International Trade and Domestic Price Stability in the Presence of Large Scale Climate Shocks

Nelson B. Villoria
Associate Professor

Department of Agricultural Economics

Kansas State University

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International trade and global risk-sharing in a more unstable climate

- Climate models predict increases in extreme weather events affecting large geographic areas and regions (Diffenbaugh and Scherer, 2011; Coumou and Robinson, 2013; Perkins-Kirkpatrick and Gibson, 2017).
- International trade is a natural way to smooth price fluctuations by procuring commodities from where they are abundant to where they are scarce.
- But if shocks are positively correlated between trading partners, international trade is ineffective to compensate negative supply shocks. (Williams and Wright, 1991, p.263).

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Research question

1. What are the roles of trade policies and geography in shaping the policy options available for price stabilization when climate shocks are correlated over large areas?

Challenges to research questions

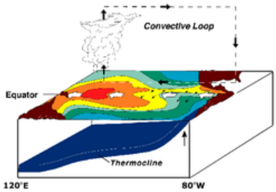
1. (Linear) correlation patterns of weather/yield shocks are weak. Time series are too short for studying tail dependency.
2. Cross-country price data on either producer or consumer prices are for short periods (e.g., FAOSTAT starts in 1991) and the definitions are unreliable (farm-gate or official prices?).
3. Heterogeneous effects across crops and countries. A regional focus on one commodity is desirable.

Empirical strategy of this paper

- For challenge 1: Use ENSO events which can be interpreted as draws from the tails of unknown weather correlation functions.
- For challenge 2: Use the structure of the gravity model of international trade to estimate prices from the variation of delivery prices embedded in the trade matrix.
- For challenge 3: Focus on maize in Eastern and Southern Africa, which is one region of the world in which negative ENSO effects, particularly from El Niño are found (e.g., Dingel, Meng, and Hsiang, 2019; Ubilava and Abdolrahimi, 2019).

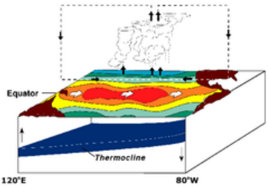
What's El Niño-Southern Oscillation phenomenon?

- Temporary change in the climate of the Pacific ocean, in the region around the equator.
- Two phases: Cold (La Niña), Warm (El Niño)



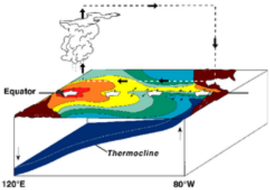
Normal Pacific pattern

Equatorial winds gather warm water pool toward the west. Cold water up wells along South American coast.



El Niño conditions

Warm water pool approaches the South American coast. The absence of cold up welling increases warming.



La Niña conditions

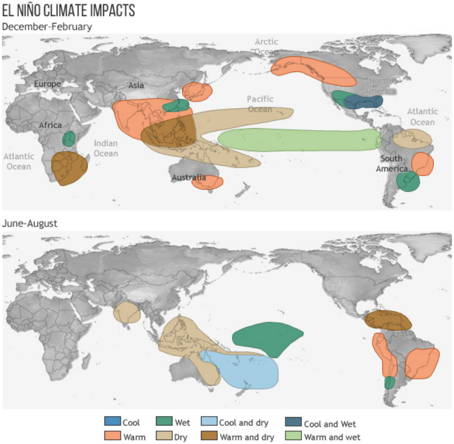
Warm water is farther west than usual.

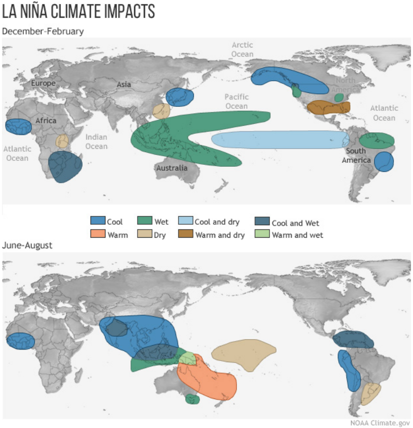
Source: Wikipedia.

Climate teleconnections

- Teleconnection in atmospheric science refers to climate anomalies being related to each other at large distances (typically thousands of kilometers)
- ENSO is the most important climate teleconnection and the main cause of worldwide climate variability after the seasonal cycle (Rosenzweig and Hillel, 2008).
- ENSO increases the global spatial correlation of cereal yields (Dingel, Meng, and Hsiang, 2019).

