The Global Effects of Carbon Border Adjustment Mechanisms

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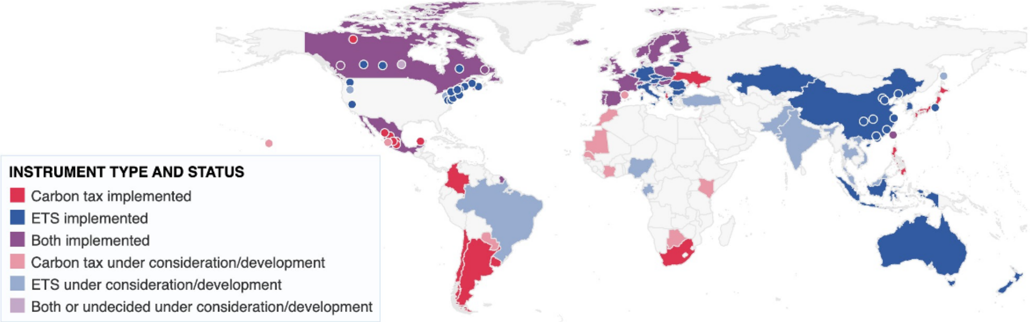
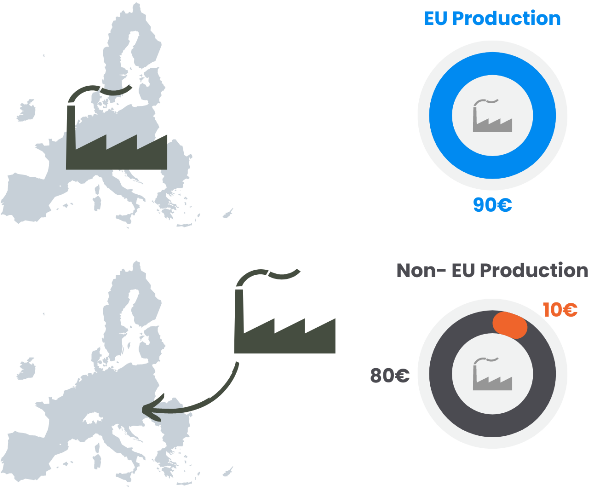
Carbon pricing around the world (2024)



Carbon border adjustment mechanism (CBAM)

Cement, iron and steel, aluminium, fertilisers, electricity and hydrogen



EU production is subject to the **EU-ETS***

(Assuming an ETS allowance price of 90€ per tonne of CO2)

Non-EU production is subject to a lower **ETS** and **CBAM certificates**

Three motivations and one concern

- Boost domestic competitiveness
- Reduce foreign emissions leakage
- Encourage foreign regulation

- But may disadvantage lower-income trading partners

Potentially regressive for lower-income countries

- Guardian (2024): "India seeks UK carbon tax exemption in free trade deal talks"
- Bloomberg (2024): "EU CBAM Damaging ASEAN Businesses?"

- Center for Global Development (2022): "Mozambique, a large aluminum exporter, could experience a fall of 1.6 percent of its GDP as a result of a shift in demand following the introduction of the CBAM"

This paper

1. Detailed global data on aluminum and steel
    - Key sectors targeted in first phase of EU/UK CBAM
    - Most emissions-intensive and heavily traded
2. Descriptive analysis of emissions
    - Lower-income countries not more emissions-intensive
3. Quantitative equilibrium model of regulation and trade
    - Welfare impacts of carbon taxation and CBAM

Carbon taxation with a CBAM

- **Increased competitiveness:** profit losses for regulated producers 15% $\downarrow$
- **Reduced leakage:** emissions increases for unregulated producers 30% $\downarrow$
- **Incentives for regulation:** free revenue for unregulated markets

- Similar incidence across lower- and higher-income countries

Background

Policy timeline

- EU CBAM proposed in 2021
  - Phase-in starting October 1, 2023 with reporting only
  - Full implementation from January 1, 2026 for target sectors
- UK CBAM announced in 2023, targeting implementation by 2027
- In discussion in Canada, Australia, and Taiwan
- Expansion of Chinese ETS to cover target sectors

EU CBAM target sectors

(%)	Trade Intensity	Global Emissions
Steel	23	11
Aluminum	41	3
Electricity	2	33
Fertilizers	60	1
Cement	2	6
Hydrogen	0.1	2

