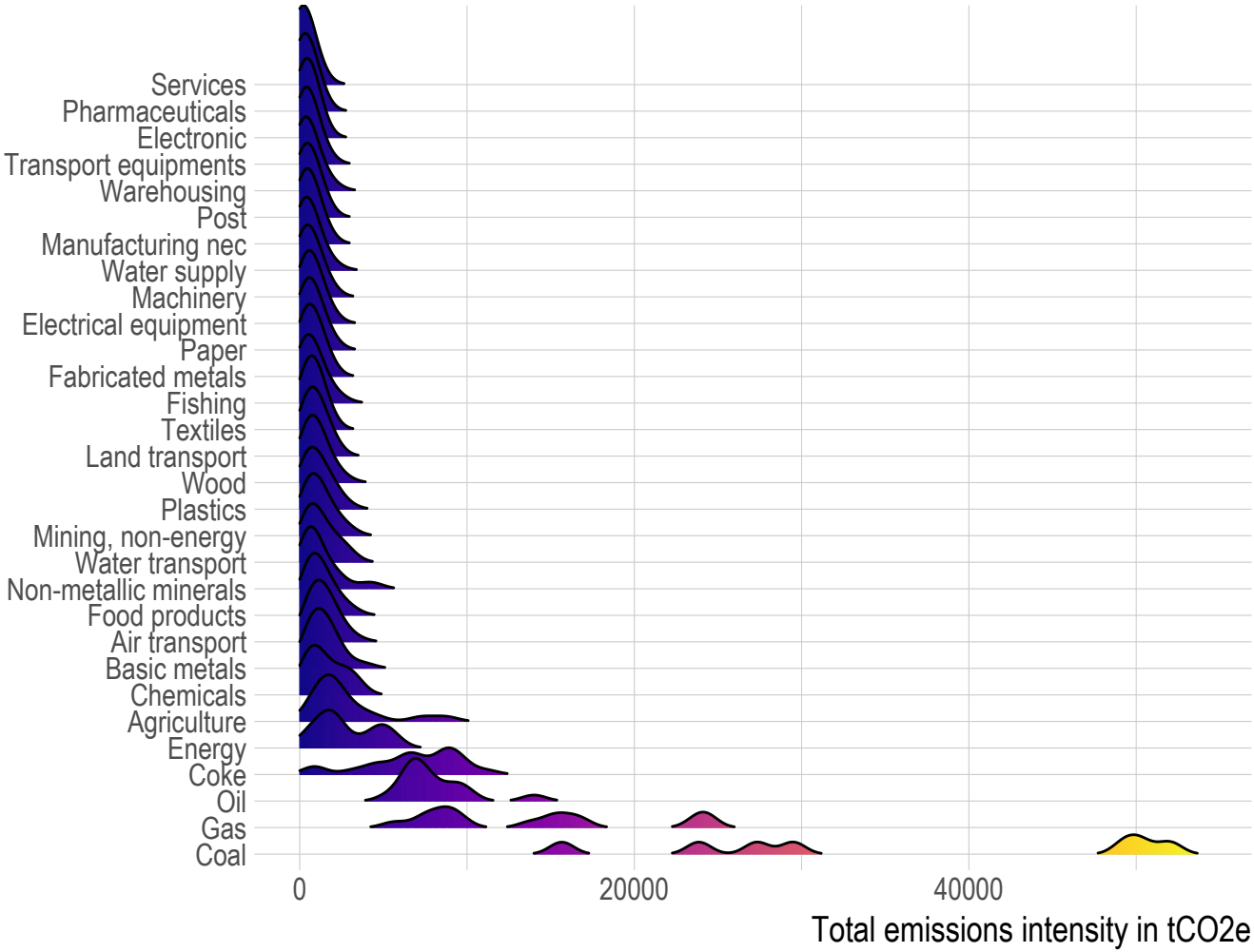
- δ_j: country j's exposure to climate damages
- CO_2: counterfactual emissions
- CO_2^B: baseline emissions
- $U_{s'j}$: preferences across sourcing origins for a given sector
- $\beta_{s'j}$: country j's expenditure share in sector s

Data: Overview

- We have data on 64 countries (including a ROW) and 44 sectors spanning the entire world economy in 2018
- Data on production, trade, and final or intermediate consumption comes from the OECD "Inter-Country Input-Output Tables"
- We split the OECD mining sector into coal, oil, and gas with Exiobase output shares
- Data on GHG emissions in CO_2 equivalents cover CO_2, CH_4, and N_2O:
  1. Mining sectors: Fuel emissions from US Energy Information Administration
  2. Mining sectors: Fugitive emissions from "Emissions Database for Global Atmospheric Research"
  3. Agricultural sector: FAO "Emissions Totals"
- Country-specific data on prices to back out quantities
  1. Mining sectors: IEA World Energy Balances Highlights
  2. Agricultural sector: we construct a price index with FAO producer prices and quantities
- Country-specific data on the social cost of carbon from Ricke et al. (2018)