El Niño and La Niña climate impacts



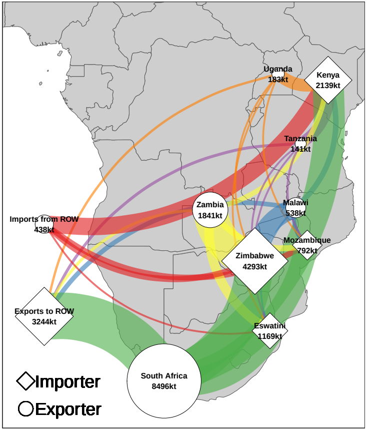


NOAA Climate.gov.

Focus: Maize in Eastern and Southern Africa

- Maize production and yields in these regions are significantly sensitive to changes in contemporaneous ENSO SSTA (Ubilava and Abdolrahimi, 2019; Sazib, Mladenova, and Bolten, 2020).
- Region faces high trading costs with the rest of the world (Porteous, 2017, 2019).
- High levels of self-sufficiency (Anderson, 2010).
- Globally, negative welfare effects of ENSO shocks concentrated in sub-Saharan Africa (Dingel, Meng, and Hsiang, 2019).

Isolated trade network: Focus countries import from and export to nearby countries in the region, with relatively little trade outside with other countries, with the exception of South Africa.



Source: Author's elaboration based on COMTRADE imports, cumulative 2010:2015.

High levels of self-sufficiency

Shares of self-sufficiency, intra- and extra-regional imports, and import share-weighted average distance (km) from intra- and extra-regional exporters

Shares of self-sufficiency, intra- and extra-regional imports, and import share-weighted average distance (km) from intra- and extra-regional exporters.

		Intra-region		Extra-region	
Country	Self-sufficiency	Import Share	km	Import Share	km
Kenya	0.94	0.82	2151.47	0.18	10371.60
Malawi	0.99	0.96	1356.91	0.04	10277.81
Mozambique	0.95	0.97	1463.78	0.03	10101.42
Uganda	1.00	0.31	2212.44	0.69	8912.38
Tanzania	0.99	0.58	1743.43	0.42	9844.04
Zambia	0.99	0.95	1375.22	0.05	10261.06
Zimbabwe	0.70	0.99	1356.04	0.01	10176.64
South Africa	0.97	0.05	2476.73	0.95	10154.68
Eswatini	0.40	1.00	1167.93	0.00	

Source: Author's elaboration based on COMTRADE imports, FAOSTAT commodity balance sheets, and CEPII's bilateral distances, cumulative 2005:2015.

Demand-side structural gravity

Due to Anderson and Van Wincoop (2003).

Structural gravity is given by the CES bilateral demands (i exports, j imports):

$$q_{ij} = \beta_{ij} \left(\frac{Q_i}{\Pi_i}\right) \left(\frac{1}{\tau_{ij}}\right)^{\sigma} \left(\frac{E_j}{P_j^{1-\sigma}}\right). \qquad (1)$$

where:

- Q_i is maize output in country i.
- E_j are total maize expenditures in destination market j.
- Π_i is the so-called Outward Multilateral Resistance term (average seller's incidence of trade costs).
- P_i, the CES price index is reinterpreted as an Inward Multilateral Resistance term (average buyer's incidence of trade costs).

Farm-gate or supply prices are given by:

$$p_i = \left(\frac{Q_i}{\Pi_i}\right)^{-\frac{1}{\sigma}}. \qquad (2)$$

.

Estimation I

Equation 1 can be conveniently taken to data by grouping importer and exporter specific variables into importer and exporter fixed effects:

$$\exp(m_{jt}) = E_{jt} P_{jt}^{\sigma-1}, \tag{3}$$

$$\exp(e_{it}) = Q_{it} \Pi_{it}^{-1}. \tag{4}$$

Adding a multiplicative error term, the empirical counterpart of equation 1 is given by:

$$q_{ij} = \exp\left(e_i - \sigma \log(\tau_{ij}) + m_j\right) \varepsilon_{ij}. \tag{5}$$

Estimation II

With the following cost function $log(\tau_{ij}^{-\sigma})$:

$$\underbrace{\gamma_1 \text{log(Distance)}_{ij} + \gamma_2 \text{Contiguous}_{ij}}_{\text{Geography}} + \underbrace{\gamma_4 \text{Dom. trade}_{ij} + \gamma_5 FTA_{ijt} + \gamma_6 WTO_{ijt}}_{\text{Policy}}. \quad (6)$$

Where:

- Distance_{ij} is either an intranational measure of distance or the bilateral distance between countries i and j, both from CEPII.
- Contiguous_{ij} is a dummy $= 1$ if the i and j share a border.
- Dom. trade_{ij} is a dummy $= 1$ for intranational trade.
- FTA_{ijt} and WTO_{ijt} =1 if a country pair belongs in the same agreement.