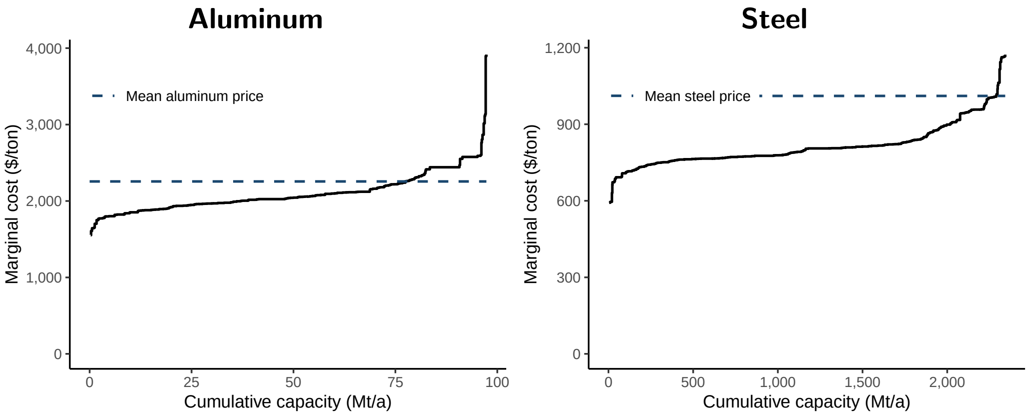
Aluminum and steel

- Globally traded commodities
  - London Metal Exchange reports global prices and facilitates trade
- Aluminum
  - Primary: smelted from alumina with CO_2 from chemistry and electricity
  - Secondary: recycled from scrap with 5-10% emissions
- Steel
  - Primary: blast furnace/basic oxygen furnace (BF-BOF) from iron ore
  - Secondary: electric arc furnace (EAF) from scrap with 35-40% emissions

Global data by plant for 2023

- Aluminum smelters from WoodMac
    - 153 worldwide with some Chinese smelters aggregated
    - Public data + site visits
    - LIC producers: 7% of global production, 9% of global emissions
- Steel mills from Climate TRACE
    - Every steel mill with capacity above 500k tons
    - Satellite and mill-level sensor data
    - LIC producers: 7% of global production, 6% of global emissions
- Production, capacity, costs, and emissions
    - Primary and secondary plants, Scope 1 and 2 emissions

Production costs and capacity



Aluminum quantities

Producers

Country	Mt	%
China	48.9	57.9
India	4.7	5.6
EU + UK	4.6	5.5
USA	4.1	4.9
Russia	4.0	4.7
Rest of world	18.1	21.5

Consumers

Country	Mt	%
China	50.8	60.2
EU + UK	9.1	10.8
USA	8.6	10.2
India	3.0	3.6
Japan	2.9	3.4
Rest of world	10.0	11.8

Steel quantities

Producers

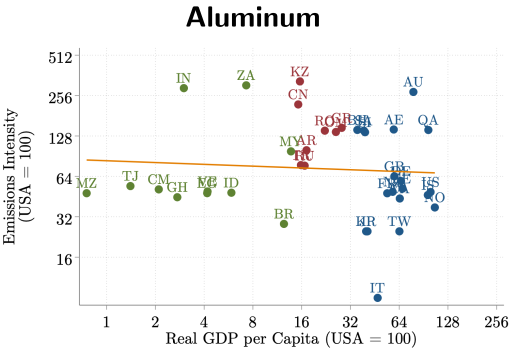
Country	Mt	%
China	860	51
EU + UK	153	9
Japan	88	5
USA	86	5
India	76	5
Rest of world	409	25

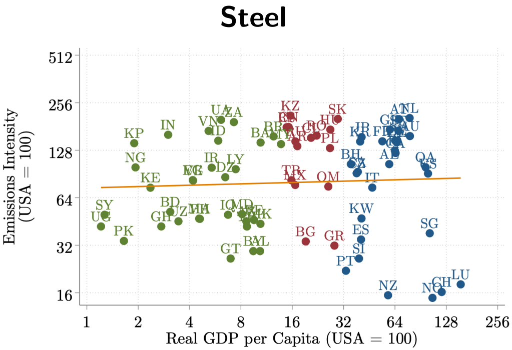
Consumers

Country	Mt	%
China	827	49
EU + UK	169	10
USA	101	6
India	77	5
Japan	68	4
Rest of world	431	26