Components

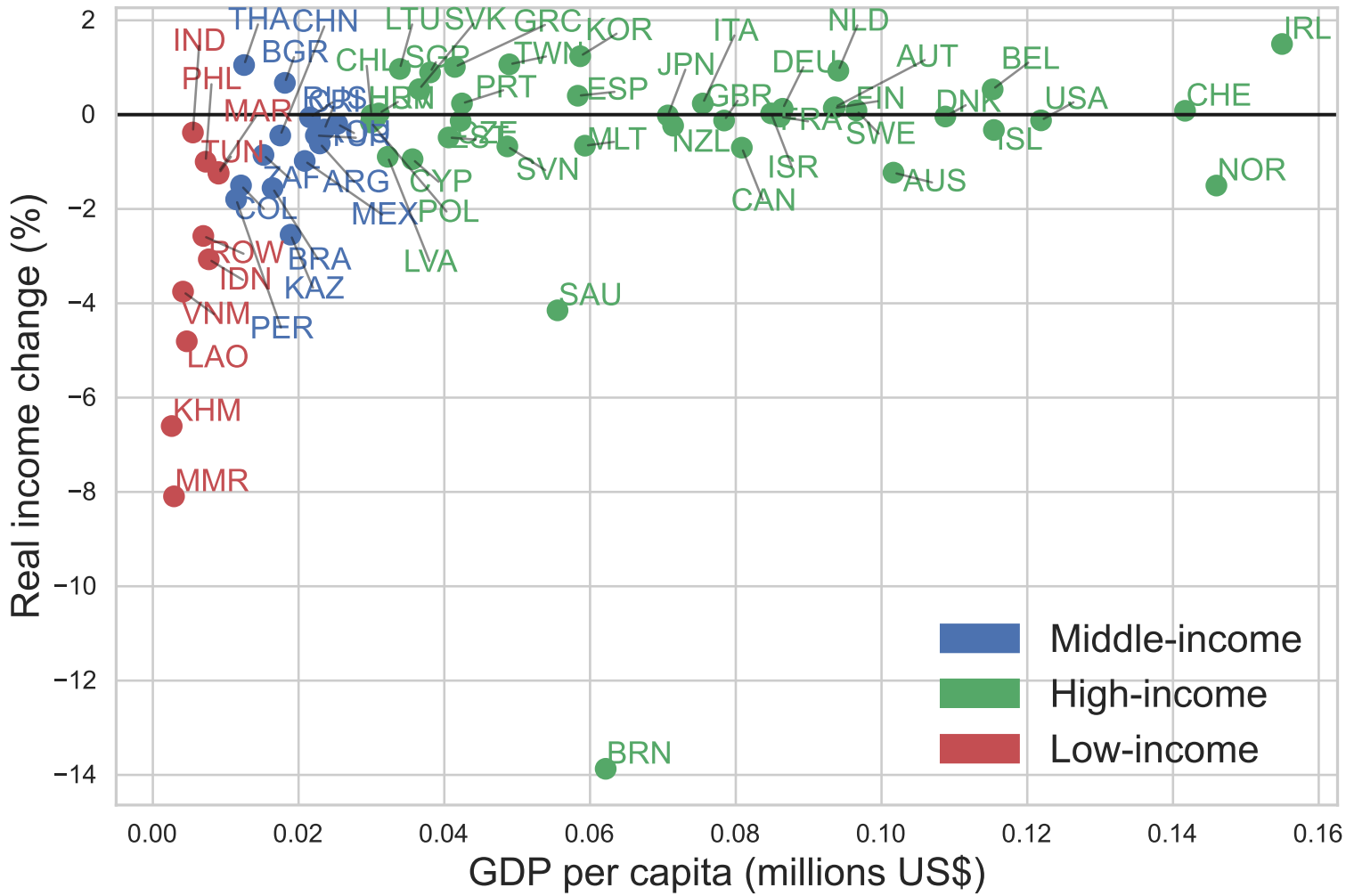
Emissions across sectors



Transport emissions | Density

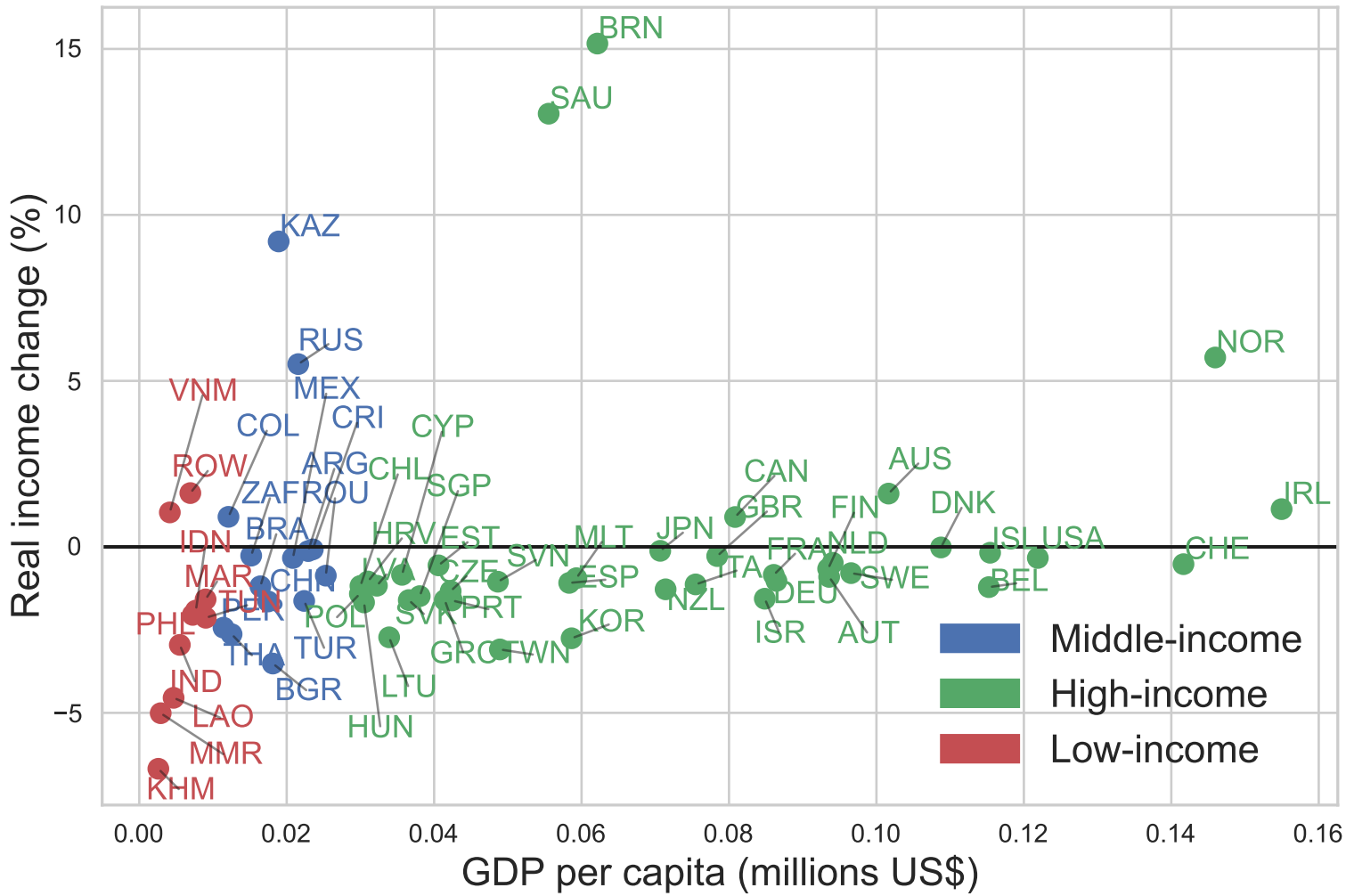
1. Benchmark Results

Results: Real income changes - Consumer tax



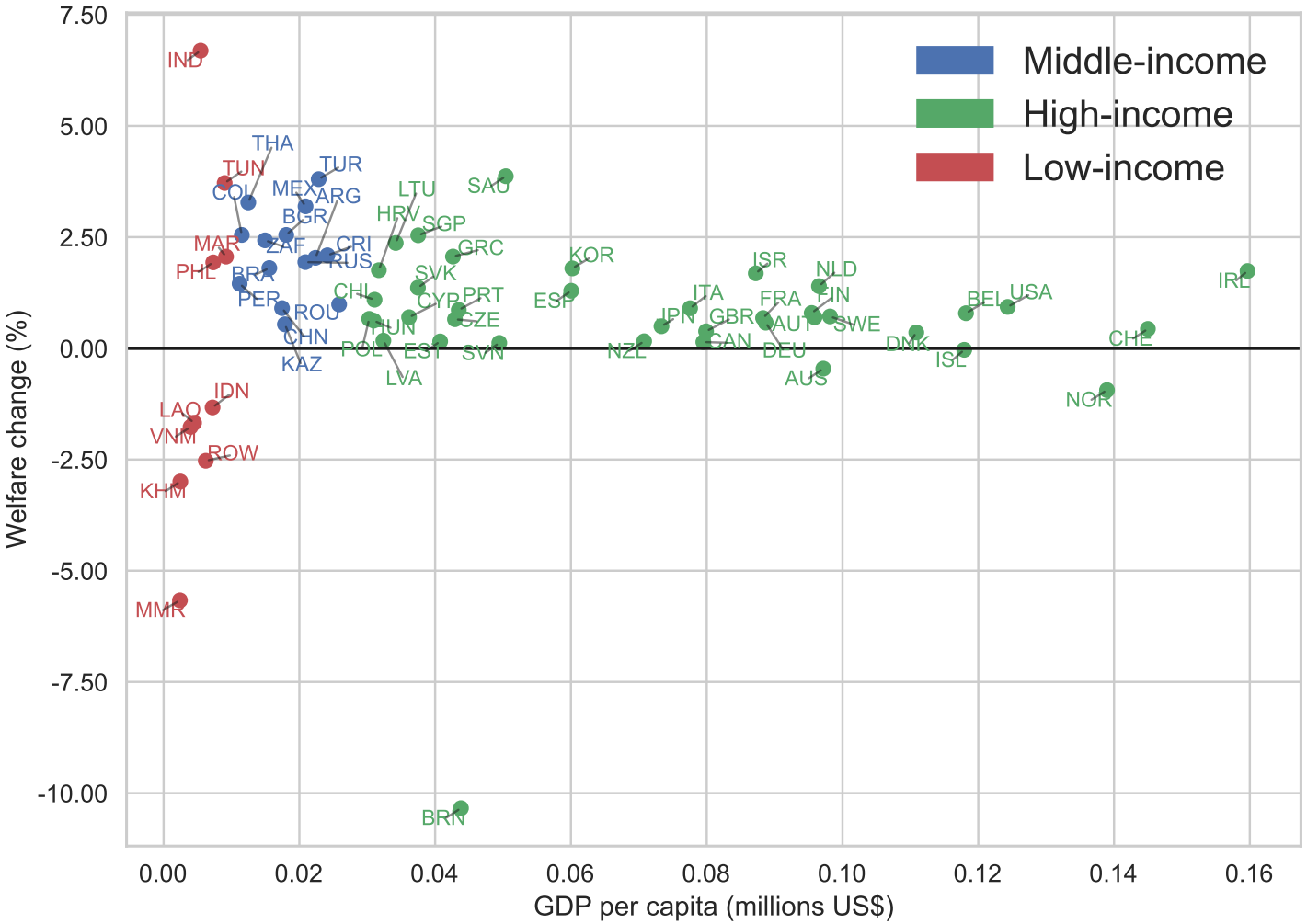
Country Reallocation | Output Reallocation | Labor Reallocation