Estimation III

- Use the Poisson Pseudo-Maximum Likelihood estimator (Santos-Silva and Tenreyro, 2006) to estimate parameters of 5 using panel data.
- PPML avoids parameter inconsistency due to the error heterokesdaticity in log-linearized constant elasticity models.
- PPML allows to include zero-valued dependent variables, which are pervasive in bilateral trade matrices.
- Fally (2015): PPML exporter and importer fixed effects automatically satisfy the add-up constraints of the Anderson and van Wincoop model.

Data

- Trade data: bilateral import quantities from COMTRADE.
- Domestic sales: maize domestic output minus exports from FAOSTAT.
- FAOSTAT import and export data are shared out using COMTRADE bilateral trade shares to ensure that the sum of all the bilateral sales and to the own market add up to FAOSTAT output.
- Gravity variables: Distances (bilateral and internal), contiguity, FTA and WTO membership, common language, colonial relationship, from CEPII.
- Final dataset covers 74 countries from 1962-2015.
- SSTA averaged over country-specific growing seasons.

Regression results

Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
Log Dist.	-2.19***	-2.19***	-2.19***	-2.11***	-2.58***	-2.04***
	(0.208)	(0.209)	(0.208)	(0.210)	(0.223)	(0.225)
Both in same FTA	1.67***	1.67***	1.67***	1.71***		1.74***
	(0.233)	(0.231)	(0.231)	(0.237)		(0.249)
Both in WTO	1.96***	1.97***	1.96***	1.96***		1.94***
	(0.298)	(0.295)	(0.296)	(0.295)		(0.293)
I[Dom. trade]	6.84***	6.61***	6.78***	7.16***	3.72***	8.69***
	(0.453)	(0.462)	(0.450)	(0.456)	(0.424)	(1.74)
I[Contiguous]	-0.079	-0.077	-0.078	-0.046	0.074	-0.037
	(0.244)	(0.245)	(0.243)	(0.242)	(0.256)	(0.251)
IQC	-0.235***	0.350*				
	(0.062)	(0.197)				
I[IQC>0]		-0.157				
		(0.153)				
IQC × I[IQC>0]		-0.701***	-0.319***			
		(0.251)	(0.080)			
Log Dist. × I[Dom. trade]						-0.228
						(0.252)
Fixed-effects						
Importer-year (3,996)	Yes	Yes	Yes	Yes	Yes	Yes
Exporter-year (3,996)	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	295,704	295,704	295,704	295,704	295,704	295,704
Pseudo R^2	0.995	0.995	0.995	0.995	0.994	0.995
Wald test (*p*-value)		0.027	0.15			0.139

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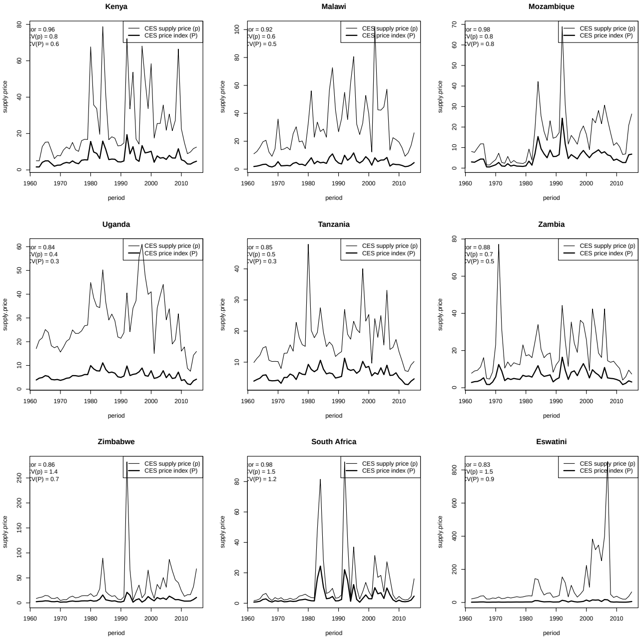
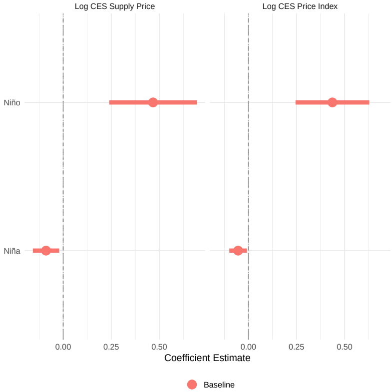
CES price indices and CES supply prices of maize in focus countries



Are the model-derived farm-gate and consumer prices in Southern and Eastern Africa sensitive to ENSO shocks?

$$\log(price_{it}) = \beta_0 + \beta_1 Niño_{it} + \beta_2 Niña_{it} + \epsilon_{ij}$$



Effects of ENSO phases on baseline log CES supply prices and log price indices in the focus countries during 1962-2015. $\log(price_{it}) = \beta_0 + \beta_1 NINO_{it} + \beta_2 NINA_{it} + \epsilon_{ij}$. 95% confidence intervals using robust standard errors. All models include country fixed effects.

