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
- $\boldsymbol{C}_i$: set of country's climate conditions (exogenous)
- $\boldsymbol{X}_i$: 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:

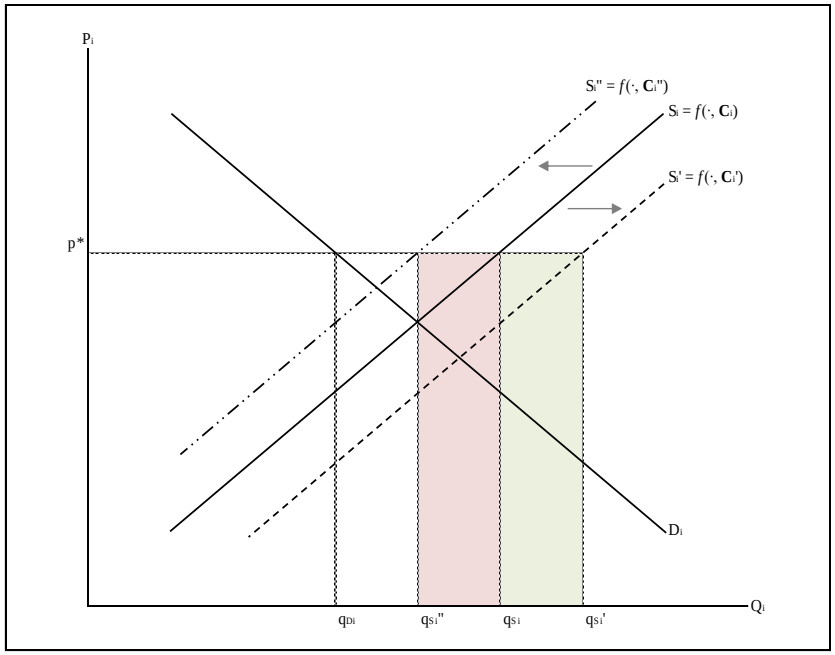
$$S_i - D_i = V_i = f(p^*, z_i, \boldsymbol{C}_i, \boldsymbol{X}_i)$$

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:

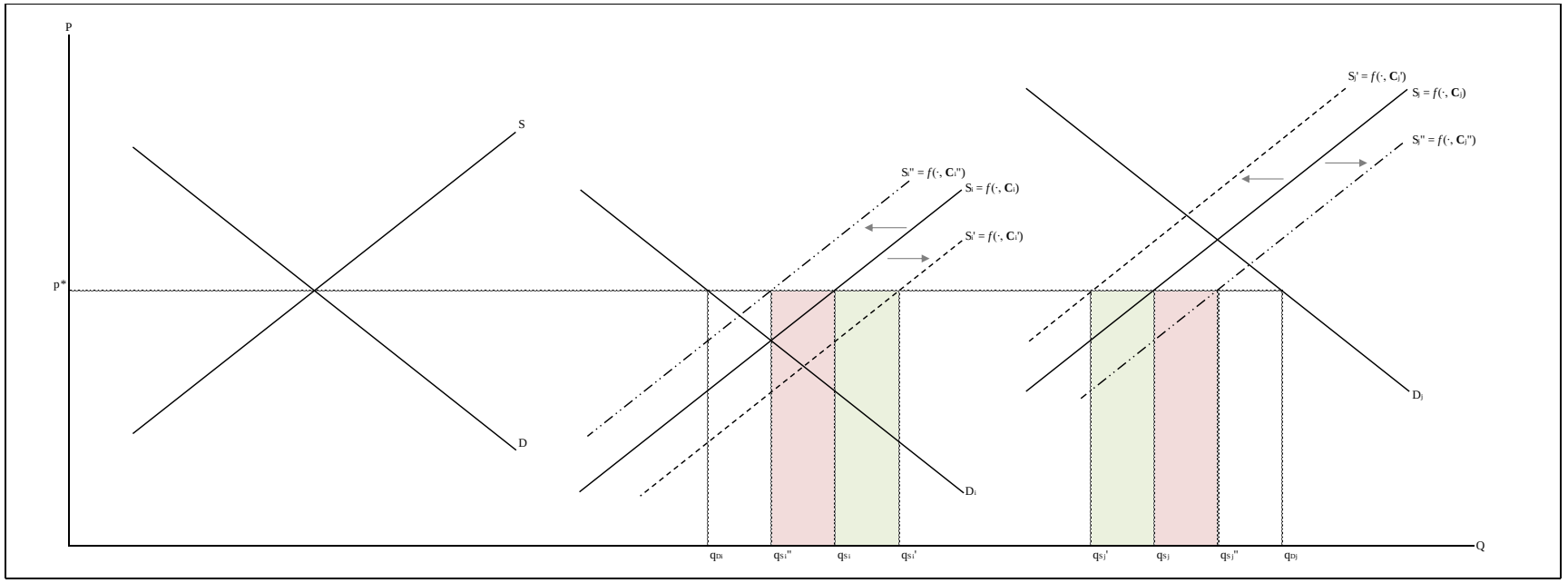
- *i* exporting country and *j* importing country
- V_i and E_j: value of output in *i* and total expenditure of *j*
- Π_i and P_j: multilateral resistances (Anderson & van Wincoop, AER 2003)
- τ_{ij}: trade distance between *i* and *j* (including time-invariant and time-varying determinants of transaction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

$$V_{it} = \boldsymbol{\beta}_r + \boldsymbol{\beta}_t + \boldsymbol{C}_i\gamma + \boldsymbol{X}_i\delta + u_{it}$$

