Foreign climate policy and domestic industry adjustment

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Motivation

- Amid weak international cooperation necessary climate efforts are likely to keep on taking the form of unilateral policy
- More ambitious unilateral policy based on carbon pricing for domestic production may face challenges in terms of acceptability and effectiveness
  - loss of competitiveness of the Energy-Intensive and Trade-Exposed Industries (EITEs)
  - perceived unfair treatment of domestic producers
  - carbon leakage: shift of production to jurisdictions with no/lower carbon pricing

Motivation

- Pricing carbon at the border, Border Carbon Adjustment (BCA), as a complement to carbon pricing on domestic production
  - **Import adjustment: carbon tariffs (M)**
  - Export adjustment: rebates on carbon pricing (X)

BCA considerations

- Implementing economy
  - level the playing field for EITEs (X/M)
  - reduce carbon leakage (X/M)
  - **spur abatement in other countries (M)**

Motivation

BCA considerations

- Implementing economy
  - **spur abatement in other countries** [?]
- Other countries
  - effect on domestic industry
  - **policy response**

This paper

- Adopt the perspective of a SOE (Colombia) facing impending BCA by partners
- Effect of BCA on domestic industry
- Scope for domestic climate policy to reduce exposure to BCA?
  - **irrespective of climate considerations**, does the (announcement of) BCA by trade partners justify the earlier/more ambitious implementation of domestic climate policy?
- Framework: Trade adjustment dynamics model
  - distinguish between immediate and long-run impacts
  - account for sluggishness: production/export costs (entrants and incumbents), installed capital

Related literature

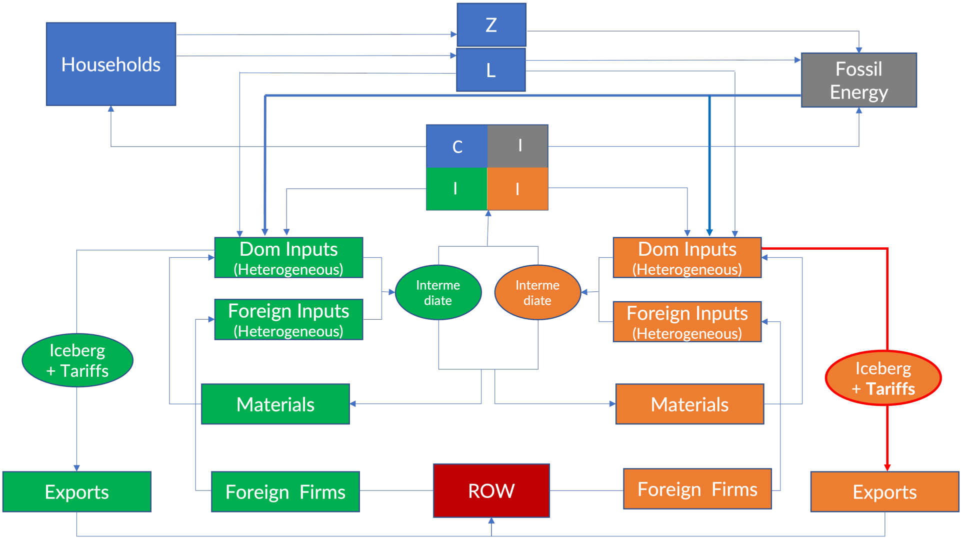
- Tariffs as instruments in the optimal unilateral policy mix: Markusen (1975); Hoel (1996); Hémous (2016); van der Ploeg (2016)
- Efficiency of alternative BCA designs and effectiveness in reducing carbon leakage / merits of different configurations: e.g., Böhringer, Bye, Fæhn, and Rosendahl (2012); Larch and Wanner (2017)
  - firm heterogeneity Balistreri and Rutherford (2012); Balistreri, Böhringer, and Rutherford (2018)
- Impact of BCA on own industry: Böhringer, Müller, and Schneider (2015)
- Strategic responses to (the threat of) BCA implementation: Böhringer, Carbone, and Rutherford (2016)
- Trade and firm dynamics: Alessandria, Arkolakis, and Ruhl (2021); Alessandria, Choi, and Ruhl (2021); Alessandria and Avila (2020); Melitz (2003)

