Carbon Taxes, Carbon Border Adjustments, and the World Trade Organization

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Motivation

- Greenhouse gas emissions are a global externality, but taxes are a local policy instrument.
- Unilateral climate policy suffers from free-riding and carbon leakage.
- Potential solution: *climate clubs* with harsh trade penalties on defectors (Nordhaus 2015).
- Explore other solutions that respect existing trade agreements.
  - Free-riding $\Rightarrow$ transfers/country-specific taxes.
  - Carbon leakage $\Rightarrow$ carbon border adjustments.

Key Question: Can carbon taxes and associated CBAs respect existing agreements in international trade while significantly reducing pollution from carbon emissions?

Paper Preview

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- Build and estimate a quantitative trade-and-emissions model to simulate policy outcomes.
  - Non-cooperative vs. cooperative regimes.
  - Uniform vs. country-specific taxes
  - CBAs based on domestic vs. exporter emissions.
  - With vs. without export rebates.
  - Direct vs. indirect emissions
  - Agricultural exemption.

Preview of Main Results

- First-best sees 50% decrease in emissions and over 5% increase in global welfare.
- Non-cooperative carbon taxes set in Nash equilibrium significantly limit climate action.
- Satisfying participation constraints for cooperation requires massive transfers.
- Country-specific taxes are key to incentivizing cooperation.
- One CBA design enables international cost-shifting and helps under non-cooperation.
- Optimal CBA design will evolve as cooperation over carbon taxes increases.

Contribution to the Literature

- **International trade and climate policy:** Elliott et al. (2010), Hémous (2016), Shapiro (2021), Copeland et al. (2022), Le Moigne et al. (2022), Campolmi et al. (2023), Martin (2023), Ma and Qin (2023), Kotlikoff et al. (2024), and Cruz and Rossi-Hansberg (2024).

- **Carbon border adjustments and climate agreements:** Nordhaus (2015), Fowlie et al. (2016), Kortum and Weisbach (2017), Harstad (2023), Iverson (2024), Farrokhi and Lashkaripour (2025), Bourany (2025), Clausing et al. (2025), and Farrokhi, Lashkaripour, and Taheri (2026)

- **This paper:**
  - No tariff punishments $\Rightarrow$ respect current agreements through WTO.
  - Analyize both transfers and country-specific taxes.
  - Show evolving optimal CBA design as degree of cooperation over carbon taxes changes.
  - Incorporate agricultural emissions.

Roadmap

- Background on carbon taxes and border adjustments
- Data
- Model and estimation
- Results
  - The global social planner
  - Non-cooperative unilateral policy
  - Cooperative climate clubs with participation constraints

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Background: Carbon Taxes

- Canonical solution: global uniform Pigouvian tax on carbon emissions.
- Absent global cooperation, countries pursue unilateral carbon taxes.
  - Production taxes put upward pressure on world prices $\Rightarrow$ carbon leakage.
  - Consumption tax puts downward pressure on world prices $\Rightarrow$ negative leakage.
- Easier (and more common) to administer carbon tax on production than consumption.
- Non-cooperative unilateral climate policies face two hurdles:
  1. Unilateral tax confers an uninternalized positive climate externality.
  2. Production taxes incentivize carbon leakage.
- In principle, tariffs based on carbon taxes and emissions can address second concern.

Background: Carbon Border Adjustments

- EU has implemented a carbon tax and is experimenting with *carbon border adjustments*.
  - Some CBA design choices remain legally contested under WTO rules.

- **Traditional CBA:** Converts production tax into consumption tax.
  - Imports charged for untaxed direct emissions.
  - Accounts for country-specific direct emissions ("discriminatory"-across-exporters CBA).
  - Rebates the carbon tax for exports.

- **Leakage Neutral CBA:** Applies tax's effect on domestic producers to neutralize leakage.
  - Imports charged for untaxed direct + indirect emissions.
  - Uses import-country emissions intensity (an "MFN" constant-across-exporters CBA).
  - Rebates the carbon tax for exports.

- Consider both designs without rebate for exports
  - Legality of rebating production-based carbon taxes remains unsettled.
  - Enables international cost-shifting through terms-of-trade improvements.

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Data

- Compile cross-section of trade and emissions data in 2018.