Results: Real income changes - Producer tax

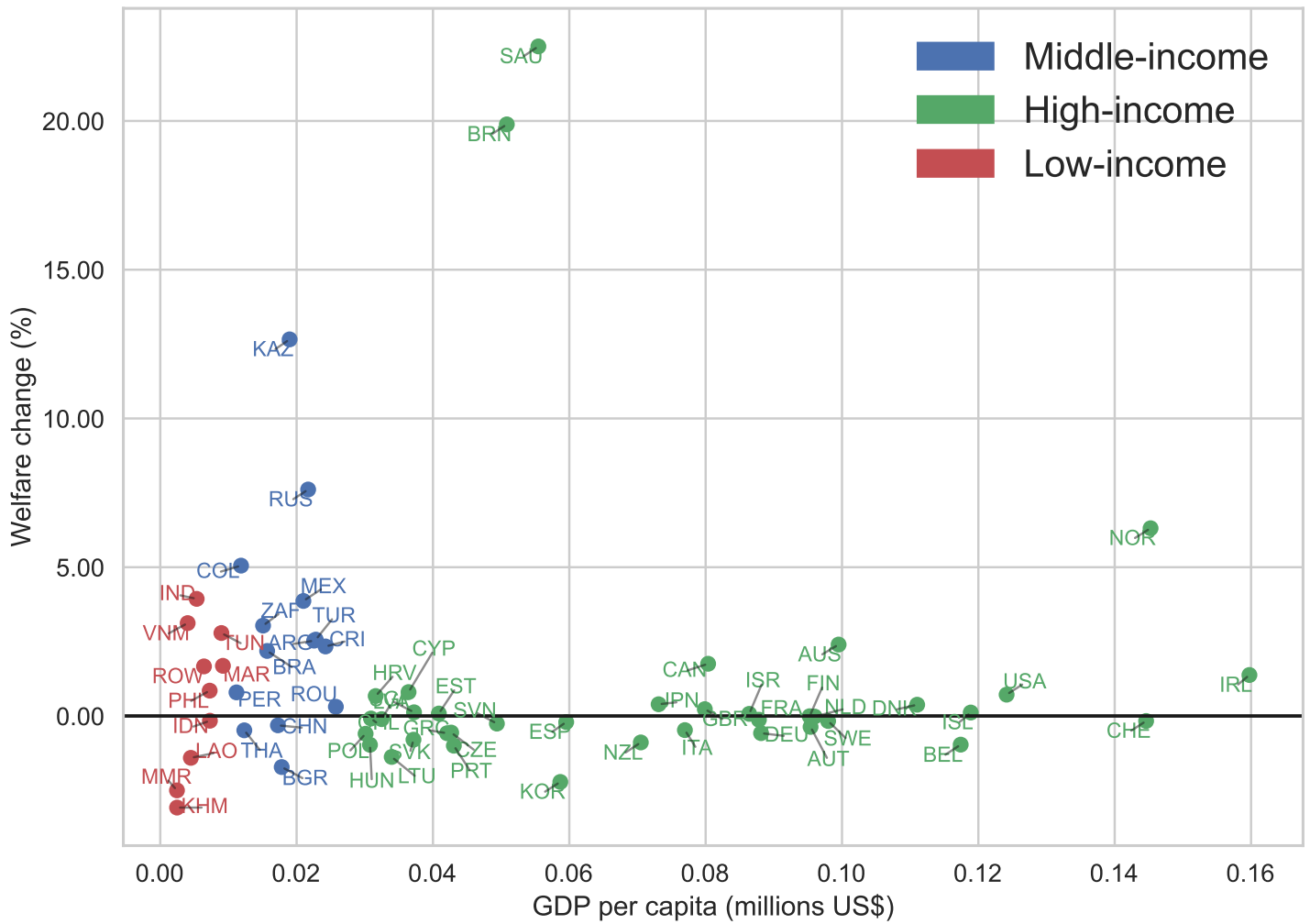


Country Reallocation | Output Reallocation | Labor Reallocation

Results: Welfare changes - Consumer tax



Results: Welfare changes - Producer tax



2. Transfers

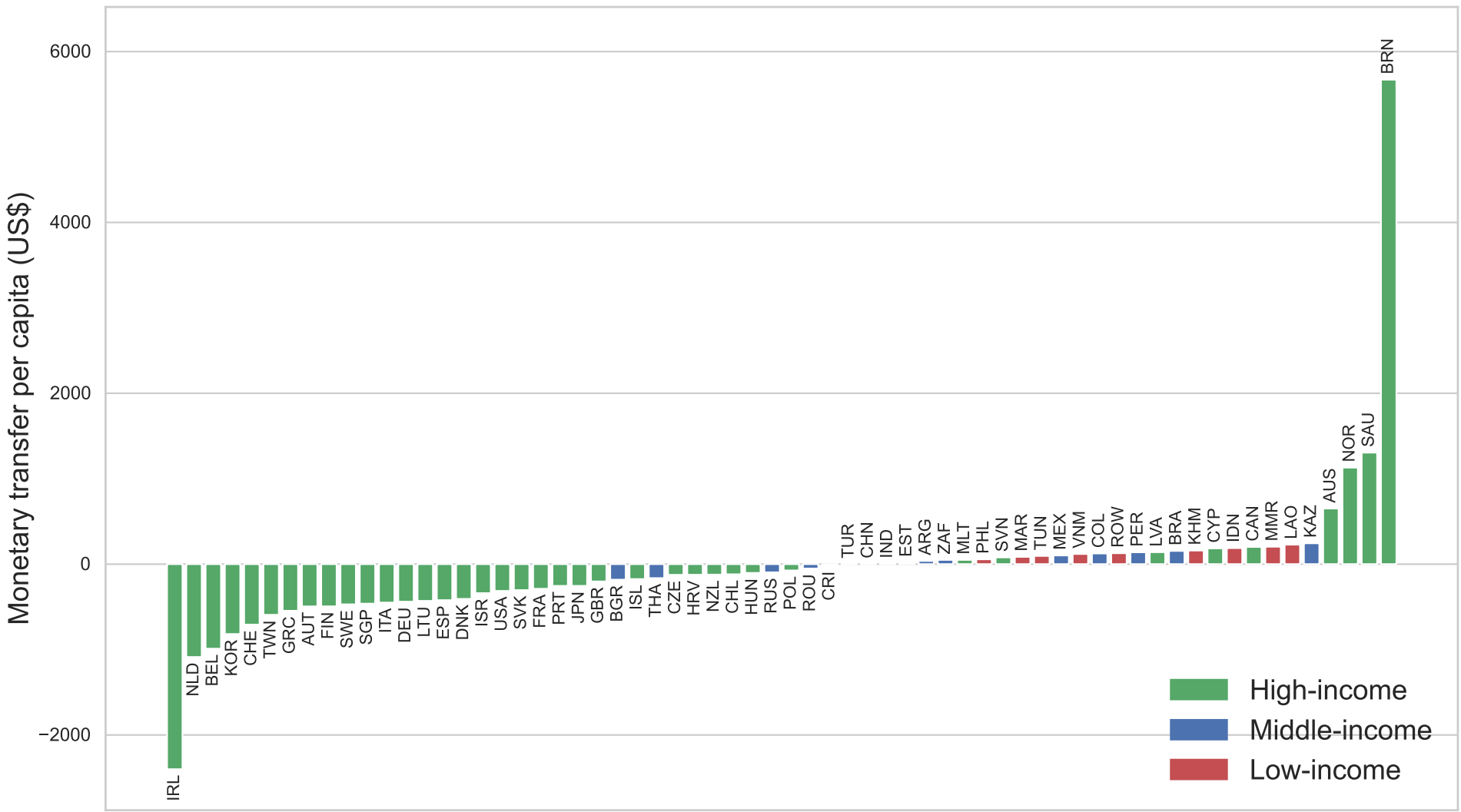
- Equal-cost scenario
- Polluter pays scenario

Transfers

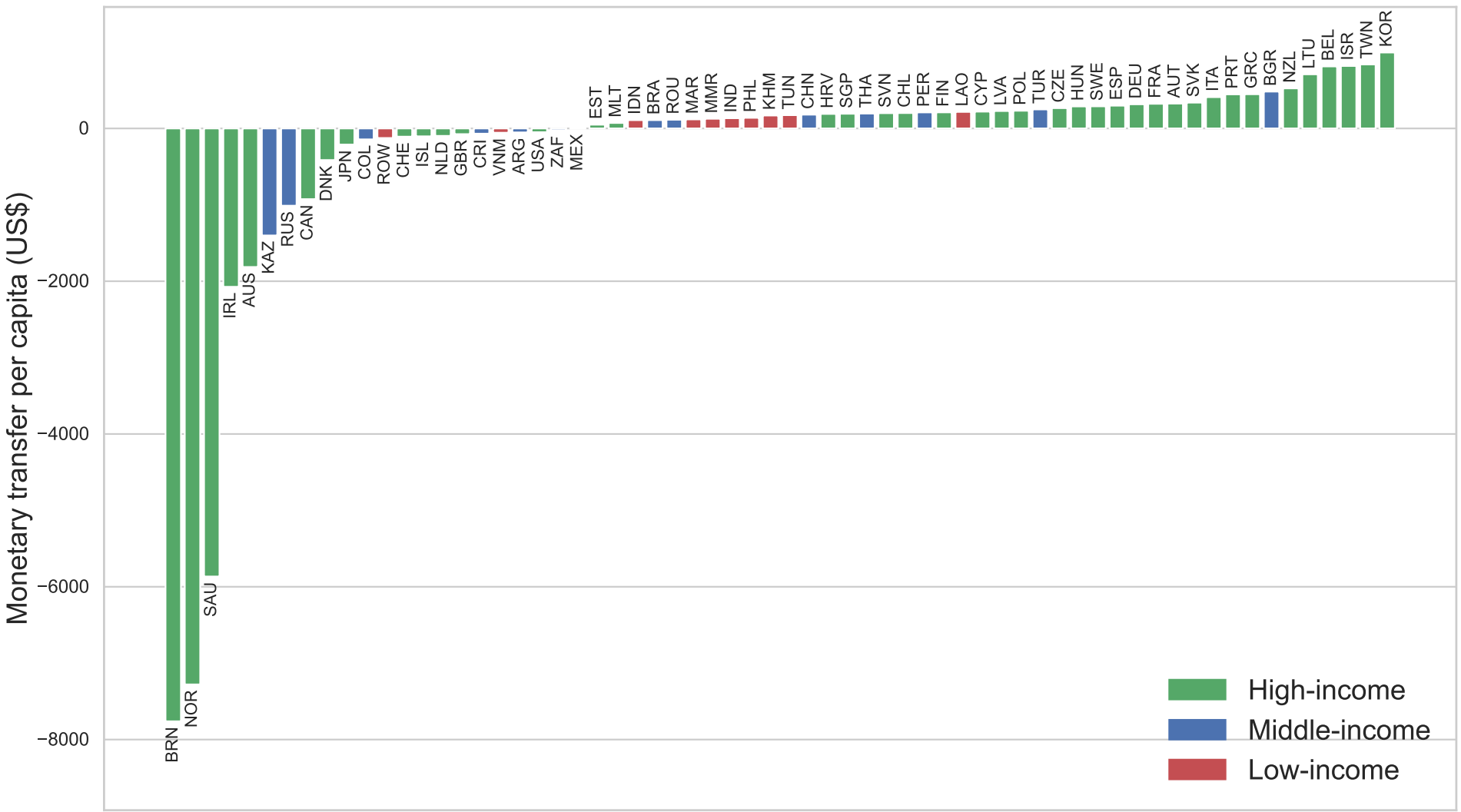
- Some countries gain, some countries lose from carbon taxation. International side payments can help to redistribute the costs of climate action
- We build on Sandmo (2006): a global Pigouvian tax can only be optimal when accounting for egalitarian concerns if paired with international lump-sum transfers
- We explore an 'equal-cost' scenario and a 'polluter pays' scenario

Equal cost real income | Polluter pays real income

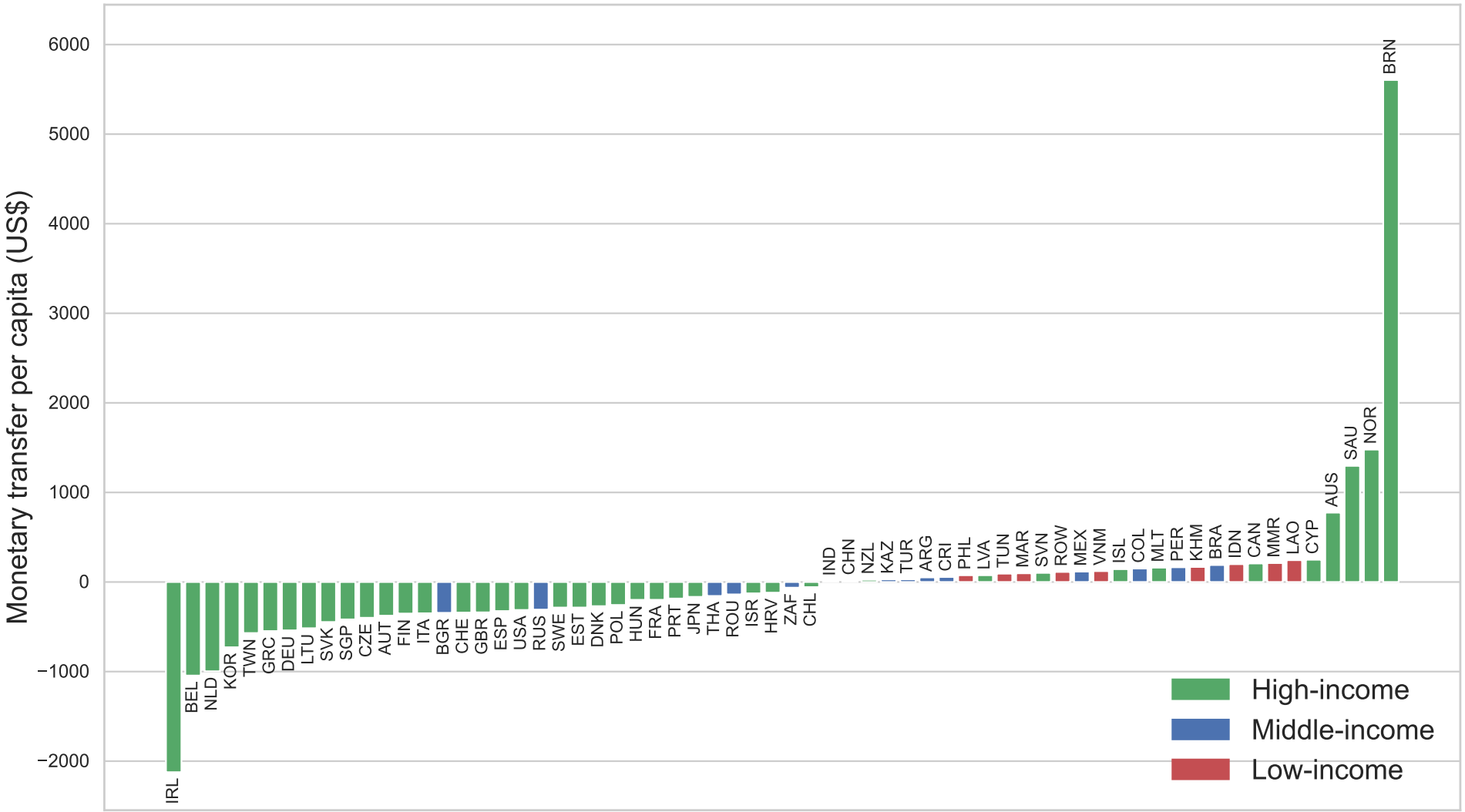
Results: Equal cost transfers - Consumer tax