Setup

Structure

- 3 economies: SOE, ROW_1 (climate conscious), ROW_2
- same 4-layered production
  - Final goods (consumption and investment)
    - ⋆ Produced combining two intermediates
  - Intermediates - 2 sectors: clean and dirty
    - ⋆ Produced using multiple varieties of (domestic and foreign) sector-specific inputs
  - Sector-specific inputs
    - ⋆ Produced using labor, materials, sector-specific capital, and fossil energy
    - ⋆ Dirty inputs are more energy intensive
  - Fossil Energy

Setup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Dom Inputs (Heterogeneous)
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Dom Inputs (Heterogeneous)
Foreign Inputs (Heterogeneous)
Iceberg + Tariffs
Materials
Materials
Iceberg + Tariffs
Exports
Foreign Firms
ROW
Foreign Firms
Exports

Setup - Intermediate goods: clean and dirty

- Multiple varieties of sector-specific inputs are used in the production of each intermediate
- A variety is identified by the input producer's productivity a and export status ex
  - From country i's perspective: $ex_i \in \{non, new, old\}$; $ex_j \in \{new, old\}$

$$\max_{\mathbf{Y}^s} P_i^s X_i^s - \sum_{ex_i} \int P_{ii}^s(a, ex_i) Y_{ii}^s(a, ex_i)\phi(a)da - \sum_{j \neq i} \tau_{ij}^s \sum_{ex_j} \int P_{ij}^s(a, ex_j) Y_{ij}^s(a, ex_j)\phi(a)da,$$

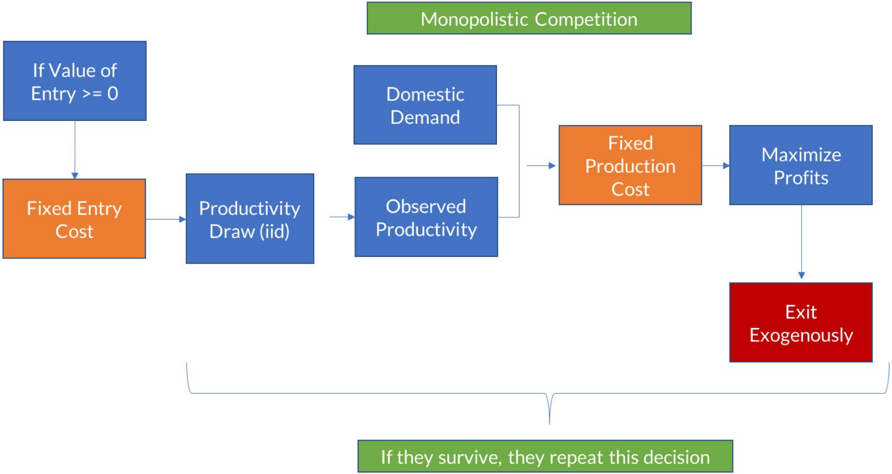
subject to

$$X_n^s = \left(\sum_n (\omega_{i,n}^s)^{\frac{1}{\theta_s}} \sum_{ex_n} \int (Y_{in}^s(a, ex_n))^{\frac{\theta_s - 1}{\theta_s}} \phi(a)da \right)^{\frac{\theta_s}{\theta_s - 1}}.$$

- $\tau_{ij}^s \geq 1$: tariffs to s-specific produced in j and exported to i
- BCA: unilateral increase by ROW_1 to the tariff on dirty inputs imports

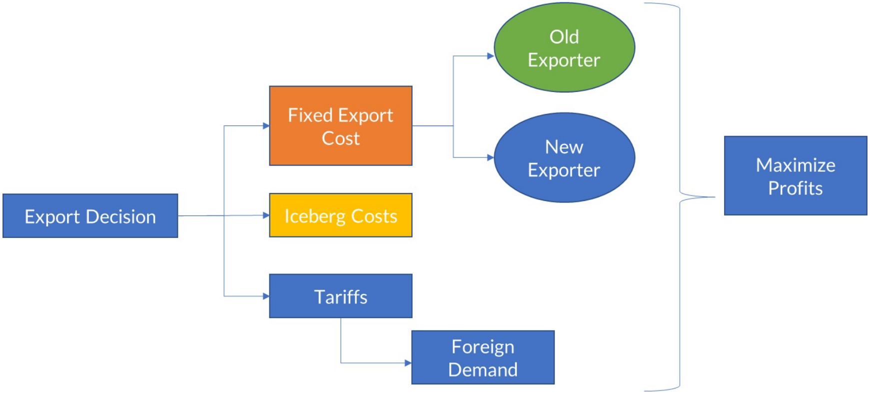
Setup - Sector specific inputs

Production decision



Setup - Sector specific inputs

Export decision



Setup - Sector-specific inputs (heterogeneous firms)

