Seminar "Empirical Issues in Trade"

# Carbon Tariffs, a Comprehensive Analysis

Giovanni Remonti

M.Sc. in Economics @ LMU Munich

June 25, 2024

# Global Carbon Emissions

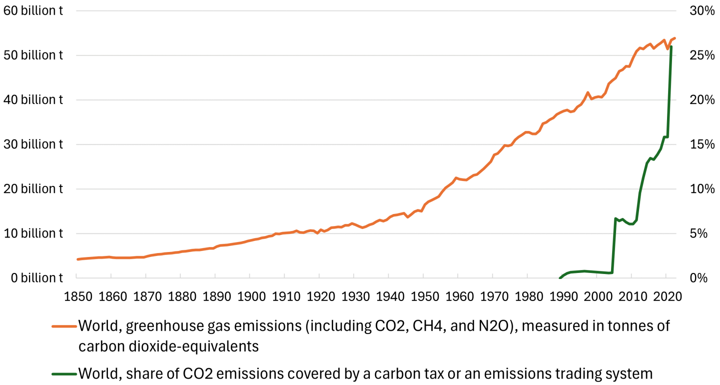



Figure: data from Our World in Data

So, why not also tax the carbon footprint of imports?

# Carbon tariffs: An analysis of the trade, welfare, and emission effects

Mario Larch, Joschka Wanner (2017)

They aim to:

1. Analyze the **impacts** of introducing carbon tariffs on trade flows, welfare, and emissions
2. **Decompose** the forces influencing emissions into three effects: scale, composition, and technique

Contribution: In the literature, they are the first to use a structural multi-sector, multi-country gravity model and isolate the forces affecting emissions together.

## Carbon tariffs: An analysis of the trade, welfare, and emission effects

Mario Larch, Joschka Wanner (2017)

Impacts of introducing carbon tariffs on:

1. **Trade flows**: reduced by 1.9% globally, in particular, countries with lower implicit carbon taxes suffer a stronger reduction
2. **Welfare**: reduced for the majority (80%) of countries, mainly developing countries in Africa and Asia due to trade flows reduction
3. **Emissions**: reduced by 0,5% globally, with significant changes in national emissions
   - 66% from the **composition** effect: most countries (80%) shift to less energy-intensive sectors, while the other share increases its emissions
   - 34% due to **scale** effect: production in real terms declines

# Mario Larch, Joschka Wanner (2017)

## Theoretical Framework

To model **trade flows**, they employ a *structural gravity equation*

To measure **welfare**, the representative consumer from country $j$ gains utility $U_l^j$ when consuming in sector $l$

- His total utility is negatively affected by the damage factor $\left[\frac{1}{1+(\frac{1}{\mu^j}\sum_{i=1}^{N} E^i)^2}\right]$ where $\mu$ is Social Cost of Carbon, $E$ emissions

To measure **carbon emissions**, they treat them as a byproduct of the energy used in each sector: higher energy costs, more emissions polluted

# Mario Larch, Joschka Wanner (2017)

## Theoretical Framework/2

**Decomposition** of the forces influencing carbon emission, exploiting the methodology illustrated by Copeland and Taylor (2003).
This yields three effects:

1. **Scale** ($\frac{\delta E^i}{\delta(\tilde{Y}^i/P^i)} > 0$): an increase in real value production increases emissions
2. **Composition** ($\frac{\delta E^i}{\delta \bar{a}^i_E} > 0$): when average energy costs share for production increases, more energy is used and emissions are emitted
3. **Technique** ($\frac{\delta E^i}{\delta(e^i/P^i)} < 0$): an increase in real energy prices leads to a decrease in emissions, as higher energy costs encourage producers to use energy more efficiently

# Mario Larch, Joschka Wanner (2017)

## Example and Mechanism

1. Assume Germany ($g$) imposes a **pure carbon tariff** $\tau_{chem}^{ig}$ on imports of the chemical sector
2. As India ($i$) taxes carbon emissions less than Germany, the carbon tariff is positive, and Indian imports are now more expensive as price $p_{chem}^{ig}$ is higher $\uparrow$
3. Therefore, Germany may decide to:
   - Reduce imports from India $X_{chem}^{ig} \downarrow$ and increase national production of chemical goods $Y_{chem}^{g} \uparrow$
     - Indian's production is lower, and also its utility decreases $U^i \downarrow$
     - Germany's production is larger, and can now attain a higher utility $U^g \uparrow$
     - Germany's emissions $e^g$ increase $\uparrow$ since produces more, but as Germany has stricter environmental regulations, global emissions $e^W \downarrow$
   - Substitute Indian imports with French ones $X_{chem}^{fg} \uparrow$ since they are less carbon-intensive, carbon tariff does not apply, and goods are cheaper

# Mario Larch, Joschka Wanner (2017)

## Data

Main **datasets** employed:

1. Global Trade Analysis Project (GTAP) 8
   - Trade data for 128 regions and 57 sectors, 2007 as reference year
2. SCC data from the Interagency Working Group on the Social Cost of Carbon (2013) and Nordhaus and Boyer (2000)
3. Country-level carbon taxes from OECD (2016)

Table: Model variables at sector-level, excerpt

| | Production (Y) (billion US-$) | Emissions (E) (mT of CO2) | Energy cost share ($\alpha$) | Carbon tariffs ($\tau_l$, mean) | Avg. Trade flows $X_l^{ij}$ |
|---|---|---|---|---|---|
| Agriculture | 25,498 | 4.62 | 0.04 | 0.002 | 21.89 |
| | (67,654) | (15.61) | (0.04) | (0.004) | (186.21) |
| Mineral | 32,605 | 73.55 | 0.51 | 0.019 | 44.06 |
| | (86,679) | (258.70) | (0.23) | (0.032) | (330.14) |
| Service | 288,220 | 48.79 | 0.09 | 0.003 | 143.65 |
| | (976,964) | (159.90) | (0.06) | (0.006) | (867.00) |

Note: standard deviations in parentheses.

# Mario Larch, Joschka Wanner (2017)

## Empirical Strategy

Analysis: compares a benchmark and a **counterfactual** case without and with carbon tariffs, respectively.

Estimation:

1. There isn't a unique and overarching measure for trade costs $T_l^{ij}$, thus they must be approximated as a function of observable factors $T_l^{ij} = \exp\left(\left(\boldsymbol{z}_l^{ij}\right)' \boldsymbol{b}_l\right)$ and estimated using the gravity equation.

# Mario Larch, Joschka Wanner (2017)

## Empirical Strategy/2

2. Authors use the **Poisson Pseudo-Maximum Likelihood (PPML) estimator** to estimate the coefficients of the gravity equation:

$$X_l^{ij} = \frac{1}{Y^W}\left(\tau_l^{ij}\right)^{-\sigma} \exp(\boldsymbol{\beta_0} + \boldsymbol{\beta_1} * \ln(DIST_{ij}) + \boldsymbol{\beta_2} * RTA_{ij} + \boldsymbol{\beta_3} * CONT_{ij} + \boldsymbol{\beta_4} * LANG_{ij} + \boldsymbol{\beta_5} * COL_{ij} + \boldsymbol{\beta_6} * COMC_{ij} + n_l^i + m_l^j) * u_l^{ij}$$

- $\beta$s are coefficients of interest
- $Y^W$ world production, and $\tau_l^{ij}$ eventual carbon tariff in place
- $n_l^i$ and $m_l^j$ are fixed effects for the exporter and importer country
- $u_l^{ij}$ random error

# Mario Larch, Joschka Wanner (2017)

## Results

Table A4: Estimation results for the gravity equation (PPML)