- **Trade data**:
  - OECD ICIO: trade flows, sectoral expenditures shares, value-added.
  - UNCAD Trains: population, tariffs, price levels.

- **Emissions data**:
  - OECD TECO2: direct emissions from fuel combustion.
  - FAO: agricultural emissions.
  - EDGAR: industrial/chemical and fugitive emissions.

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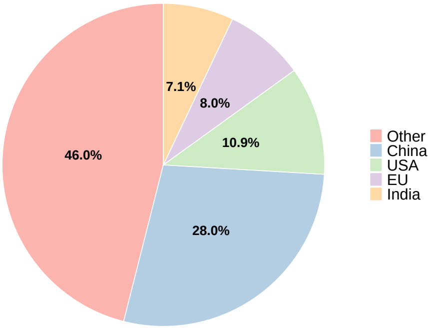
Share of emissions by country



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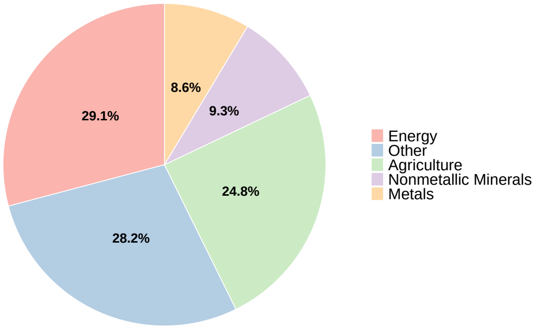
Share of emissions by sector



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Armington model: global trade with production emissions (Shapiro 2021).

- **Demand:** Representative households with Cobb-Douglas utility across sectors.
  - CES substition across country varieties within sector.
- **Production:** Cobb-Douglas technology using labor and intermediate inputs.
  - Country-sector specific productivity and emissions per unit.
  - Carbon taxes enter as specific per-unit production costs.
- **Trade Costs:** iceberg, tariffs, and carbon border adjustments.
- **Equilibrium:** market clearing with gravity-determined bilateral trade flows.
- **Welfare:** weighted sum of country real income net of global emissions damages.

$$W = \sum_i \underbrace{\eta_i}_{\text{welfare weight}} \left(\underbrace{\frac{Y_i}{P_i}}_{\text{real income}} - \underbrace{\delta_i(E - E_0)}_{\text{emissions cost relative to baseline}} \right)$$

Estimation

- Quantitative trade-and-emissions model with 19 regions and 17 sectors (4 non-traded).
- **Step 1:** Estimate baseline trade equilibrium (no carbon policy).
  - Offline Parameters: substitution elasticity ($\sigma = 6$), expenditure shares, input-output shares.
  - Estimated parameters: iceberg trade costs and country-sector productivity.
  - Target moments: bilateral trade shares and relative price levels.
  - Estimation: GMM subject to market clearing with wages at observed labor-value added.
- **Step 2:** Calibrate emissions intensity, carbon damages, and welfare weights.
  - Emissions intensity: observed country-sector emissions per unit of modeled output.
  - Global carbon damages: calibrated to $51/ton social cost of carbon.
  - Country carbon damages: proportional to real income shares.
  - Welfare weights: chosen so optimal global transfers are zero at baseline.

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Results: Social Planner's First-best

- Compute social planner's optimal uniform tax and compare to baseline.

Exemptions	None	Agriculture
Uniform Carbon Tax	\$51.25	\$50.97
Total Relative Welfare	5.15%	3.53%
Relative Emissions	-49.84%	-34.36%

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- Exempting agriculture reduces benefits by a third.

Results: Non-cooperative Nash Carbon Taxes

- Compute non-cooperative best-response carbon taxes with different CBA designs.

CBA	None	Traditional	Leakage Neutral
Total Relative Welfare	1.45%	1.50%	1.34%
Relative Emissions	-9.58%	-10.11%	-10.22%
Average Carbon Tax	$3.97	$3.08	$4.97
EU Carbon Tax	$9.92	$13.02	$9.67
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- While taxes vary between CBA designs, outcomes similar.
- Free-riding dominates carbon leakage in incentivizing low non-cooperative carbon taxes.