Intra-temporal problem of an input producer with productivity a and prior export status ex

$$\max_{\mathbf{P}^s,\, ex'} P^s_{ii}(a,ex)Y^s_{ii}(a,ex) + ex' \sum_{j\neq i} P^s_{ji}(a,ex) Y^s_{ji}(a,ex)$$

$$-\left(W_i l^s_i + R^s_i k^s_i + \tau^z_i P^z z^s_i + P^{M_s}_i m^s_i + W_i f^s_{p,i} + ex' W_i f^s_{ex,i}\right),$$

subject to

$$Y^{CD,s}_i = (k^s_i)^{\alpha^s_i}(l^s_i)^{\kappa^s_i}(m^s_i)^{1-\alpha^s_i-\kappa^s_i},$$

$$Y^s_i = a^{\frac{1}{\theta_s - 1}} \left[(1-\omega^{y,s}_i)^{\frac{1}{\gamma^s_i}} (Y^{CD,s}_i)^{\frac{\gamma_s - 1}{\gamma_s}} + (\omega^{y,s}_i)^{\frac{1}{\gamma^s_i}} z_{i,s}^{\frac{\gamma^s_i - 1}{\gamma^s_i}}\right]^{\frac{\gamma^s_i}{\gamma^s_i - 1}},$$

and

$$Y^s_i = Y^s_{ii} + ex' \xi^s_{ex,ij} Y^s_{ji}.$$

This paper

Viewpoint of SOE (Colombia) facing impending BCA by partners

- Effect of BCA on domestic industry
- Scope for domestic climate policy to reduce exposure to BCA?
  - **irrespective of climate considerations**, does the risk of BCA introduction by partners justify the earlier/more ambitious implementation of domestic climate policy?

Data & Calibration

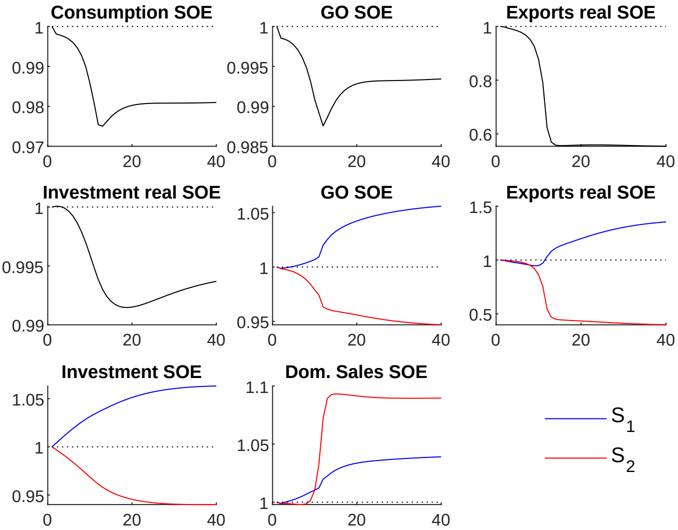
- Calibrate the SOE to the Colombian manufacturing sector
- Reclassify data in two sub-sectors
  - Dirty (high risk of carbon leakage according to the EU CBAM)
  - Clean (rest)
- Main data sources
  - 2019 Manufacturing Census (firm level) [MC]
  - 2010 Input-Output Matrix (sector level) [IO]
- Targeted moments
  - Trade Openness [IO]
  - Fraction of (new/old) exporters [MC]
  - Sales premium of exporters [MC]
  - Share of exports of new exporters [MC]
  - calibrated parameters:
    - ξ_0, ξ_1, f_0, f_1, f_p
- Other moments
  - Cross-sector share of materials (λ^M) [IO]
  - Sector shares final goods (ω^c, ω^K) [IO]

