Optimal environmental border adjustments under the General Agreement on Tariffs and Trade

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GTAP conference
June 19, 2020

Motivation

- Subglobal carbon policy
  - Carbon leakage - subglobal carbon policy stimulates carbon emissions in unregulated regions
  - Border carbon tariff to correct carbon leakage
  - Import tariff can be used to exploit terms-of-trade
- Cooperative trade under GATT
  - But, cooperative trade agreements would restrict the use of the carbon tariff to environmental policy only
- Advised policy response: set carbon tariff level at domestic carbon price (Stiglitz (2013), Cosbey et al. (2012))

Research question

- What is the optimal border tariff to a cross-boarder externality under cooperative trade (GATT consitency)?
  - How does this deviate from contemporary advice?
  - Is this difference empirically important?

Literature review

- Border tariff can mitigate cross border externalities *and* extract rents from foreign countries
  - Markusen (1975), Hoel (1996)
- Setting border tariff on embodied carbon based on the domestic carbon price is advised
  - Stiglitz (2013), Cosbey et al. (2012), Aldy and Stavins (2008)

Analytic model (basically same as Markusen (1975))

- Two countries (N and S) and two goods (X and Y)
- Global pollution (Z) is a function of production X: $Z = Z(X_N, X_S)$
- Country N gets disutility from pollution Z: $U_N = U_N(C_{XN}, C_{YN}, Z)$
- We consider case where country N cares environment and implements tax on domestic production X and tariff on import of good X from country S (m_X)
- Policy instruments:
  - Emission tax on production X
  - Emission tariff on import X
- Country S does not respond

Optimal policies in non-cooperatieve trade setting (basically same as Markusen (1975))

Optimal emission tax on production X is Pigouvian rate as we expect:

$$\text{tax on production X} = \underbrace{-q_Z}_{\text{Pigouvian rate}}$$

Optimal emission tariff includes strategic component as well as environmental component:

$$\text{tariff} = \underbrace{\frac{m_X}{\frac{\partial Z}{\partial X_S}} \frac{dp^*}{dm_X}}_{\text{strategic component}} \underbrace{-q_Z \frac{dX_S}{dp^*} \frac{dp^*}{dm_X}}_{\text{environmental component}}$$

Cooperative trade: Böhringer et al. (2014)

Country, N, has to pay compensating international transfer T such that terms-of-trade rents cannot be realized:

$$\begin{aligned} U_S(C_{XS}, C_{YS}) - \bar{U}_S &\geq 0 \\ T &\geq 0 \\ T(U_S - \bar{U}_S) &= 0 \end{aligned}$$

Optimal policies in cooperative trade setting

Once we add compensating international transfer from country N to country S, optimal emission tax on production X is still Pigouvian rate:

$$\text{tax on production X} = \underbrace{-q_Z}_{\text{Pigouvian rate}}$$

Optimal import emission tariff includes only environmental component, but not just Pigouvian rate:

$$Tariff = \underbrace{-q_Z}_{\text{Pigouvian rate}} \underbrace{\frac{dX_S}{dp^*}\frac{dp^*}{dm_X}}_{=1?}$$

Optimal tariff is smaller than Pigouvian rate

- Since country S exports good X, production of X in country S is equal to consumption of X in country S and their export of good X ($X_S = C_{SX} + m_X$)

$$\underbrace{\frac{dX_S}{dp^*}\frac{dp^*}{dm_X}}_{<1} = \underbrace{\frac{dC_{SX}}{dp^*}\frac{dp^*}{dm_X}}_{-\ +} + \underbrace{\frac{dm_X}{dp^*}\frac{dp^*}{dm_X}}_{1}$$

$$\text{Optimal tariff} = (\text{Pigouvian rate}) * \frac{dX_S}{dp^*}\frac{dp^*}{dm_X}$$

Interpretation of optimal tariff

- Optimal tariff = (Pigouvian rate)*$\dfrac{dX_S}{dp^*}\dfrac{dp^*}{dm_X}$
- Pigouvian rate is adjusted by:
  - $\dfrac{dp^*}{dm_X}$: How much south price is decreased by reduction of import: Market power
  - $\dfrac{dX_S}{dp^*}$: How much production is decreased by price decrese: Flexibility of foreign production (and consumption)
- Because of consumption increase ($\dfrac{dC_{SX}}{dp^*}\dfrac{dp^*}{dm_X}$), production would not be decreased as much as import, optimal tariff is adjusted accordingly.