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CBA, **No Export Rebate**	None	Traditional	Leakage Neutral
Total Relative Welfare	1.45%	2.07%	1.41%
Relative Emissions	-9.58%	-14.12%	-10.99%
Average Carbon Tax	\$3.97	\$7.45	\$5.27
EU Carbon Tax	\$9.92	\$16.03	\$9.90
China Carbon Tax	\$8.22	\$9.26	\$7.86

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- Traditional without export rebate performs best in non-cooperative regime.
- With inefficiently low taxes, helps to allow countries to capture positive externalities.
  - This design addresses both leakage *and* the positive climate spillover.

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- Removing export rebate enables cost-shifting through terms-of-trade improvment.
- Traditional without export rebate performs best in non-cooperative regime.
- With inefficiently low taxes, helps to allow countries to capture positive externalities.
- EU considering export rebates in future CBAM design despite WTO concerns.

Results: Climate Clubs with Baseline Participation Constraint

- Compute club optimal cooperative taxes that satisfy baseline participation constraint.

Tax Regime	Uniform		Country-Specific
Transfers	Yes	No	Yes
Total Relative Welfare	5.19%	4.71%	5.15%
Relative Emissions	-49.48%	-37.95%	-49.55%
Min Carbon Tax	-	-	$37.29
Avg Carbon Tax	$51.46	$29.67	$50.66
Max Carbon Tax	-	-	$58.35

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- Country-specific taxes achieve ≈first-best, distributing gains w/o transfers.

- Traditional CBAs do not help and Leakage Neutral CBA hurts.
  - Cooperative, near-efficient, carbon taxes eliminate value of CBA distortions.

Results: Climate Clubs with Free-Rider Participation Constraint

- Consider one country's incentive to deviate and free-ride on the club's climate policy.

- Compute cooperative taxes that satisfy free-rider and baseline participation constraints.

Results: Climate Clubs with Free-Rider Participation Constraint

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- Without transfers, there *does not exist* a feasible uniform tax for the club.

Results: Climate Clubs with Free-Rider Participation Constraint

- Consider one country's incentive to deviate and free-ride on the club's climate policy.
- Compute cooperative taxes that satisfy free-rider and baseline participation constraints.
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- We consider country-specific taxes without CBAs.

Results: Climate Clubs with Free-Rider Participation Constraint

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- We consider country-specific taxes without CBAs.

Free-rider Country	Indonesia	China	USA
Total Relative Welfare	4.98%	4.90%	5.15%
Relative Emissions	-49.73%	-47.39%	-49.55%
Average Club Carbon Tax	\$55.94	\$60.86	\$50.51
Free-rider Country Carbon Tax	\$8.02	\$27.48	\$49.67

Results: Climate Clubs with Free-Rider Participation Constraint

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- Country-specific taxes are neccesary and enable performance near first-best.

Conclusion

- Quantitative analysis of carbon tax cooperation and WTO-compatible CBA design.
- Three key takeaways:
  1. Country-specific carbon taxes substantially improve the scope for international cooperation.
  2. Theory of second best: allowing export rebates depresses taxes and harms global welfare.
  3. We find that optimal policy evolves as cooperation evolves.
- In a non-cooperative environment:
  - Nash taxes are far below social optimal.
  - No-rebate Traditional CBAs improve welfare (relevant for EU CBAM).
  - Taxing agriculture delivers little additional benefit.
- In a cooperative environment:
  - Country-specific taxes replicate much of the gains from transfers.
  - CBAs are unnecessary.
  - Taxing agriculture yields significant gains.

Thank you!

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Results: Non-cooperative Nash Carbon Taxes with Agricultural Exemption

- Compute non-cooperative best-response carbon taxes with different CBA designs.

CBA, **No Export Rebate**	None	Traditional	Leakage Neutral
Total Relative Welfare	1.2%	1.67%	1.12%
Relative Emissions	-8.01%	-11.49%	-8.91%
Average Carbon Tax	\$3.98	\$9.50	\$6.57
EU Carbon Tax	\$11.41	\$19.17	\$10.14
China Carbon Tax	\$8.23	\$9.08	\$7.96

- Removing export rebate improves performance of traditional CBA.
- **Result 4:** Traditional without export rebate performs best in non-cooperative regime.
- **Result 5:** Agriculture exemption is less relevant in non-cooperative regime. GoBack