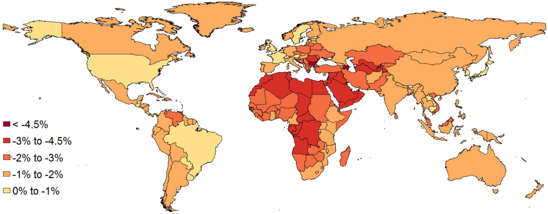
| dep. var. | (1) $X_{agr.}$ | (2) $X_{apr.}$ | (3) $X_{che.}$ | (4) $X_{equ.}$ | (5) $X_{food}$ | (6) $X_{mac.}$ | (7) $X_{met.}$ | (8) $X_{mine.}$ | (9) $X_{mini.}$ | (10) $X_{oth.}$ | (11) $X_{pap.}$ | (12) $X_{ser.}$ | (13) $X_{tex.}$ | (14) $X_{wood}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ln $DIST$ | -1.14** | -0.93** | -0.92** | -0.60** | -0.92** | -0.77** | -0.93** | -1.22** | -1.33** | -0.50** | -0.95** | -0.35** | -1.08** | -0.93** |
| | (0.052) | (0.083) | (0.038) | (0.063) | (0.040) | (0.040) | (0.043) | (0.062) | (0.11) | (0.099) | (0.046) | (0.032) | (0.052) | (0.098) |
| $RTA$ | 0.22* | 0.053 | 0.40** | 0.87** | 0.52** | 0.20** | 0.19* | 0.11 | 0.100 | 0.26 | 0.45** | 0.14* | 0.26** | 0.43** |
| | (0.088) | (0.11) | (0.069) | (0.099) | (0.067) | (0.071) | (0.085) | (0.11) | (0.16) | (0.20) | (0.091) | (0.059) | (0.087) | (0.15) |
| $CONT.$ | 0.36** | 0.35** | 0.17* | 0.50** | 0.44** | 0.20** | 0.51** | 0.41** | 0.16 | 0.10 | 0.61** | 0.36** | 0.10 | 0.71** |
| | (0.096) | (0.12) | (0.076) | (0.094) | (0.080) | (0.075) | (0.076) | (0.099) | (0.25) | (0.14) | (0.080) | (0.078) | (0.091) | (0.12) |
| $LANG$ | 0.32** | 0.45** | 0.024 | 0.084 | 0.29** | 0.18* | 0.098 | 0.24* | 0.036 | 0.19 | 0.25** | 0.14* | 0.52** | 0.12 |
| | (0.11) | (0.11) | (0.093) | (0.11) | (0.083) | (0.089) | (0.098) | (0.11) | (0.20) | (0.14) | (0.098) | (0.060) | (0.086) | (0.13) |
| $COL.$ | 0.17 | 0.27$^{+}$ | 0.27* | -0.11 | 0.48** | 0.11 | 0.43** | 0.13 | 0.87** | 0.24$^{+}$ | 0.21* | 0.030 | 0.050 | 0.29** |
| | (0.16) | (0.15) | (0.11) | (0.14) | (0.093) | (0.11) | (0.10) | (0.12) | (0.23) | (0.14) | (0.10) | (0.070) | (0.15) | (0.10) |
| $COMC.$ | 0.49** | -0.45* | 0.20$^{+}$ | 0.47$^{+}$ | 0.74** | 0.088 | 0.49* | 0.43* | 0.71$^{+}$ | 1.31** | 0.72** | -0.25$^{+}$ | -0.54** | 0.63** |
| | (0.16) | (0.19) | (0.12) | (0.25) | (0.14) | (0.16) | (0.21) | (0.20) | (0.41) | (0.29) | (0.16) | (0.15) | (0.14) | (0.15) |
| Obs. | 16,256 | 16,256 | 16,256 | 16,256 | 16,256 | 16,256 | 16,256 | 16,256 | 16,256 | 16,256 | 16,256 | 16,256 | 16,256 | 16,256 |
| Pseudo-$R^2$ | 0.776 | 0.962 | 0.901 | 0.936 | 0.849 | 0.906 | 0.846 | 0.769 | 0.641 | 0.929 | 0.920 | 0.886 | 0.894 | 0.849 |

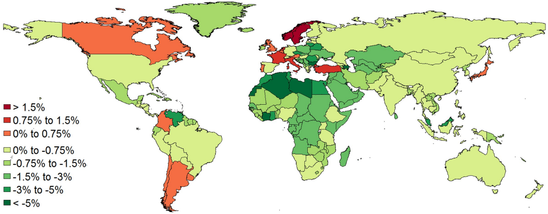
**Notes:** All regressions include importer and exporter fixed effects and a constant, the coefficients of which are not shown. Robust standard errors are given in parentheses. $^{+}$, * and ** denote statistical significance at the 10, 5 and 1 percent level, respectively.

# Mario Larch, Joschka Wanner (2017)

## Results/2

Top: percentage change in **trade flows** with pure carbon tariffs




Bottom: percentage change in **carbon emissions** with pure carbon tariffs

# Mario Larch, Joschka Wanner (2017)

## Extension: Reinforced Low-Carbon Consumer Preferences

1. In Larch et al. (2017), pollution does not directly enter into the consumer choice
   - Nowadays, I believe **consumers actively choose ex-ante a low-carbon consumption bundle** = more micro foundation
2. Measures of the Social Cost of Carbon are often uncertain and **underestimated**: it's difficult to capture the real damage suffered by the consumers.
   - Eg. Larch et al. (2017) 29\$/t, Bilal et al. (2024) 1056\$/t.

$$U_l^j = \left[ \sum_{i=1}^{N} (\beta_l^i)^{\frac{1-\sigma_l}{\sigma_l}} \left( \frac{q_l^{ij}}{\boxed{\mathbf{1 + \delta_l^j I_l^{ij}}}} \right)^{\frac{\sigma_l - 1}{\sigma_l}} \right]^{\frac{\sigma_l}{\sigma_l - 1}}$$

where $\delta_l^j \in (0, 1)$ captures the preference for low-carbon intensive goods, $I_l^{ij}$ is carbon intensity of goods

# Mario Larch, Joschka Wanner (2017)

## Conclusions

The counterfactual analysis by Larch et al. (2017) demonstrates the (modest) **effectiveness of carbon tariffs** in reducing global carbon emissions, without extreme negative effects on trade flows and welfare.

Despite this positive result, no country in the world had implemented such a tariff before October 2023, when the European Union declared the introduction of a **Carbon Border Adjustment Mechanism (CBAM)**.

- In line Larch et al. (2017), first findings from Korpar et al. (2023) show that European emissions fall by 0.24%, while global emissions decrease by 0.08%.

**Thank you for your attention!**

Questions?