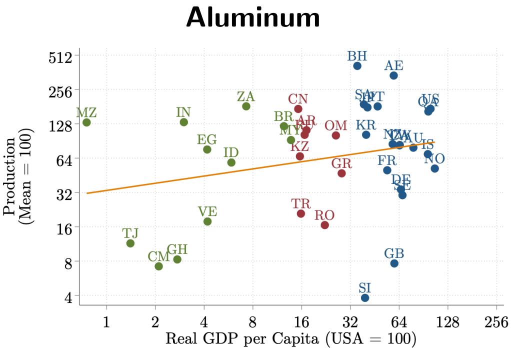
Descriptives

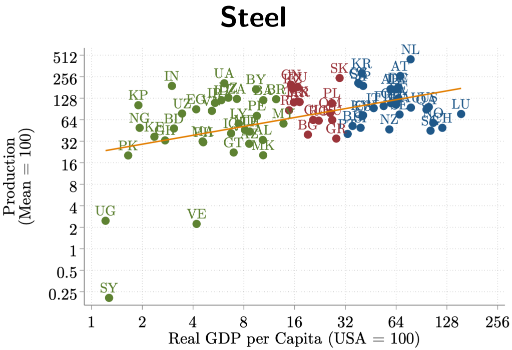
Emissions intensity by income



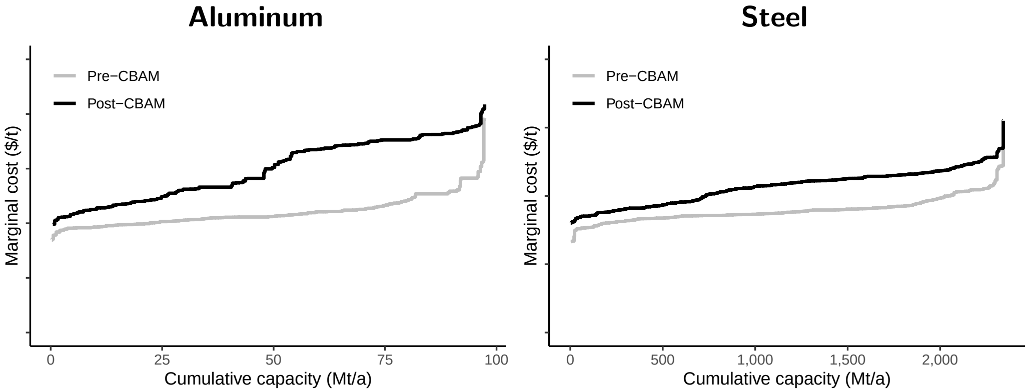


Production scale by income

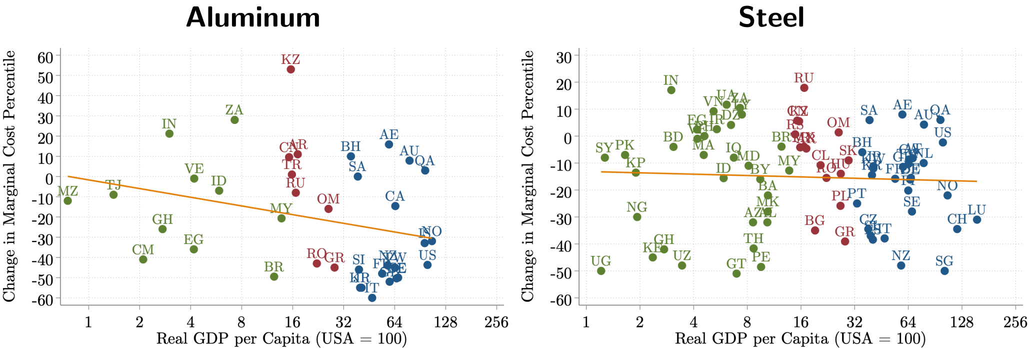




CBAMs add to costs



CBAM impacts by income



Model

Environmental regulation with global trade

- Demand by market, supply by plant
  - Regulated and unregulated markets R and U
- Regulator in R considers a CBAM
  - Plants can shift sales across markets
  - Will quantify distributional effects