Policy counterfactuals

1. **Extreme unilateral trade liberalization/facilitation (unilateral policy):** Remove the border of the focus countries: I.e., Dom. $\text{trade}_{ij} = 1$ for all focus countries i, so trading with other countries is as costly as trading domestically.
2. **Reduce distance to the rest of the world:** Bilateral distances for all the countries i are capped at the import-share weighted average distance from their closest partners ($\text{Distance}_{i.}$): $\text{Distance}_{ij} = min(\text{Distance}_{ij}, \text{Distance}_{i.}), i \neq j, i \in$ focus countries.
3. 1 and 2 combined.

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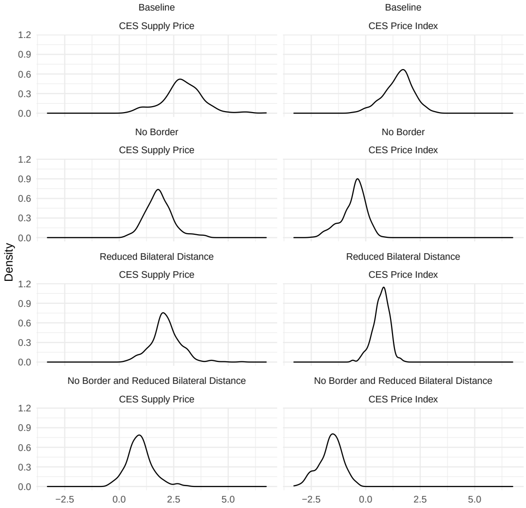
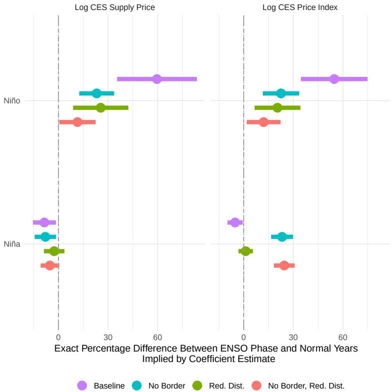
Prices are lower and less variable in the three counterfactuals (all reductions are statistically significant at 99% confidence levels) :



Distribution of CES supply prices and CES price indices under baseline and counterfactual policy scenarios.

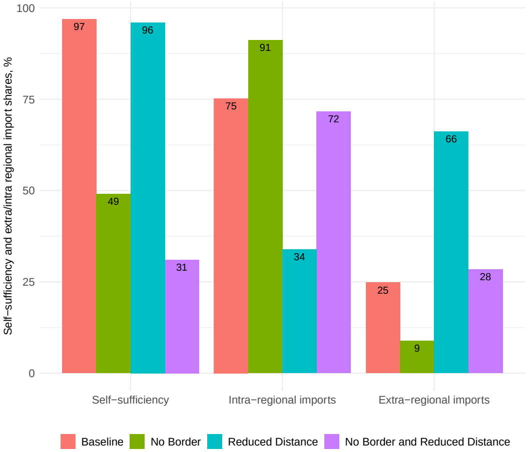
Counterfactual prices are less sensitive to ENSO, but most meaningful reduction is achieved when the two measures are in place:

$$\log(price_{it}) = \beta_0 + \beta_1 Niño_{it} + \beta_2 Niña_{it} + \epsilon_{ij}$$



Effects of ENSO phases on baseline and counterfactual log CES supply prices and log price indices in the focus countries during 1962-2015. 95% confidence intervals using robust standard errors. All models include country fixed effects.

Border reduction encourages intra-regional imports from countries vulnerable to ENSO. Distance reductions encourage extra-regional imports, with little change in volumes imported:



Self-sufficiency, intra- and extra-regional import shares in the focus countries, observed and for conterfactual experiments. Self-sufficiency rates are domestic sale-weighted averages of individual countries' self-sufficiency rates. Intra- and extra-regional import shares are import-weighted averages of individual countries' shares. Source: observed domestic sales and imports are from FAO and COMTRADE, as explained in the Data section. Counterfactual shares are predicted values from estimated regressions under border elimination and/or distance reduction.

Conclusions

- Results suggests a limited role for trade to significantly eliminate price spikes when supply shocks are correlated among close trading partners that face high costs with the rest of the world.
- ENSO is predictable, and its evolution under climate change is uncertain.
- However, main argument is valid for non-ENSO extremes correlated across several countries.

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