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Impacts of Climate Change on Global Agri-Food Trade

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Impacts of climate change on global agri-food trade



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Background and motivation

Conceptual framework

Econometric framework

Data

Results

Background

- **Agriculture highly sensitive to CC** across the globe (Deschenes & Greenstone, AER 2007; Mendelsohn & Massetti, REEP 2017)
- **CC affects world production, markets, trade** (Reilly & Hohmann, AER 1993)
- While trade patterns are likely to be affected by CC, trade itself is an adaptation strategy to CC (Hsiang, AnnRevResEcon 2016)
- **CC may alter comparative advantages** across countries and trigger changes in trade patterns (Zimmermann et al, FAO 2018)
- **Trade favors food reallocation from surplus to deficit regions** (FAO, 2018)

On trade and adaptation in agriculture: Reilly & Hohmann (AER 1993), Costinot, Donaldson, Smith (JPE 2016), Gouel & Laborde (NBER 2019)

CC impacts and countries' economic development

- CC impacts likely to differ for countries with different levels of development
- Low-latitude countries often developing economies, high-latitude countries often developed economies (Zimmermann et al, FAO 2018)
- CC less severe in equatorial than in temperate and polar regions, but low adaptation capability of developing countries (Reilly and Hohmann, AER, 1993)
- Developing and developed countries may have **different** –if not conflicting– **trade strategies** to face CC (Rosenzweig & Parry, Nature 1994) and **different resiliency** to CC

Our contribution

Econometric analyses combine approaches used in:

- **Ricardian studies** (e.g. Mendelsohn et al, AER 1994): CC impacts on trade
- **Gravity-based studies** (e.g. Bergstrand, REStat 1985): CC impacts on bilateral trade
 - i. Impacts of CC on value of exports (for developed and developing countries)
 - ii. Impacts of CC on bilateral trade (for developed and developing countries)

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CC impacts on country's trade value

A simplified framework

- Climate: exogenous factor affecting productivity (e.g. Mendelsohn et al, AER 1994)
- CC may alter comparative advantage, i.e. country's relative ability to produce –and export(import) excess of supply(demand)– (French, JIntEcon 2017)

Let be:

- country i : small open economy, net exporter(importer) for agri-food sector
- p^* : exogenous market price, depending on events and conditions in RoW
- z_i : known technology
- \mathbf{C}_i : set of country's climate conditions (exogenous)
- \mathbf{X}_i : set of country-specific time-invariant and time-varying characteristics

Aggregate agri-food demand and supply (D_i and S_i)

Export (import) value of i (V_i) is:

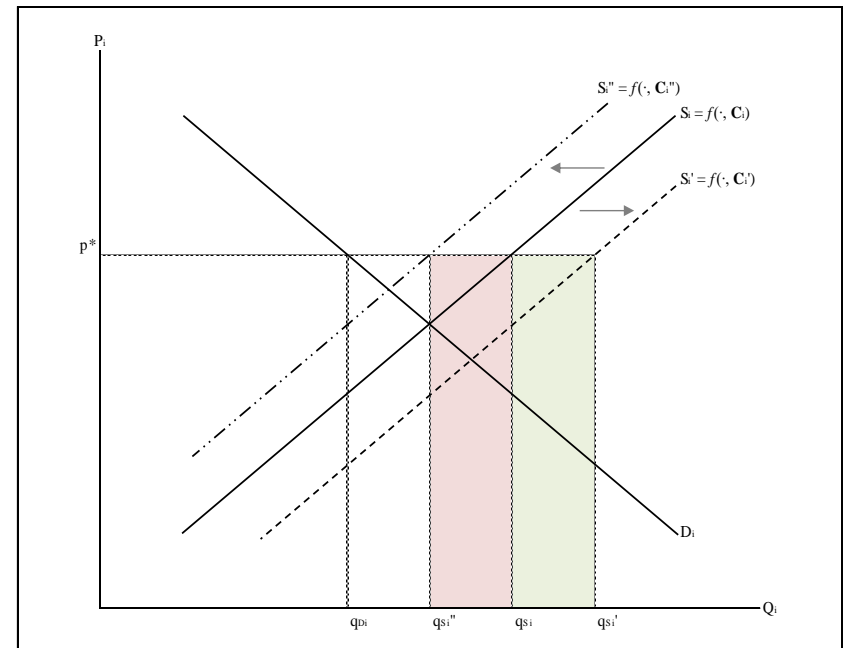
$$S_i - D_i = V_i = f(p^*, z_i, \mathbf{C}_i, \mathbf{X}_i)$$