Demand by market m

$$\log D^m = \delta^m + \varepsilon^m \log P^m$$

- Log-linear with calibrated $\varepsilon^m = -0.25$

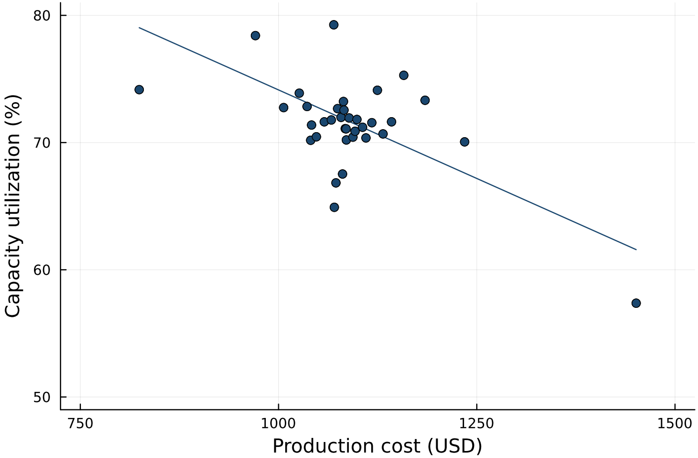
Supply by plant i

$$s_i^m = \bar{s}_i o_i^m, \quad o_i^m = \frac{\exp(v_i^m)}{1 + \exp(v_i^m)}$$

$$u_{il}^m = v_i^m + \epsilon_{il}, \quad v_i^m = \beta(p_i^m - c_i) + \epsilon_i$$

- Production s_i depends capacity utilization o_i^m via choice to operate lines ℓ
- Observed capacity $\bar{s}_i$, cost c_i, and price p_i^m
- Constant marginal cost and no market power

Logit estimation with metals j and countries k



$$\log\left(\frac{o_{ijk}}{1-o_{ijk}}\right) = \beta(P_j - \bar{\tau}_k \bar{e}_{ijk} - c_{ijk}) + \mu_j + \mu_k + \epsilon_{ijk}$$

Carbon taxation

$$p_i^m = P^m - \tau^m e_i$$
$$\log e_i = \log \bar{e}_i - \gamma(\tau^m - \bar{\tau}^m)$$

- Without a CBAM, $P^m = P$ and $D(P^*) = S(P^*)$
- Carbon regulation induces abatement response with calibrated $\gamma = 0.3$

Carbon border adjustment mechanism

$$\alpha^R = \tau^R - \tau^U > 0$$

$$\begin{aligned} p_i^m &= \max\{p_i^{mR}, p_i^{mU}\} & p_i^{RR} &= P^R - \tau^R e_i & p_i^{UR} &= P^R - \tau^R e_i \\ r_i^m &= \mathbb{1}(p_i^{mR} > p_i^{mU}) & p_i^{RU} &= P^U - \tau^R e_i & p_i^{UU} &= P^U - \tau^U e_i \end{aligned}$$

- Plants choose destination market
- Given prices (P^H, P^L) and home regulation (τ^H, τ^L)

Markets clear

$$D^R(P^{R*}) = S^R(P^{R*}, P^{U*}; \alpha^R)$$
$$D^U(P^{U*}) = S^U(P^{R*}, P^{U*}; \alpha^R)$$

- CBAM induces reallocation
  - Price P^R rises and pulls clean supply to R
  - Price P^U falls as dirty supply pushed to U
- Can compute welfare: CS, PS, G, E

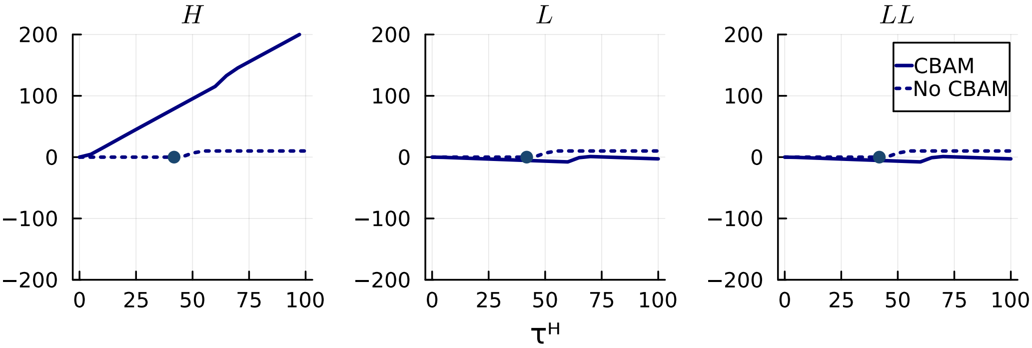
Counterfactuals

Policy simulations

- Carbon regulation in market H
  - Relative to business as usual
  - With and without a CBAM
- Impacts on H, L, LL
  - H: EU + UK [+ China]
  - L: all other countries
  - LL: low and lower-middle income countries
- Calculate price and welfare impacts
  - Regulation and reallocation effects

H = EU + UK (6.5% of global consumption)