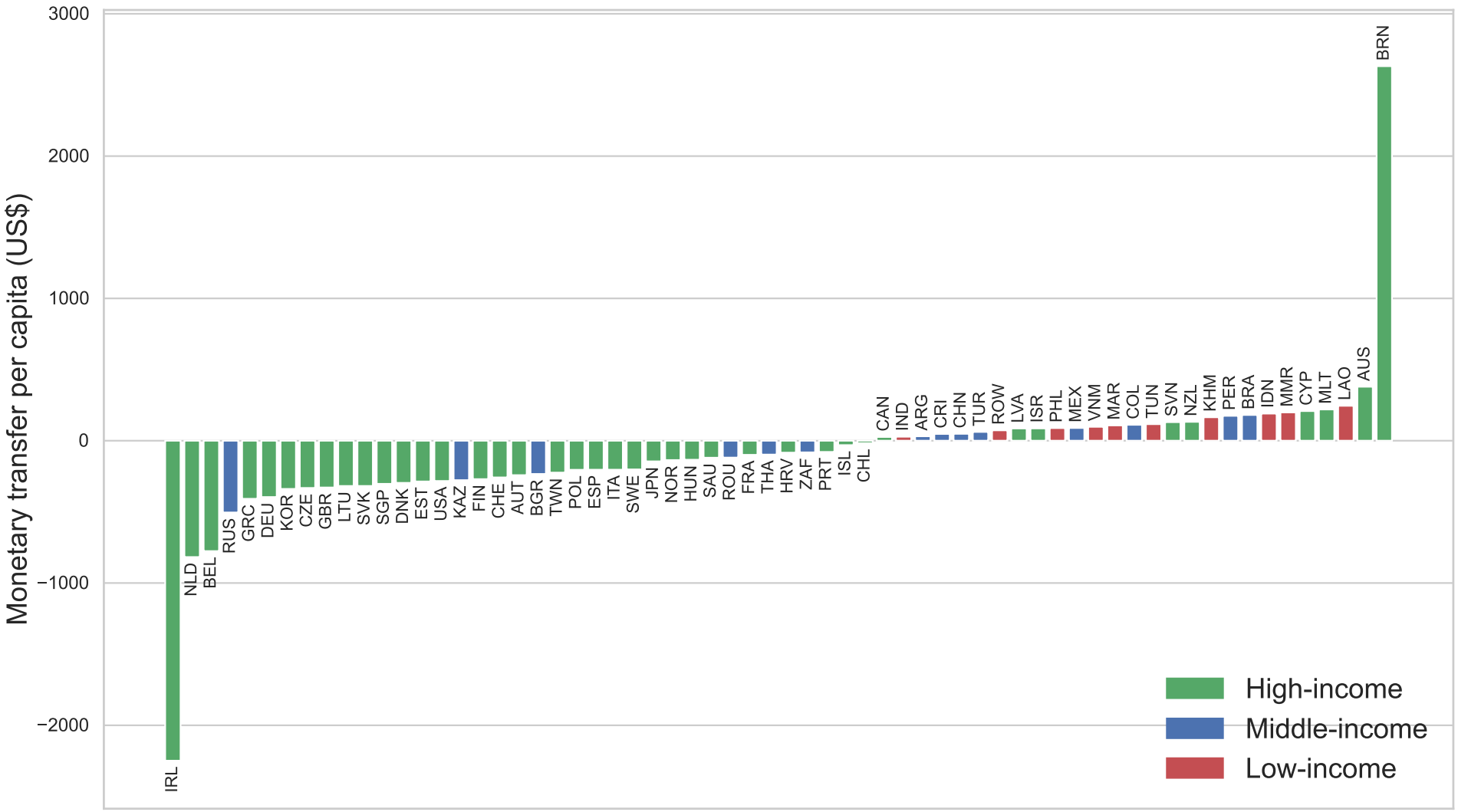
Results: Equal cost transfers - Producer tax



Results: Polluter pays transfers - Consumer tax



Results: Polluter pays transfers - Producer tax



3. Heterogeneous Carbon Prices

Heterogeneous Carbon Prices

Does the IMF proposal introduce more or less fairness between the economic North and the economic South?

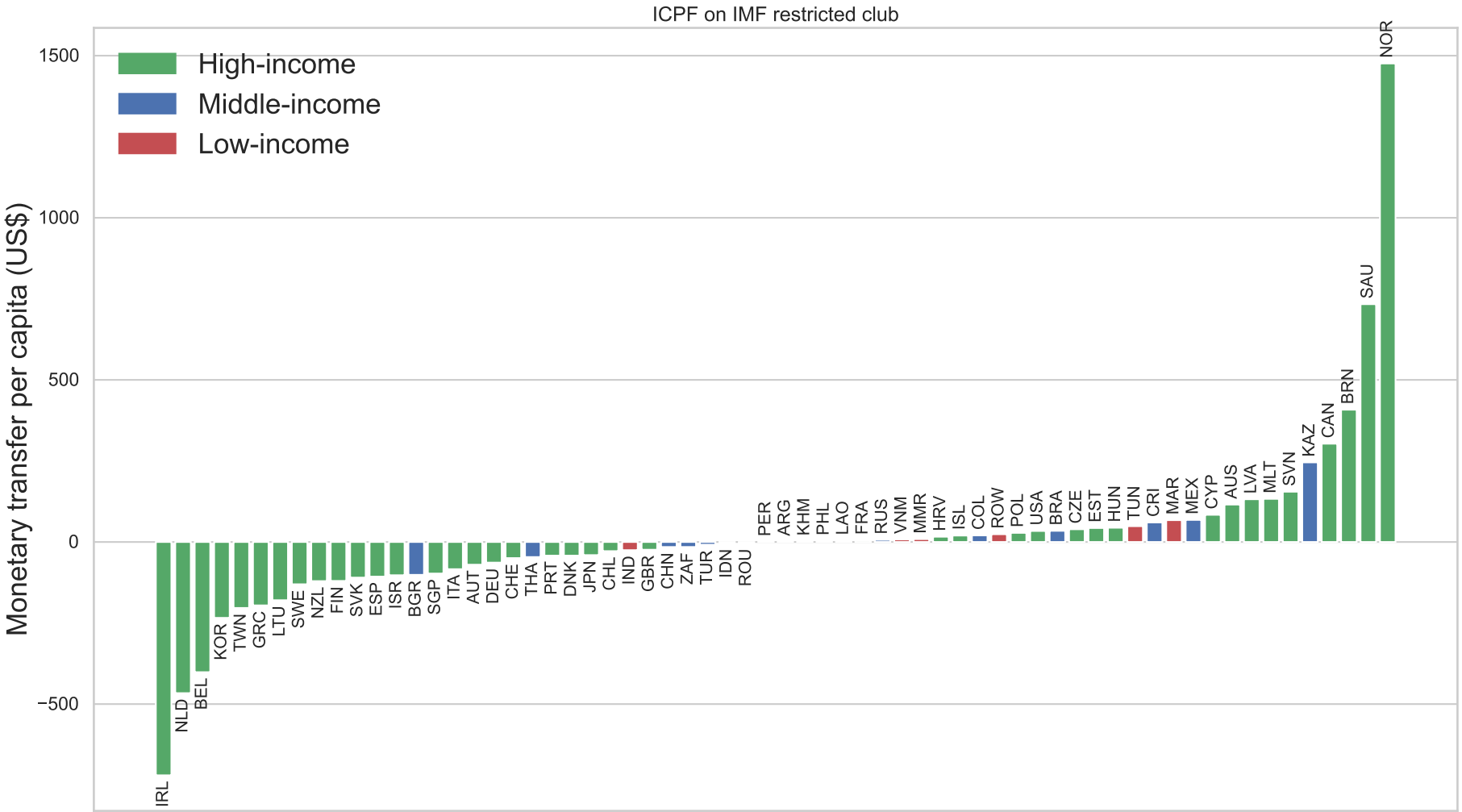
- We compare this policy to a clear benchmark: the uniform tax that generates the same emissions reduction as in the policy
- Our measure of fairness: equal-cost transfers
- Our measure of efficiency: changes in real income

IMF Price Floor

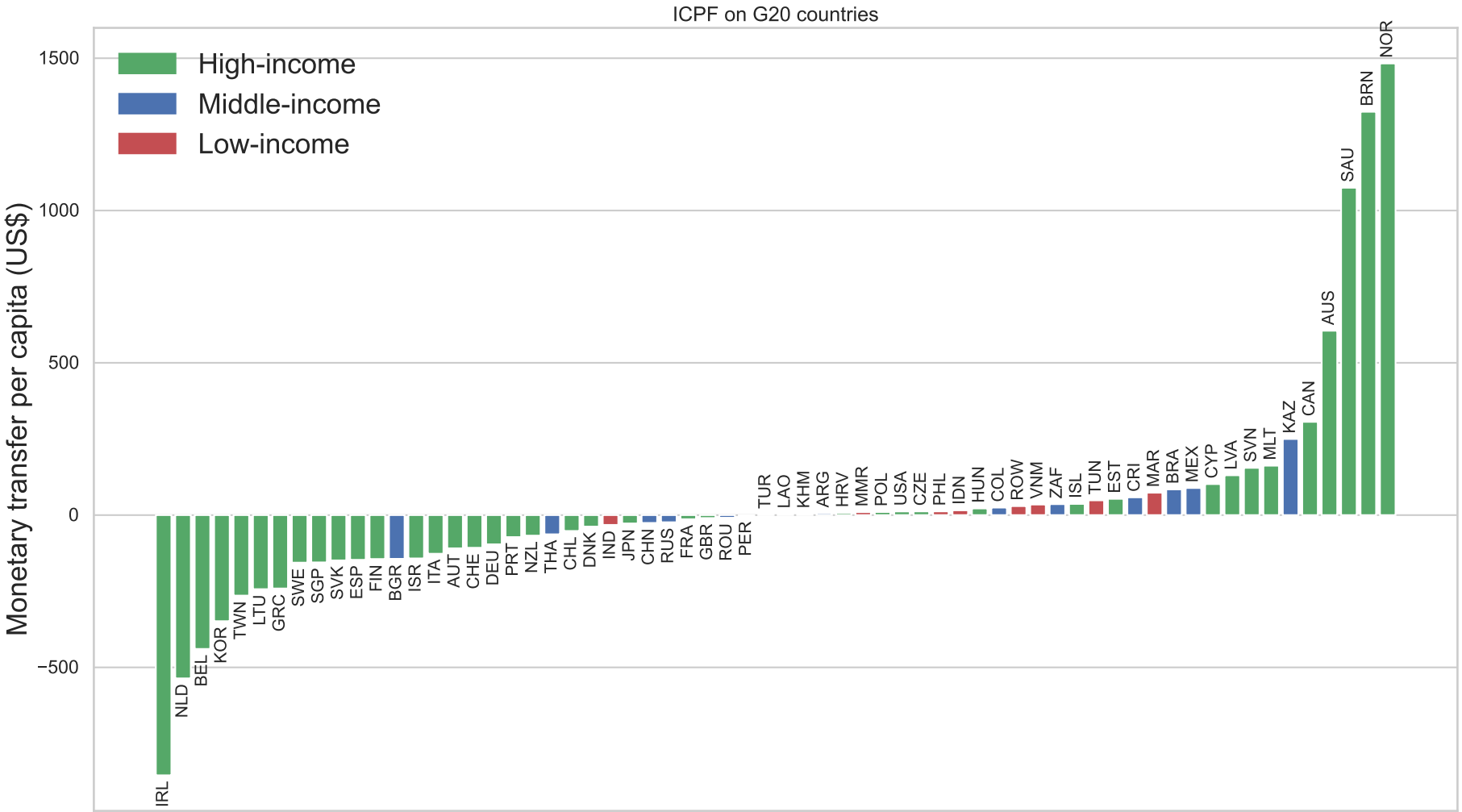
- The IMF suggests a "Price Floor" policy for carbon taxes
- There are several core country configurations
  - Restricted club: Canada, China, the European Union, Great Britain, India, and the United States
  - All G20 countries
  - Key players: EU, U.S., China, India, Indonesia, Russia, Brazil, and South Africa
  - All countries
- It suggests different tax rate for countries depending on their income levels:
  - 25$ per ton of CO2eq for low-income countries,
  - 50$ for middle-income countries,
  - 75$ for high-income countries.