Changes in country's trade value due to CC

CC shifts S_i (but leave D_i unaffected)

Given exogenous p^* higher(lower) than domestic price

- if CC shifts S_i rightward, the value of exports increases (green area)
- if CC shifts S_i leftward, the value of exports decreases (red area)



Shifts in country's aggregate agri-food supply due to CC alter trade values

Impacts of CC heterogeneity on bilateral trade

A simple framework

CC may change comparative advantages and thus bilateral trade values

(Heerman & Sheldon, NBER 2018)

- if CC increases differences between trading partners, the specialization may expand bilateral trade
- If trading partners have similar climate, they may specialize in similar agri-food productions, thus specialization may reduce bilateral trade

Let be:

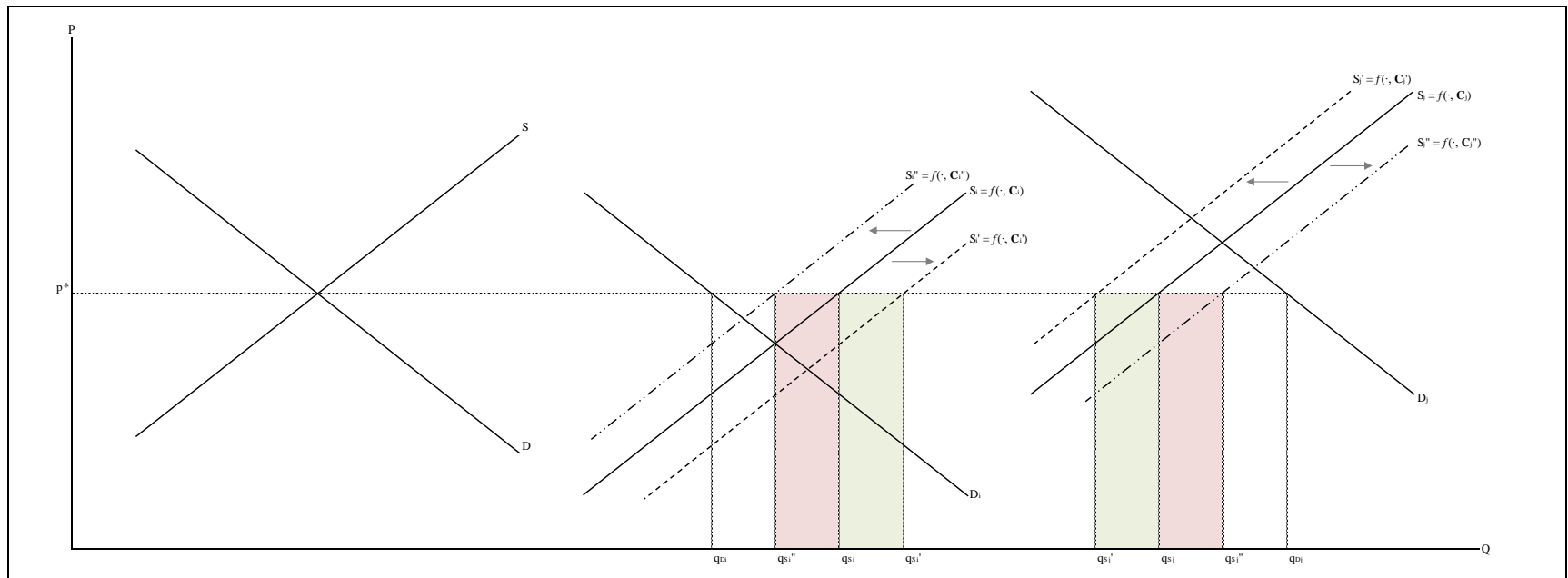
- i exporting country and j importing country
- V_i and E_j : value of output in i and total expenditure of j
- Π_i and P_j : multilateral resistances (Anderson & van Wincoop, AER 2003)
- τ_{ij} : trade distance between i and j (including time-invariant and time-varying determinants of transaction costs)