- V_{it}: log value of total exports of *i* at time *t*
- $\boldsymbol{\beta}_r$ and $\boldsymbol{\beta}_t$: region and time FE, controlling for exogenous market prices (Bozzola et al, ERAE 2018) and known technology time-variant (Kim & Moschini, LandEcon 2018)
- $\boldsymbol{C}_i$: country-specific climate normals of temperature (T) and precipitation (P) (quadratic relationship between V_{it} and $\boldsymbol{C}_i$)
- $\mathbf{X}_i$: 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)

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

- γ_T, γ_{T^2}, γ_P, γ_{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)

$$V_{ijt} = e^{\{\boldsymbol{\beta}_{it}+\boldsymbol{\beta}_{jt}+\boldsymbol{\beta}_{ij}+\boldsymbol{C}_{ijt}\boldsymbol{\lambda}+\boldsymbol{\Omega}_{ijt}\mu\}}\varepsilon_{ijt}$$

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

Trade volume effects: $TVE = \hat{\lambda}_{\boldsymbol{W}} * 100$

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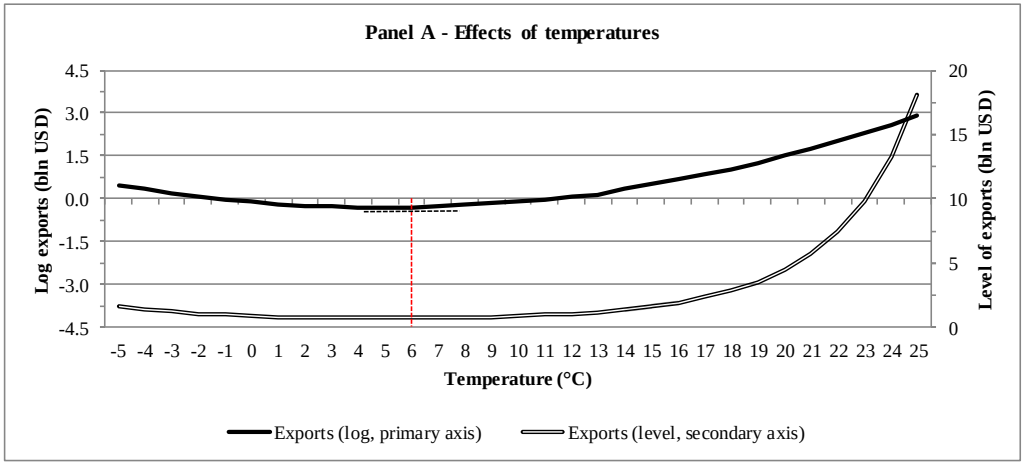
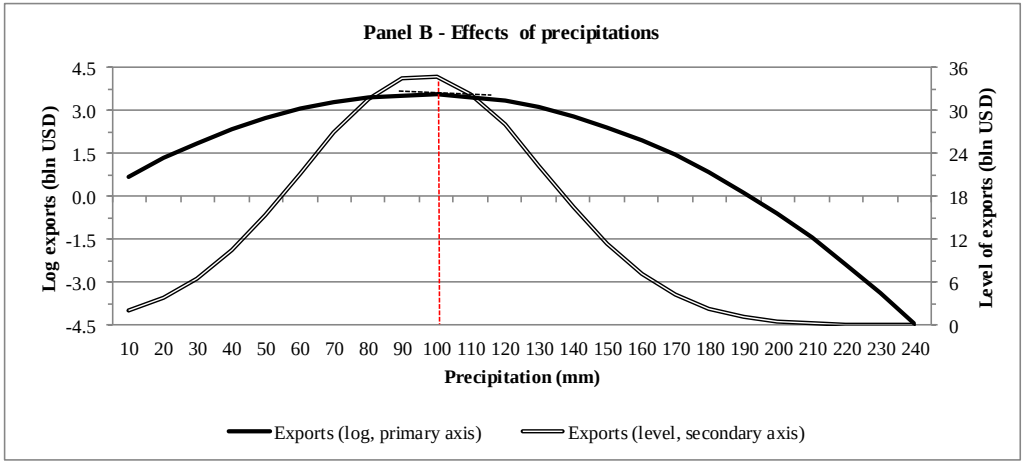
Effects of CC on exports and turning points





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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