Incremental Carbon Taxes

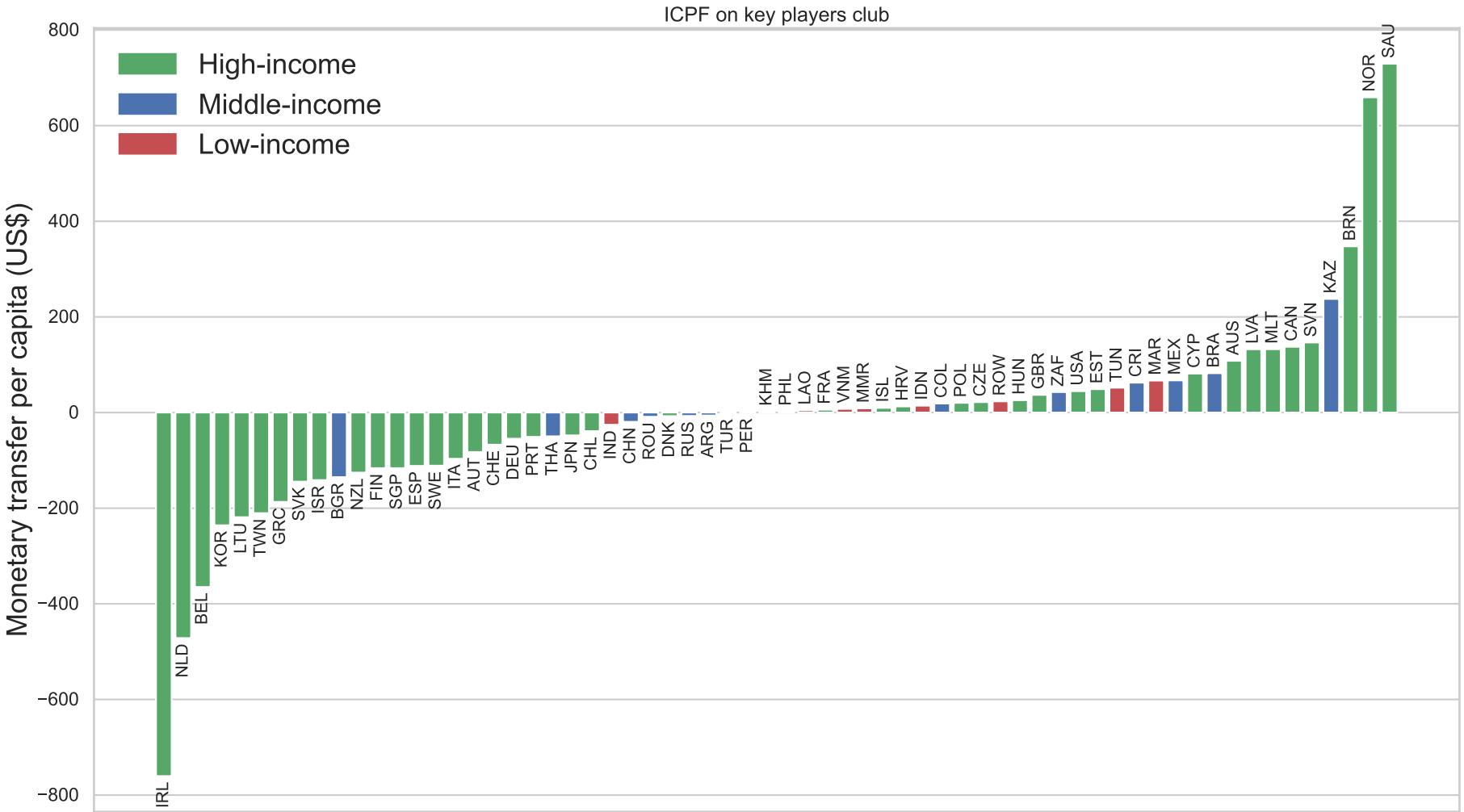
Results: IMF Price Floor - Restricted Club - Consumer Tax



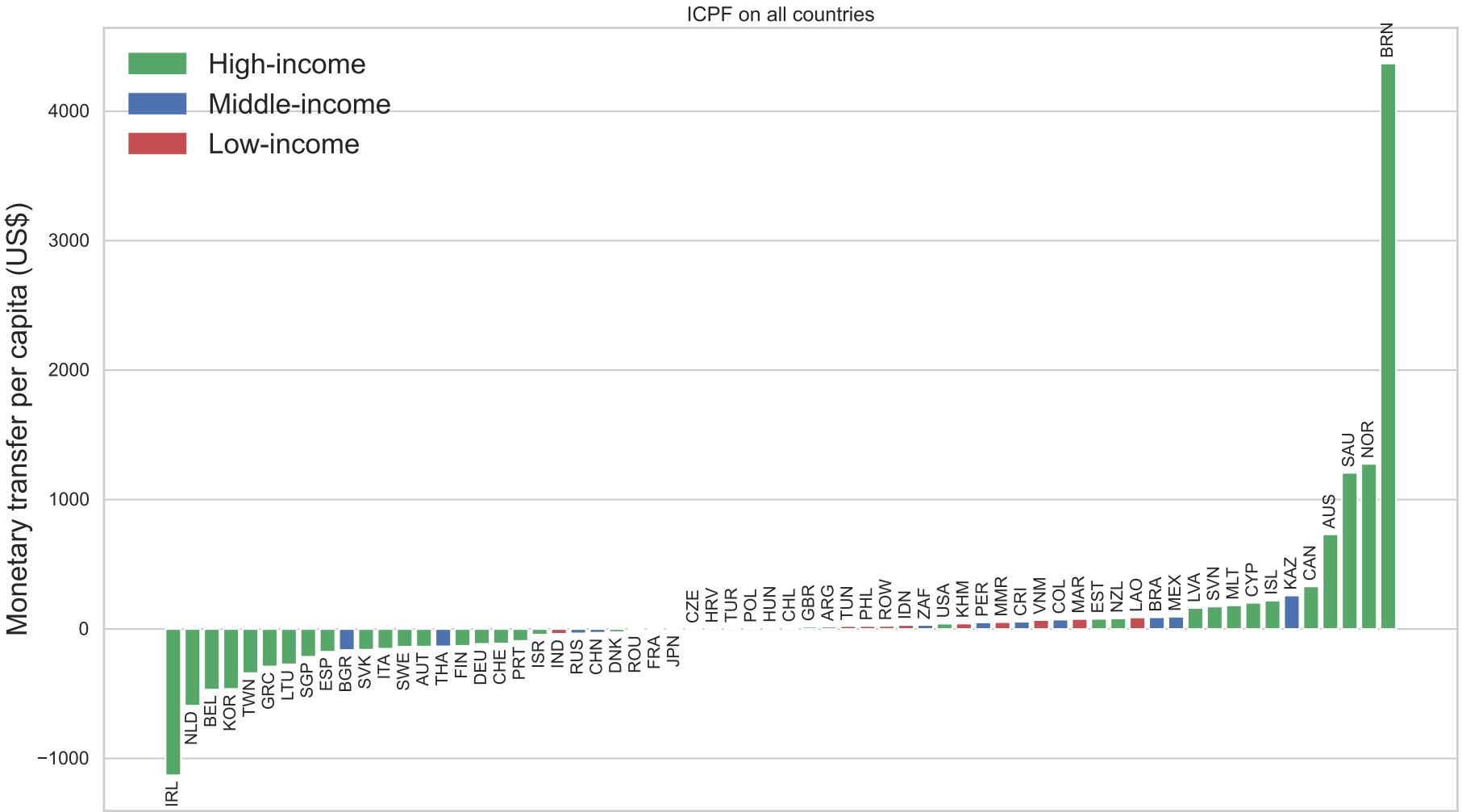
Results: IMF Price Floor - G20 - Consumer Tax



Results: IMF Price Floor - Key players - Consumer Tax



Results: IMF Price Floor - All countries - Consumer Tax



Results: IMF Price Floor

	Uniform Tax	Emissions	Real Income	Transfers
Restricted Club	18	-21	-0.17	9
G20	26	-26	-0.16	18
Key Players	21	-22	-0.18	4
All Countries	45	-36	-0.04	-3

Robustness

Our results are robust to the following checks:

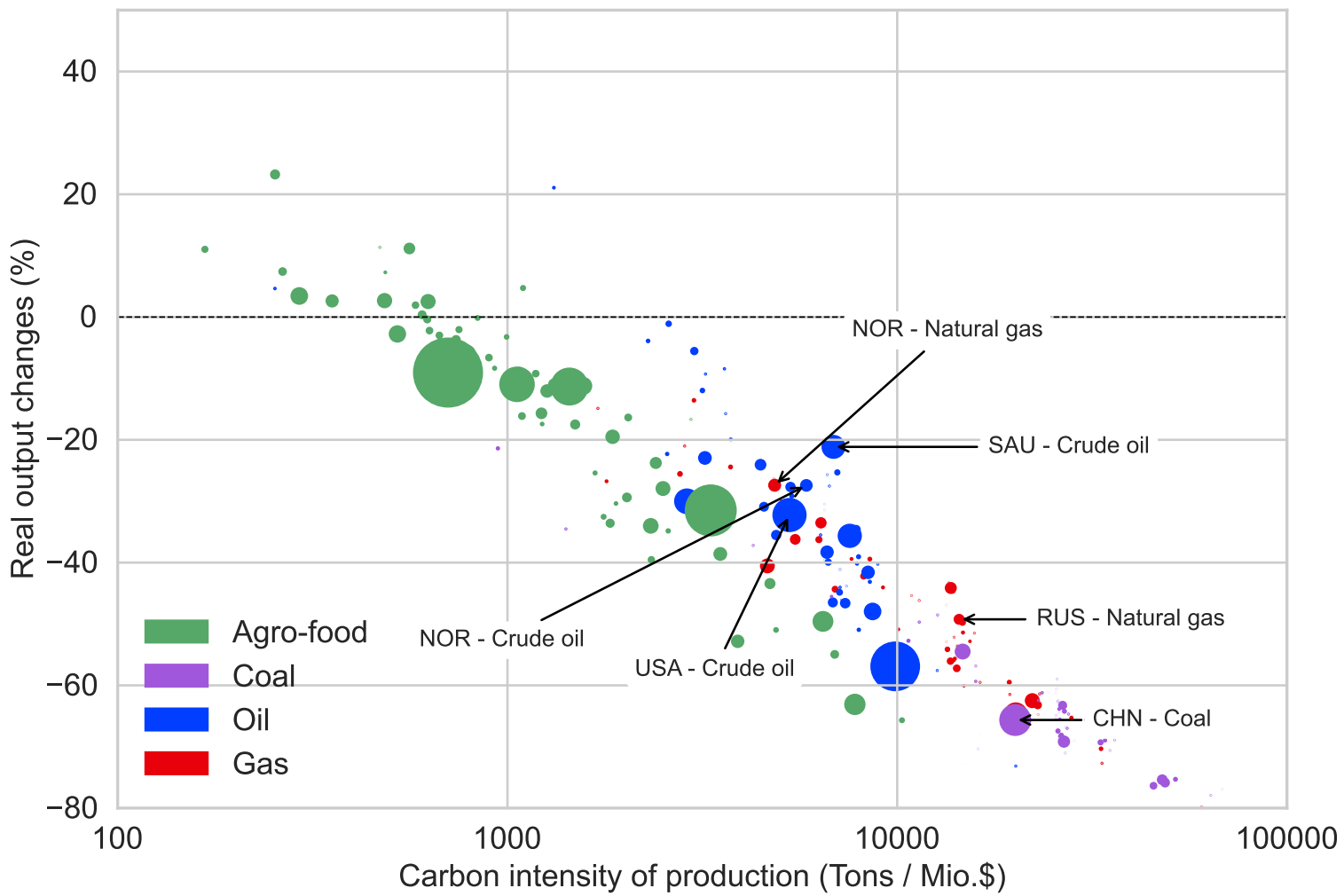
- Alternative trade elasticity estimates Elasticity
- Plausibility of shifts in trade patterns Plausibility

Conclusion

We conduct the first comprehensive quantitative analysis of the distributional effects of carbon pricing across countries

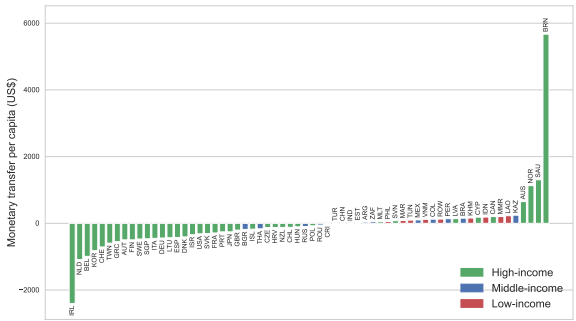
1. A uniform carbon tax strongly exacerbates between-country inequality
2. Realistic cross-country transfers of an average of USD89-200 per person from the Global North to the Global South could remedy this inequality
3. Heterogeneous pricing schemes such as the IMF proposal do not necessarily lead to fairer outcomes and lower costs

Results: Plausibility

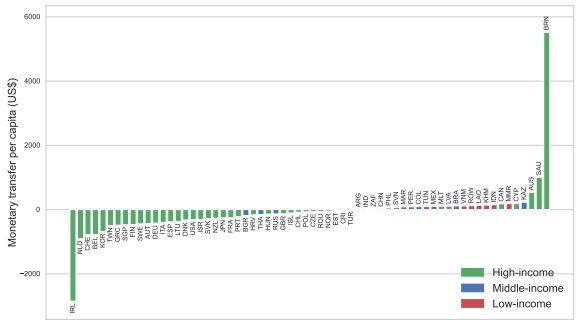


Back

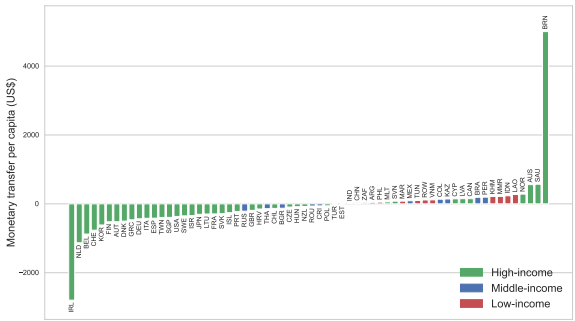
Robustness: Equal cost transfers by elasticity - Consumer tax