Bilateral trade (V_{ij}) is explained by the following structural gravity system:

$$V_{ij} = \frac{V_i}{\Pi_i} \frac{E_j}{P_j} \tau_{ij}$$

Changes in the value of bilateral trade due to CC

- Exogenous p^* : higher than domestic price in i ; lower than domestic price in j
- If CC shifts S_i rightward and shifts S_j leftward (green areas): bilateral trade increases
- If CC shifts S_i leftward and shifts S_j rightward (red areas): bilateral trade decreases



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Ricardian model (pooled OLS)

$$V_{it} = \beta_r + \beta_t + C_i\gamma + X_i\delta + u_{it}$$

- V_{it} : log value of total exports of i at time t
- β_r and β_t : region and time FE, controlling for exogenous market prices (Bozzola et al, ERAE 2018) and known technology time-variant (Kim & Moschini, LandEcon 2018)
- C_i : country-specific climate normals of temperature (T) and precipitation (P) (quadratic relationship between V_{it} and C_i)
- X_i : country-specific characteristics (latitude, longitude, dummy for developed exporter)
additional controls: % of population w/ access to electricity, % of rural population w/ access to electricity, avg. level of tariffs, presence of multilateral NTMs

Marginal impacts

Percentage change in export values associated with a marginal increase in temperature and precipitation climatologies (i.e. rolling 30-years averages)

$$\frac{\partial \hat{V}}{\partial T} \cdot \frac{1}{\hat{V}} = (\gamma_T + 2\gamma_{T^2}\bar{T}) * 100 \quad \text{and} \quad \frac{\partial \hat{V}}{\partial P} \cdot \frac{1}{\hat{V}} = (\gamma_P + 2\gamma_{P^2}\bar{P}) * 100$$

- $\gamma_T, \gamma_{T^2}, \gamma_P, \gamma_{P^2}$: pooled OLS coefficients estimated for long-run mean temperature and precipitation and their quadratic functions
- \bar{T} and \bar{P} : sample means of 30-years rolling average temperature and precipitation

Gravity model (PPML)

$$V_{ijt} = e^{\{\beta_{it} + \beta_{jt} + \beta_{ij} + C_{ijt}\lambda + \Omega_{ijt}\mu\}} \varepsilon_{ijt}$$

- V_{ijt} : exports value of country i to country j at time t
- β_{it} and β_{jt} : time-varying FE: multilateral resistances (Yotov et al, WTO 2016)
- β_{ij} , country-pair FE (Egger and Nigai, JIntEcon 2015)
- C_{ijt} : long-run absolute differences in mean temperature and precipitation
- Ω_{ijt} : controls for tariff levels, bilateral NTMs, RTAs, dummy for developed exporter

Trade volume effects:

$$TVE = \hat{\lambda}_W * 100$$

Background and motivation

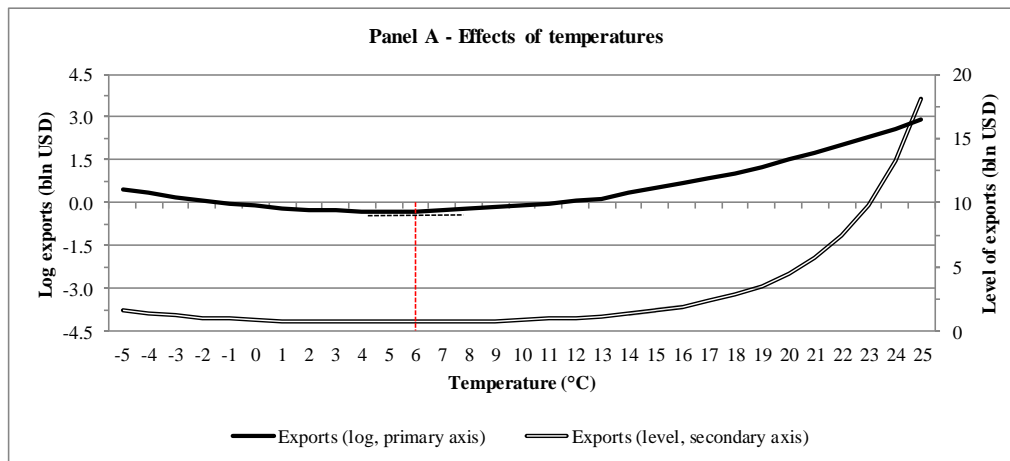
Conceptual framework

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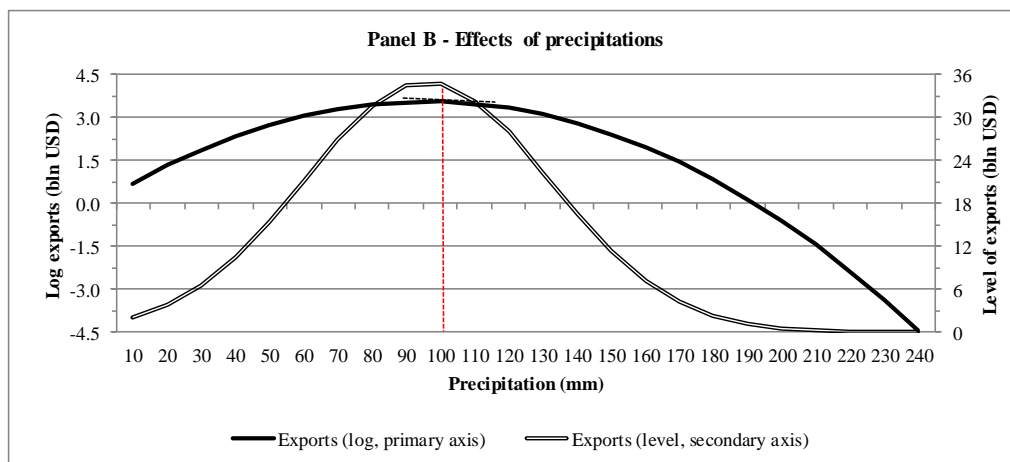
Data

Results

Effects of CC on exports and turning points



Notes: Dep. var: value of total exports (log and level) in food and beverage sector (BEC); annual temperature in °C, annual precipitation in mm/year.



Turning points:

- 5-6 °C for temperatures of exporter
- 95-100 mm for precipitations of exporter

Marginal impact of CC on exports

Table: Marginal impact (MI) of climate and change in countries' export values (Δ avg exp)

	All		Developed		Developing	
	MI (%)	Δ avg exp (bln \$)	MI (%)	Δ avg exp (bln \$)	MI (%)	Δ avg exp (bln \$)
Temperature (+1 °C)	11.91 [9.59; 14.22]	2.41	5.68 [4.75; 6.60]	1.82	17.01 [13.29; 20.73]	1.81
Precipitation (+5 mm)	8.73 [6.40; 11.05]	1.77	9.66 [7.15; 12.2]	3.09	7.96 [5.80; 10.15]	.85

Notes: MI significant at the 1% level and obtained from pooled OLS coefficients, evaluated at average temperature and precipitation of all, developed and developing exporters; 95% C.I. in brackets. Δ avg exp considers average exports of all, developed and developing exporters

Marginal impact of CC on bilateral exports

Table: Trade volume effect (TVE) of climate distance and change in bilateral exports (Δ avg exp)

	All		Developed		Developing	
	TVE (%)	Δ avg exp (bln \$)	TVE (%)	Δ avg exp (bln \$)	TVE (%)	Δ avg exp (bln \$)
Difference in temperature (+1 °C)	38.07%	.19	49.86%	.42	-44.29%	-.10
Difference in precipitation (+5 mm)	82.12%	.42	37.87%	.32	84.75%	.20

Notes: TVE obtained from PPML coefficients, evaluated at average differences in temperature and precipitation.
 Δ avg exp considers average bilateral exports of all, developed and developing exporters

Take-home message

- Higher **temperatures** tend to increase exports
- Larger differences in CC tend to be **beneficial** for trade
- **CC impacts vary across countries** with different economic development
 - i. Changes in temperature have more marked differentiated impacts for developed and developing exporters
 - ii. Differences in CC matter for bilateral trade, and favor developed exporters

Thanks

Comments are welcome

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