Policy Exercises

- SOE and two other economies ROW_1 and ROW_2
  - ROW_1 climate conscious coalition: announces a tariff increase on dirty sector imports in 10yrs (and implements it)
- 2-alternative BCA designs
  - **Unconditional** tariff hike: tariff remains constant at new higher level
  - Tariff hike **conditional** on (fossil) domestic policy: tariff increase is inversely proportional to domestic tax on fossil energy (such that **effective tax** on Z equalizes)
- Policy Response by SOE
  - No policy adjustment
  - Increase domestic tax on fossil energy: (tighter) climate policy

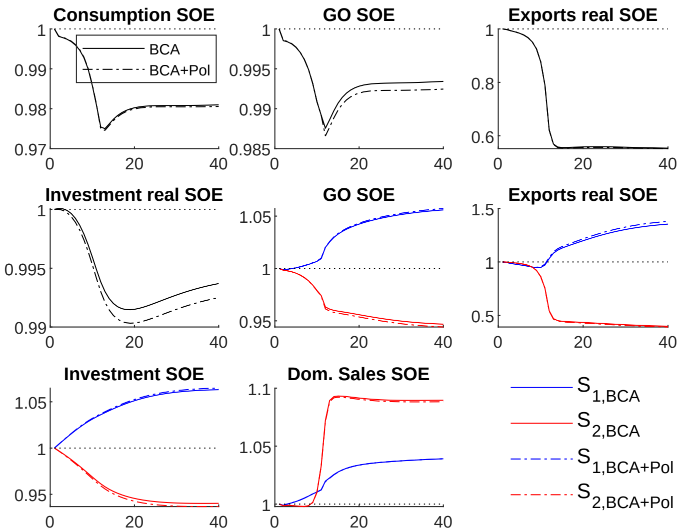
Results - BCA without SOE policy response

intermediates: clean and dirty



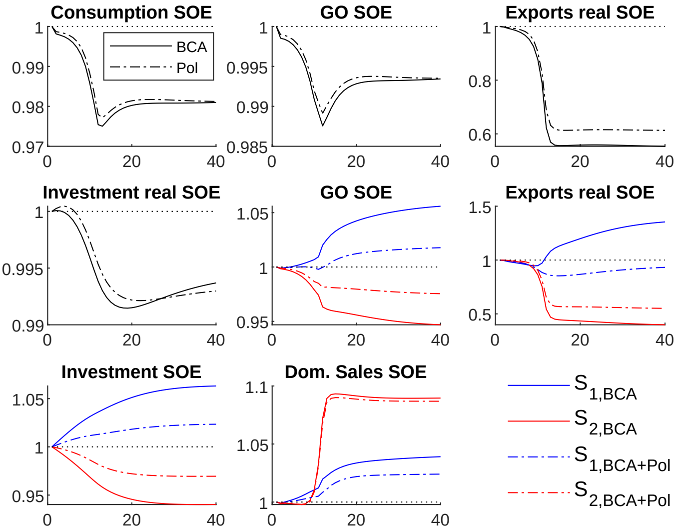
Results - Unconditional BCA with SOE policy response

intermediates: clean and dirty



Results - Conditional BCA with SOE policy response

intermediates: clean and dirty



Results - Welfare Comparison: Static V. Dynamic

Static change in consumption:

$$\Delta C_{ss} = \ln(C_{new}/C_0) * 100$$

Dynamic change in consumption:

$$\Delta C_{dym} = \sum_{t=0}^{\infty} \beta^t \ln(C_t/C_0) * 100$$

Scenario	Static	Dynamic	Relative Static	Relative Dynamic
BCA	-1.64	-1.48		
Uncond. BCA + Pol	-1.69	-1.50	1.03	1.01
Cond. BCA (.50) + Pol	-1.99	-1.39	1.21	0.94