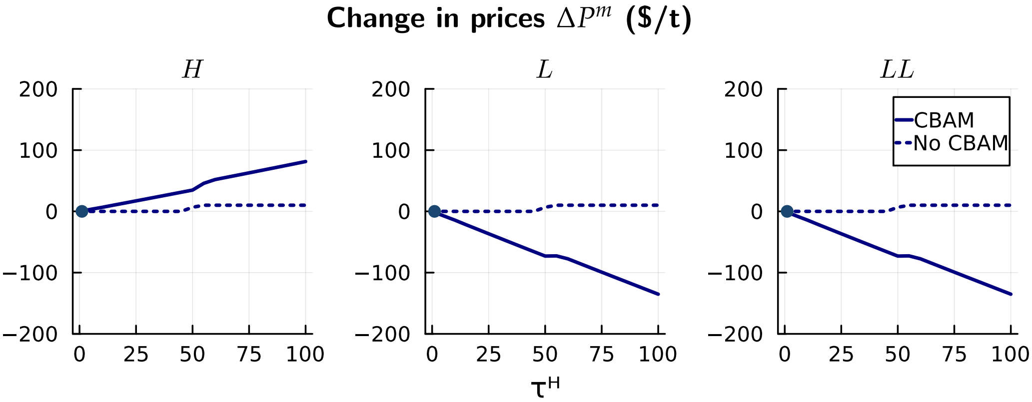
Change in prices ΔP^m (\$/t)



Regulation effect: no CBAM

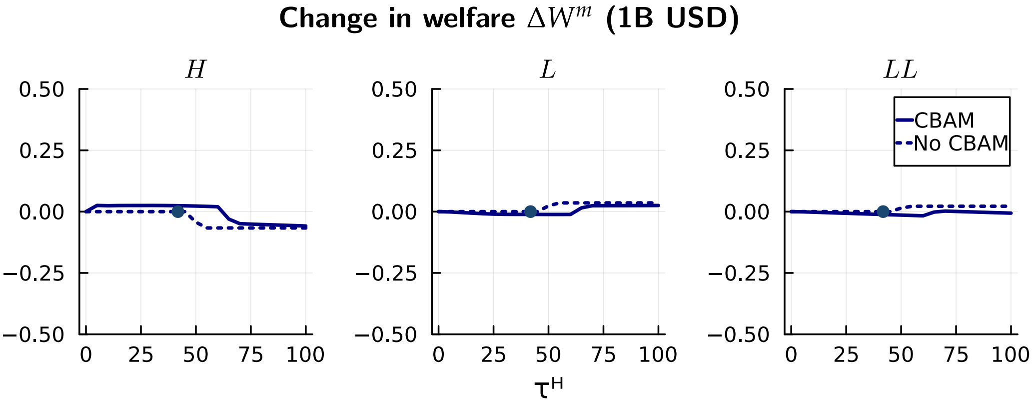
Reallocation effect: CBAM - no CBAM

H = EU + UK + China (68.4% of global consumption)



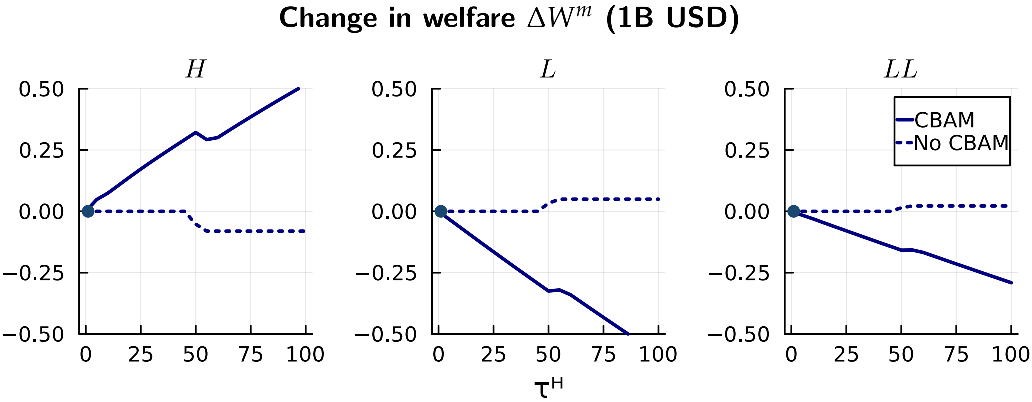
Less reallocation effect for H, more for L

H = EU + UK (6.5% of global consumption)



Relatively small welfare consequences, especially with CBAM

H = EU + UK + China (68.4% of global consumption)



Meaningful welfare gains for H: CS $\downarrow$, PS $\downarrow$, G $\uparrow\uparrow$

But at welfare cost to L and LL

Conclusion

Summary

- Aluminum emissions not necessarily higher in lower-income countries
- CBAM rewards clean producers in lower-income countries

- Simulations with steel, electricity, and other sectors
- Policy spillovers through government revenue