Empirical simulation model

- Static multi-region CGE model baed on GTAP 7.1 data

Table: Scope of the Empirical Model

Regions:		**Goods:**	
`Annex-I`	Annex I (except Russia)	`OIL`	Refined oil products
`MIC`	Middle-High Income, n.e.c.	`GAS`	Natural Gas
`LIC`	Low Income Countries, n.e.c.	`ELE`	Electricity
		`COL`	Coal
		`CRU`	Crude Oil
		`ALU`	Aluminum
		`NFM`	Other Nonferrous metals
		`EIT`	Energy Intensive, n.e.c.
		`TRN`	Transportation
		`AOG`	All other goods

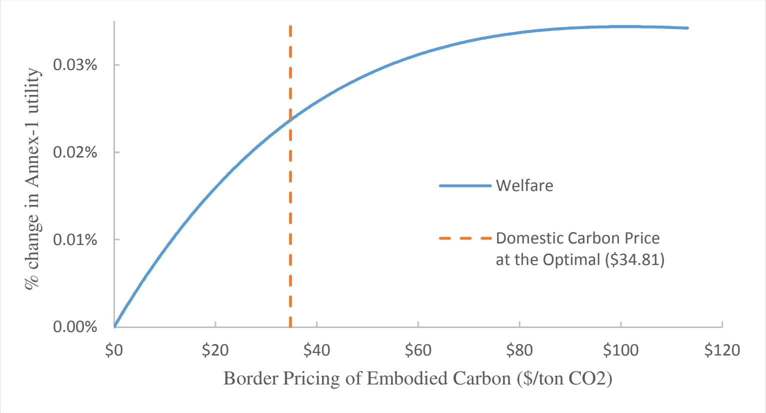
Empirical simulation model (cont.)

- Rutherford (2010) GTAPinGAMS static structure with MRIO embodied-carbon accounting
- Simple explicit representation of environmental valuation for the Annex-I (OECD) region
  - Utility is CES (constant elasticity of substitution) function of aggregate consumption and environmental quality.
  - US$35 per ton of CO2 in Annex-I region is simulated (roughly 20% reduction from the benchmark) to create reference equilibrium where Annex-I implements "domestic" carbon price but no border carbon adjustments.
- Border carbon adjustments on non-ferrous metals (energy and trade intensive)

Scenarios

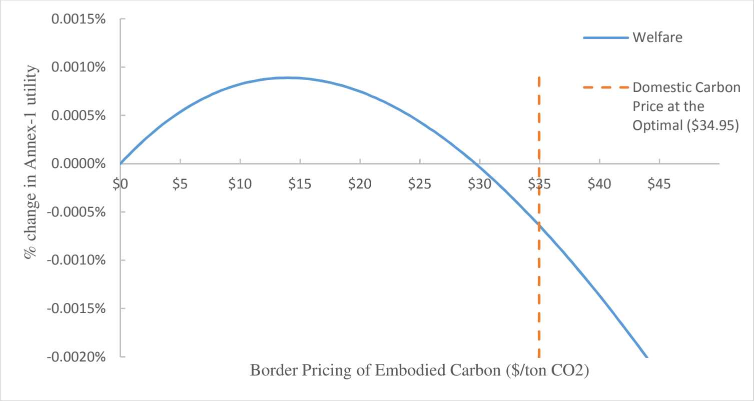
- Carbon tariff is implemented on non-ferrous metals
  - Scenario 1. Non-cooperative trade case: Without transfer from Annex I to MIC (middle Income countries) and LIC (low income countries)
  - Scenario 2. Cooperative trade case: With transfer such that MIC and LIC are not worse off because of border carbon adjustments

Results of no transfer case (Non-cooperative trade setting)



- Strategic component is included in optimal carbon tariff.
- Optimal carbon tariff is three times the domestic carbon price (tariff/domestic carbon price $= 3$).

Results with transfer (cooperative trade setting)



- Strategic component is suppressed with transfer.
- Optimal carbon tariff is 60% lower than the domestic carbon price (tariff/domestic carbon price = 0.4).