Results - Welfare Comparison: Static V. Dynamic

Static change in consumption:

$$\Delta C_{ss} = \ln(C_{new}/C_0) * 100$$

Dynamic change in consumption:

$$\Delta C_{dym} = \sum_{t=0}^{\infty} \beta^t \ln(C_t/C_0) * 100$$

Scenario	Static	Dynamic	Relative Static	Relative Dynamic
BCA	-1.64	-1.48		
Cond. BCA (.75) + Pol	-2.25	-1.35	1.09	0.97
Cond. BCA (.50) + Pol	-1.99	-1.39	1.21	0.94
Cond. BCA (.25) + Pol	-1.78	-1.44	1.37	0.91

Conclusions

- Effect of BCA on SOE's economy
  - Sectoral re-composition (dirty to clean) partially mitigates the negative effect of targeted BCA (but it takes time)
  - Relevance of dynamics
    - overshooting in aggregate responses (graduality in response)
- Policy response by SOE
  - Unconditional tariff adjustment: domestic policy makes things worse
  - Conditional tariff adjustment ('true' BCA): domestic policy results in welfare improvement
  - Relevance of dynamics
    - transition smoothing
    - overall welfare evaluation may reverse
  - Conditionality reverses the sectoral support for domestic climate policy (PE considerations?)

Current/next steps

- Calibration refinement
- Alternative BCA design
  - Result based
- Comparison of different tax levels
- Alternative scenarios
  - Reaction by ROW_2
  - Anticipation V. Surprise

Thank you

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Model Implied Moments

Small Open Economy

Moment	*Clean*	*Dirty*
Trade Openness	0.35	0.38
Share of exporters (/all)	0.25	0.28
Share of new exporters (/exporters)	0.40	0.45
Sales premium exporters (avg./avg. all)	2.0	1.8
Share of exports (new)	0.2	0.2

Table 1: Moments SOE

Back

Setup - Final goods production

Consumption

$$\max_{X_i^{c,s}} P_i^c C_i - \sum_s P_i^s X_i^{c,s},$$

subject to

$$C_i = \left(\sum_s \left(\omega_i^{c,s}\right)^{\frac{1}{\theta}} \left(X_i^{c,s}\right)^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}.$$

Investment

$$\max_{X_i^{K_{s+,s'}}} P_i^{K_{s+}} I_i^{s+} - \sum_{s'} P_{i,t}^{s'} X_i^{K_{s+,s'}},$$

subject to

$$I_{i,t}^{s+} = \left(\sum_{s'} \left(\omega_i^{K_{s+,s}}\right)^{\frac{1}{\sigma_{s+}}} \left(X_{i,t}^{K_{s+,s}}\right)^{\frac{\sigma_{s+}-1}{\sigma_{s+}}} \right)^{\frac{\sigma_{s+}}{\sigma_{s+}-1}}.$$

$X_i^{c,s}$: intermediate $s \in \{clean, dirty\}$ used to produce the consumption good
$X^{K_{s+,s}}$: intermediate s used to produce the investment good $s+ \in \{clean, dirty, energy\}$

Setup - Materials and intermediate demand

Materials

$$\max_{X_i^{M_s,s}} P_i^{M_s} M_i^s - \sum_{s'} P_{i,t}^{s'} X_i^{M_s,s'},$$

subject to

$$M_{i,t}^s = \left(\sum_{s'} \left(\lambda_i^{M_{s,s'}} \right)^{\frac{1}{\sigma_{m,s}}} \left(X_{i,t}^{M_{s,s'}} \right)^{\frac{\sigma_{m,s}-1}{\sigma_{m,s}}} \right)^{\frac{\sigma_{m,s}}{\sigma_{m,s}-1}} .$$

$X_i^{M_{s,s'}}$: intermediate s' used to produce materials specific to s

Demand for intermediate s

$$X_i^s = X_i^{c,s} + \sum_{s+} X_i^{K_{s+,s}} + \sum_{s'} X_i^{M_{s',s}}.$$

Setup - Intermediate goods: clean and dirty

$$\max_{Y^s_{i,i}, Y^s_{i,j}} P^s_i X^s_i - \sum_{ex} \int P^s_{i,i}(a, ex) Y^s_{i,i}(a, ex) \phi(a) da - \sum_{j \neq i} \tau^s_{i,j} \sum_{ex^*} \int P^s_{i,j}(a, ex^*) Y^s_{i,j}(a, ex^*) \phi(a) da,$$

subject to

$$X^s_i = \left(\sum_j (\omega^s_{i,j})^{\frac{1}{\theta_s}} \sum_{ex} \int \left(Y^s_{i,j}(a, ex) \right)^{\frac{\theta_s - 1}{\theta_s}} \phi(a) da \right)^{\frac{\theta_s}{\theta_s - 1}}.$$