(a) Caliendo-Parro estimation



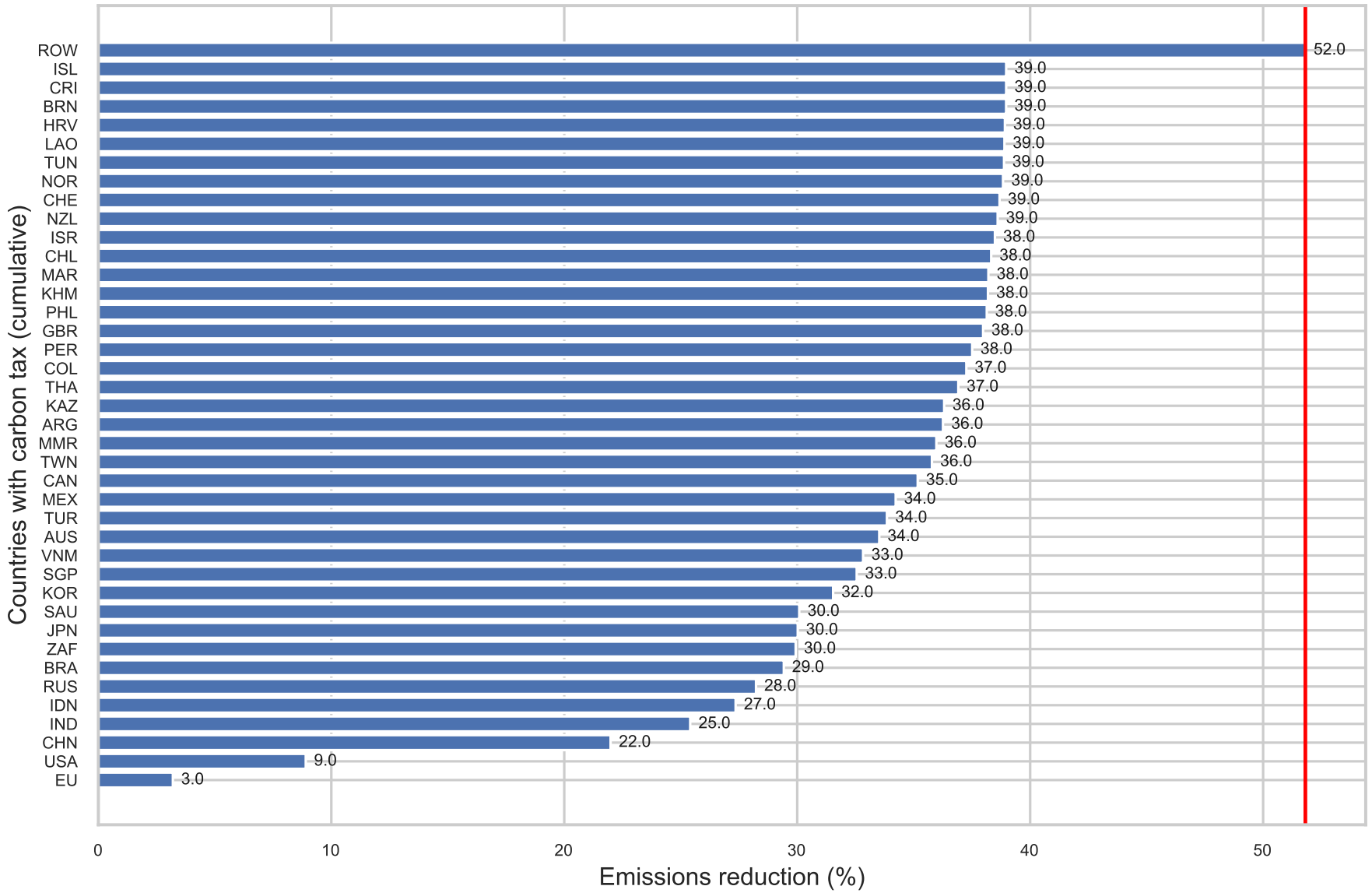
(b) Aggregated elasticities



(c) Fontagne estimation

Back

Incremental Carbon Tax



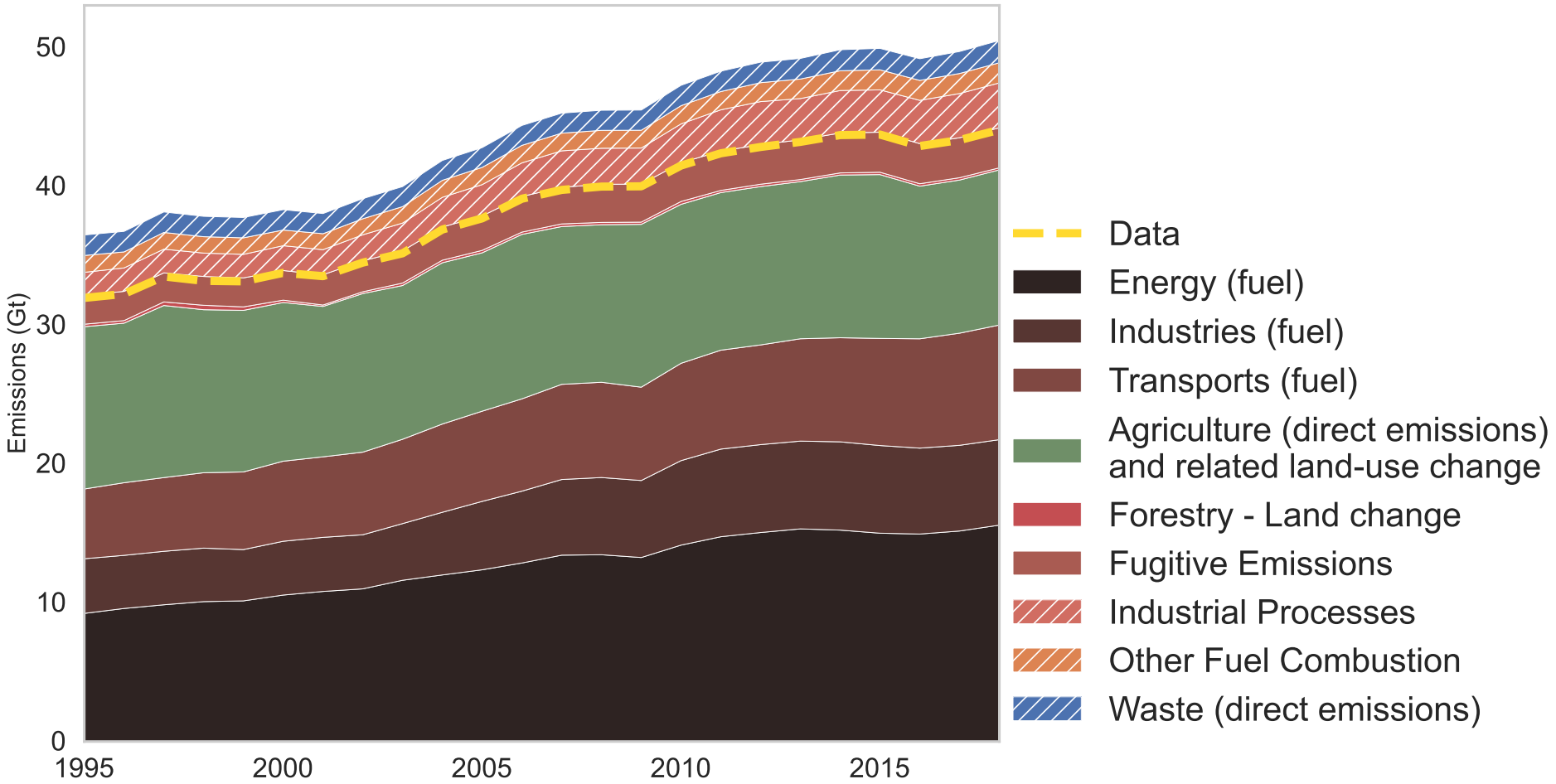
Back

Model: Transportation

- We treat transportation services as just another intermediate input in production
- Traded goods need more transportation services because of iceberg trade costs
- However, all inputs are then scaled up and not just transportation services