Sensitivity analysis

Table: Sensitivity Analysis on Optimal Border Carbon Pricing Relative to the Optimal Domestic Carbon Price

	Settings			Ratio: $\tilde{\tau}/\tilde{t}_X$		
	low	central	high	low	central	high
Armington Substitution Multiplier	0.5	1.0	2.0	0.55	0.40	0.23
Materials SubstitutionElasticity	0.0	0.5	1.0	0.44	0.40	0.36
Resource Substitution Multiplier	0.5	1.0	2.0	0.37	0.40	0.43
Energy Substitution Elasticity	0.05	0.5	5.0	0.39	0.40	0.43

- Higher armington Elas.: less market power and lower optimal carbon tariff.
- Higher foreign material sub. elast.: More foreign consumption response and lower optimal carbon tariff.
- Higher resource sub. elas.: More foreign production response and higher optimal carbon tariff.
- Higher energy sub. elas.: More foreign production response but even with large increase of this elasticity, small increaes in optimal carbon tariff because this is indirect way to influence production response

Conclusions

- Optimal carbon tariff is sensitive to regulated region's international market power and the unregulated region's consumption and production responses.
- Because of consumption increase of emission intensive goods in foreign countries, optimal carbon tariff is lower than domestic carbon price
- As currently proposed or prescribed, carbon tariff is beggar-thy-neighbor policy
- Our numerical simulation shows empirical importance as well

Thank you!

- Questions?

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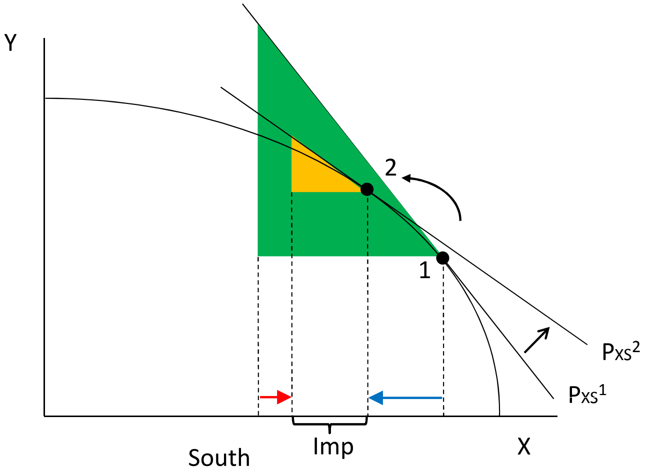
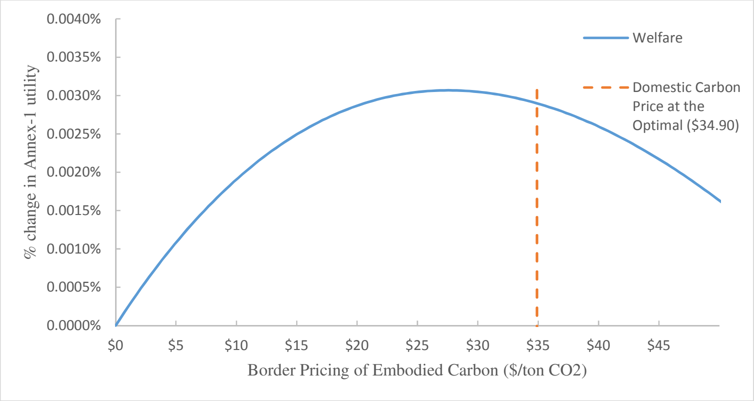
Basic intuition



$$d(Imp) = d(X_S) - d(X_S^{Cons})$$

Full border adjustments with transfer



- Export subsidy and import tariff are counteracting each other (Lerner's symmetry)
- Optimal full border adjustments (import tariff and export subsidy) are 20% lower than the domestic carbon price.

More detailed explanation on sensitivity analysis

	Settings			Ratio: $\tilde{\tau}/\tilde{t}_X$		
	low	central	high	low	central	high
Armington Substitution Multiplier	0.5	1.0	2.0	0.55	0.40	0.23
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- Higher resource sub. elas.: More foreign production response and higher optimal carbon tariff.
  - e.g., less non-ferrous metals lead to less electricity consumption, and less coal consumption, and lower coal price, and coal production is more responsive
- Higher energy sub. elas.: More foreign production response but even with large increase of this elasticity, small increaes in optimal carbon tariff because this is indirect way to influence production response
  - e.g., less non-ferrous metals lead to less electricity consumption and here we reduce more electiricy consumption, but then coal production responsiveness is unchanged