$\tau^s_{i,j} \geq 1$: tariffs to s-specific inputs exported from j to i BCA: unilateral increase by ROW_1 to the tariff on dirty inputs imports

Setup - Sector-specific inputs (heterogeneous firms)

Intra-temporal problem of an input producer with productivity a and prior export status ex

$$\max_{\mathbf{P}^s,\, ex'} P_{ii}^s(a,ex)Y_{ii}^s(a,ex) + ex' \sum_{j\neq i} P_{ji}^s(a,ex)Y_{ji}^s(a,ex)$$
$$-\left(W_i l_i^s + R_i^s k_i^s + \tau_i^z P^z z_i^s + P_i^{M_s} m_i^s + W_i f_{p,i}^s + ex' W_i f_{ex,i}^s\right),$$

subject to

$$Y_i^{CD,s} = (k_i^s)^{\alpha_i^s}(l_i^s)^{\kappa_i^s}(m_i^s)^{1-\alpha_i^s-\kappa_i^s},$$

$$Y_i^s = a^{\frac{1}{\theta_s - 1}} \left[(1-\omega_i^{y,s})^{\frac{1}{\gamma_i^s}} (Y_i^{CD,s})^{\frac{\gamma_s - 1}{\gamma_s}} + (\omega_i^{y,s})^{\frac{1}{\gamma_i^s}} z_{i,s}^{\frac{\gamma_i^s - 1}{\gamma_i^s}}\right]^{\frac{\gamma_i^s}{\gamma_i^s - 1}},$$

and

$$Y_i^s = Y_{ii}^s + ex' \xi_{ex,ij}^s Y_{ji}^s.$$

Setup - Sector-specific inputs (heterogeneous firms)

The value of an active firm is given by

$$V_s^i(ex', a, ex) = \pi_i^s(a, ex) - W_i f_{p,i}^s - ex' W_i f_{ex,i}^s + n_i Q_i EV_i^s(ex'),$$

- $\pi_i^s(a, ex)$: maximized intra-temporal (variable) profits
- $Q_{i,t} = \beta E_t U'(C_{i,t+1})/U'(C_{i,t})$: stochastic discount factor
- $1 - n_i$: exo. exit rate
- $EV_i^s(ex')$: expected value of a firm with current export status ex'

Setup - Sector-specific inputs (heterogeneous firms)

The value of an active firm is given by

$$V_s^i(ex', a, ex) = \pi_i^s(a, ex) - W_i f_{p,i}^s - ex' W_i f_{ex,i}^s + n_i Q_i EV_i^s(ex'),$$

- $\pi_i^s(a, ex)$: maximized intra-temporal (variable) profits
- $Q_{i,t} = \beta E_t U'(C_{i,t+1})/U'(C_{i,t})$: stochastic discount factor
- $1 - n_i$: exo. exit rate
- $EV_i^s(ex')$: expected value of a firm with current export status ex'

Productivity thresholds for: non-exporters, new exporters, and old exporters:

- Marginal producer: $\pi_i^s(a_{p,i}^s, 0) = W_i f_{p,i}^s$; $a_{p,i}^s$, productivity threshold to produce
- Marginal exporters: $V_i^s(1, a_{ex,i}^s, ex) = V_i^s(0, a_{ex,i}^s, ex)$; $a_{ex,i}^s$, productivity threshold to export given prior status ex

Setup - Fossil Energy

$$\max_{L_i^z, Z_i^{ed}} P^z Z_i - W_i L_i^z - R_i^z K_i^z - P_i^{z,e} Z_i^{ed},$$

subject to

$$Z_i = (L_i^z)^{1-\alpha_{z,i}-\mu_{z,i}} (K_i^z)^{\mu_{z,i}} (Z_i^{ed})^{\alpha_{z,i}}.$$

- Fossil energy, Z, is tradable
- Z^{ed}: Endowment of (raw) fossil resource flow