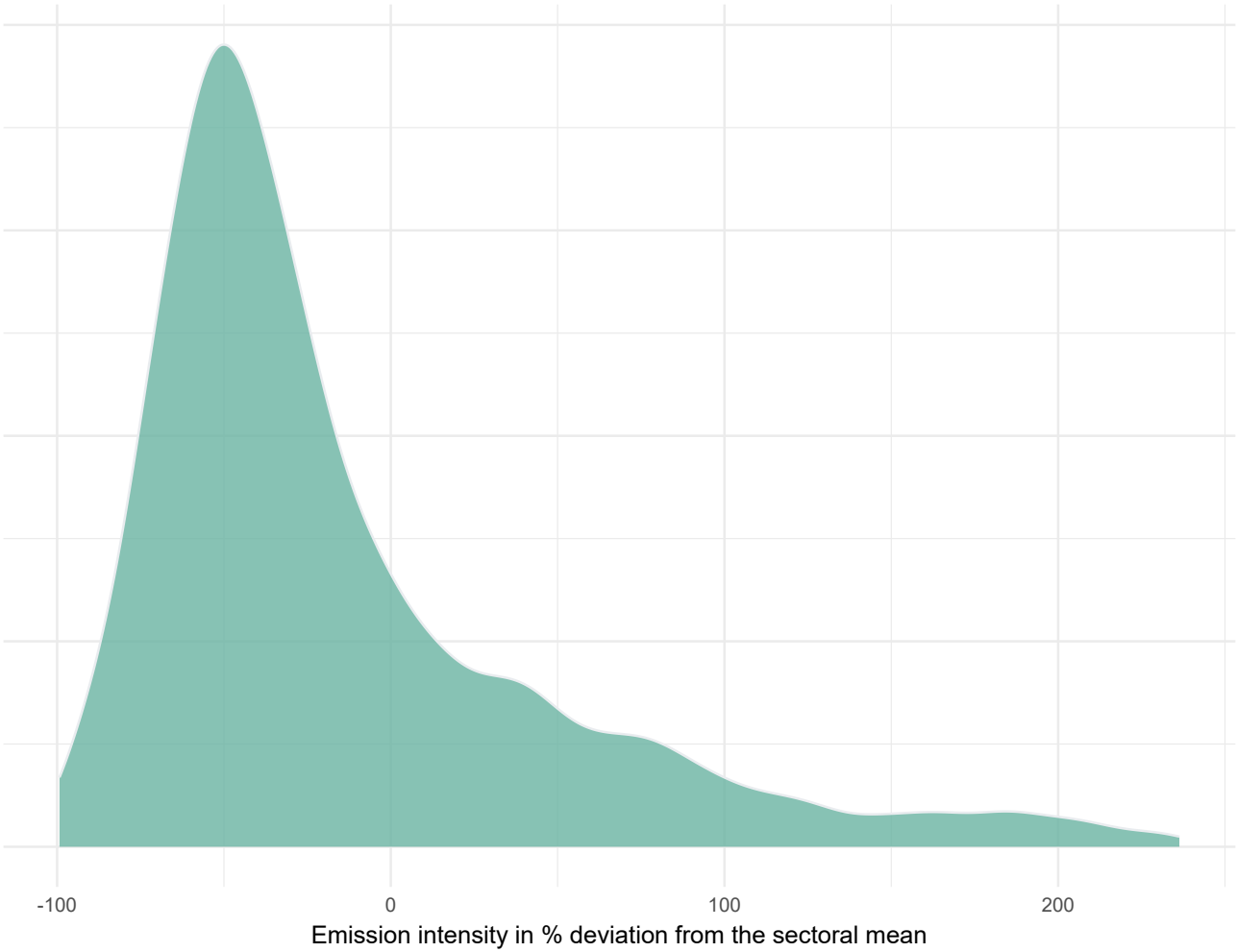
back

Data: Emissions by source



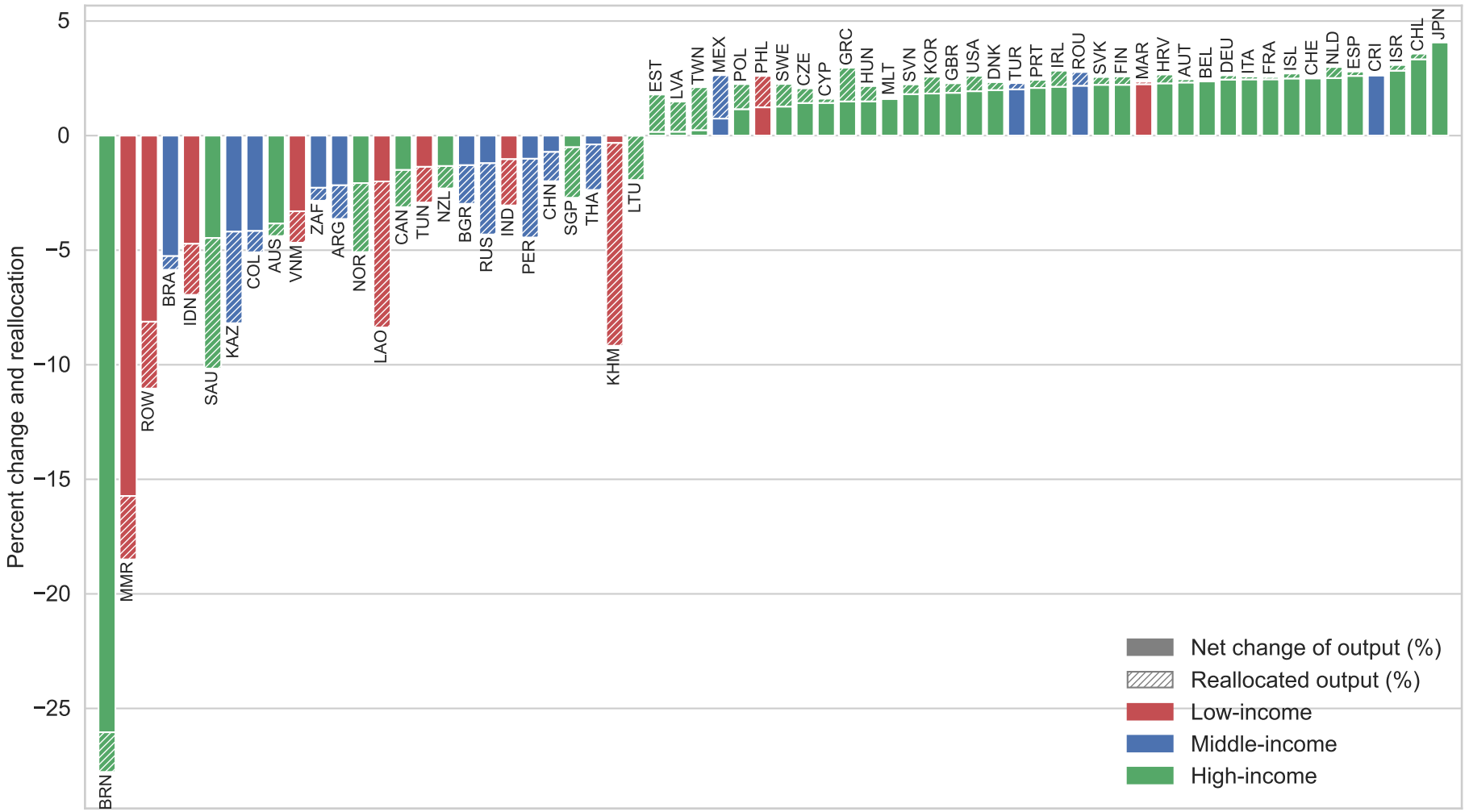
back

Emissions density



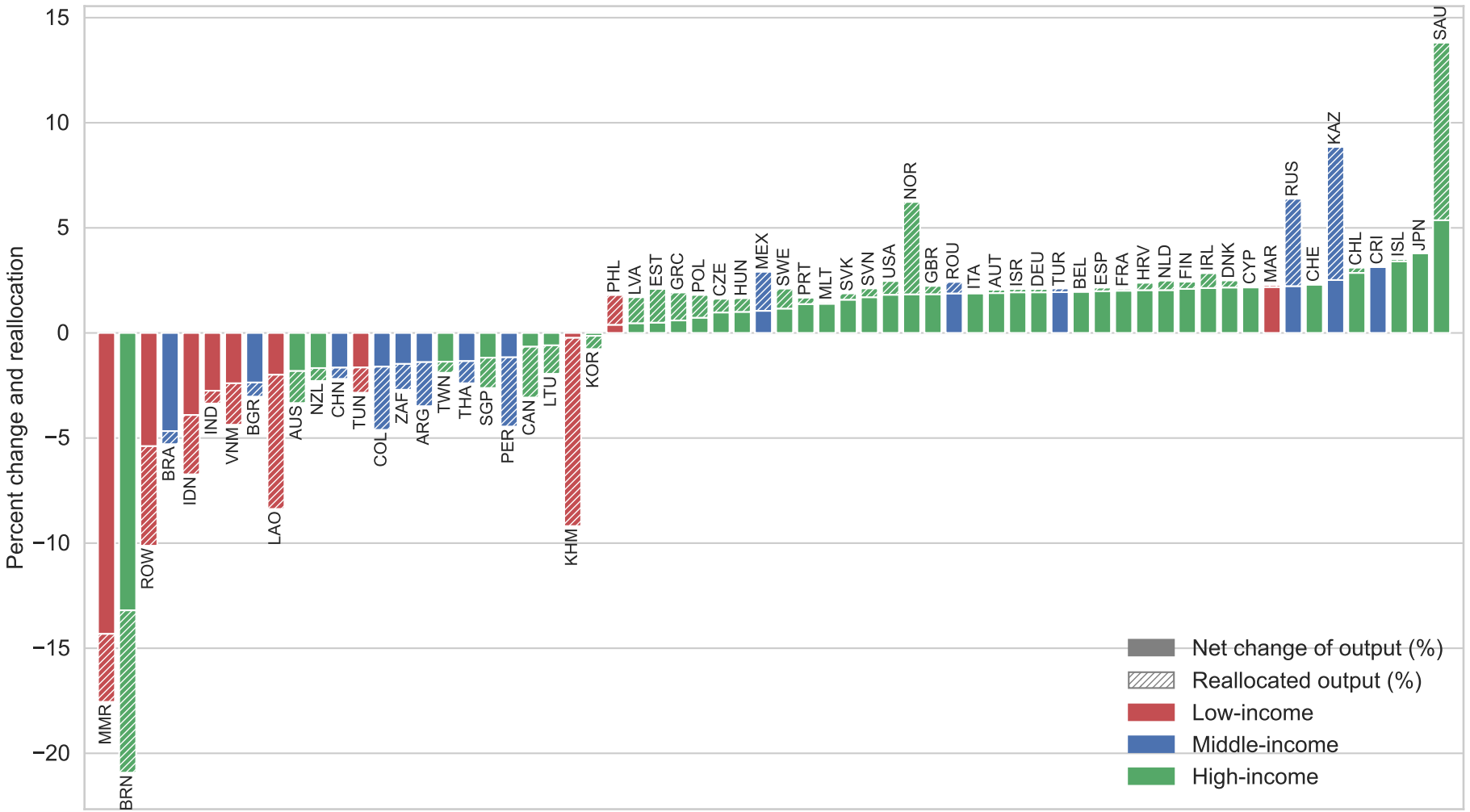
back

Results: Country reallocation - Consumer tax



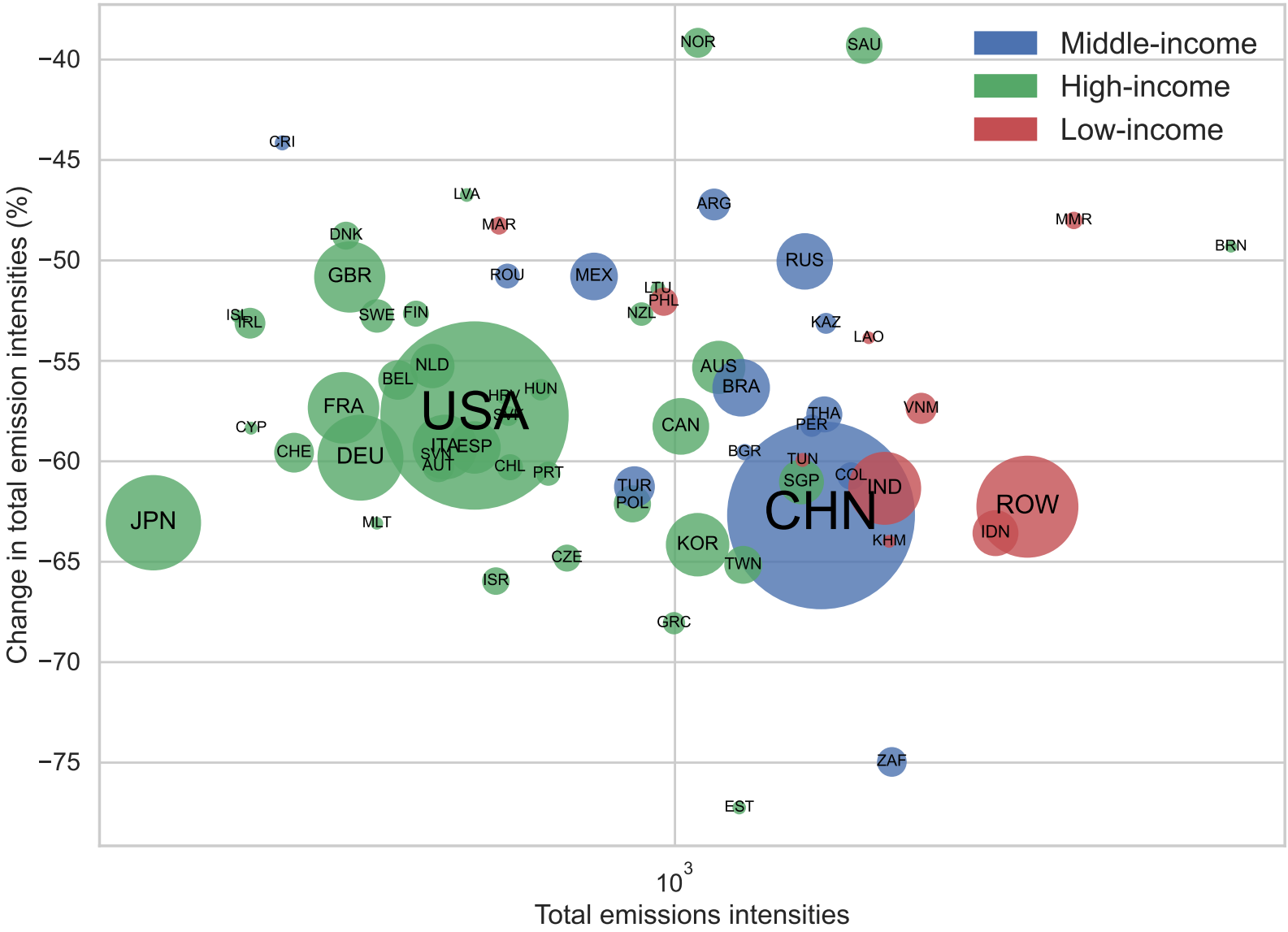
back

Results: Country reallocation - Producer tax



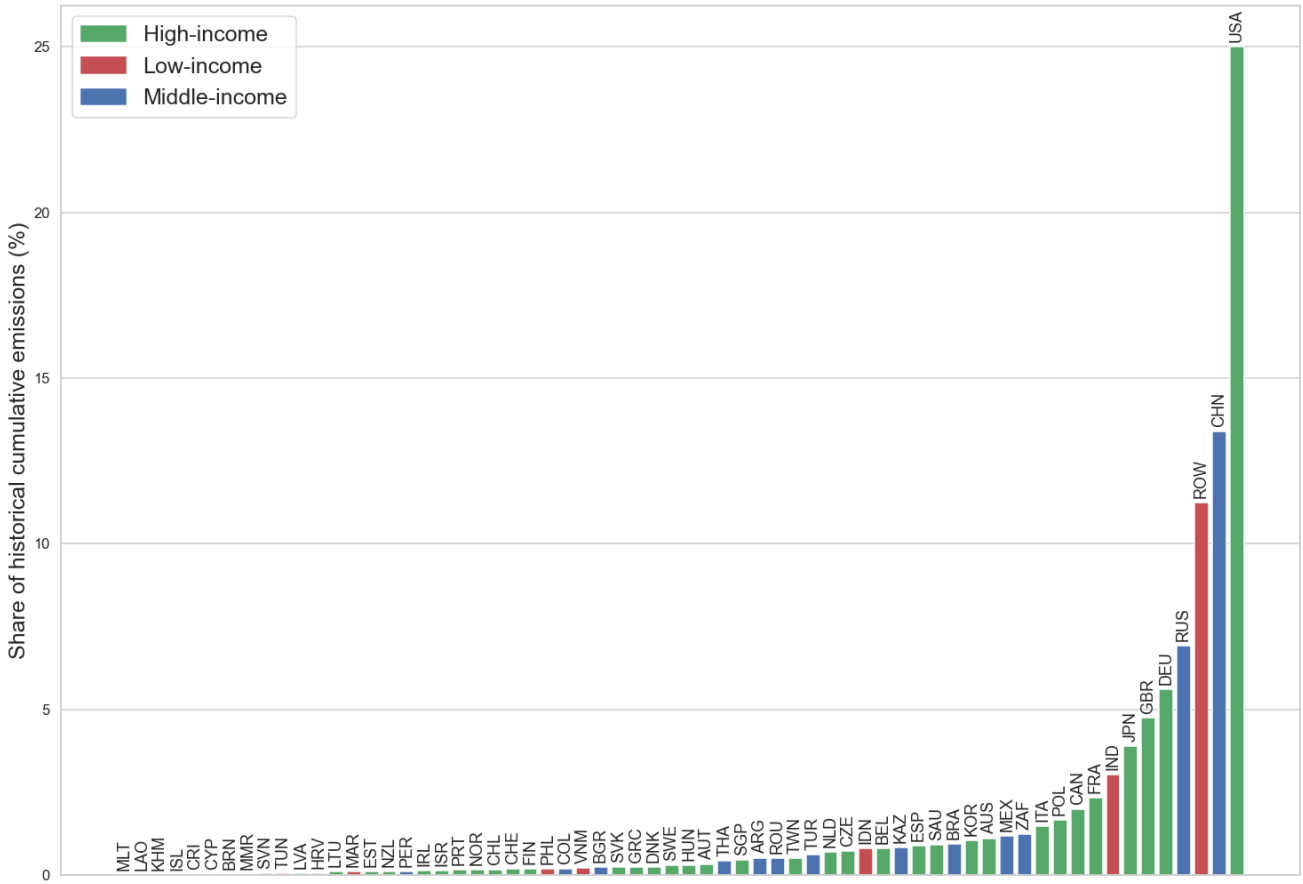
back

Change in emissions intensities



Back

Cumulative emissions



back