Food Policy in a Warming World

Allan Hsiao
Princeton University

Jacob Moscona
Harvard University

Karthik Sastry
Princeton University

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CBOT wheat ($ per bushel)

Source: FT, Refinitiv

Question

- Trade can facilitate climate adaptation
  - But trade policy responds to shocks
- **How does trade policy affect climate damages?**
  - Endogenous vs. exogenous trade policy
  - Aggregate vs. distributional effects

This paper

1. **Theory:** model of agricultural policy, trade, production, climate
   - Ambiguous effects of climate shocks on policy
   - Government weighs constituent welfare against fiscal revenue
2. **Empirics:** new global data by country, crop, year (1980-2011)
   - Domestic shocks lead to consumer aid, especially during elections
   - Foreign shocks lead to producer aid, partially offsetting consumer aid
3. Quantify climate damages with model + empirical estimates
   - Endogenous trade policy increases damages by 9%

Contributions

1. Climate damages and trade with **endogenous government policy**
   - Mendelsohn et al. 1994, Deschênes & Greenstone 2007, Lobell & Field 2007, Schlenker & Roberts 2009, Lobell et al. 2011, Ortiz-Bobea et al. 2021
   - Costinot et al. 2016, Baldos et al. 2019, Gouel and Laborde 2021, Carleton et al. 2022, Hultgren et al. 2022, Rudik et al. 2022, Cruz & Rossi-Hansberg 2023, Nath 2023
2. Trade policy and politics for **climate adaptation**
   - Grossman & Helpman 1994, Goldberg & Maggi 1999, Fajgelbaum et al. 2020, Adão et al. 2023
   - Johnson 1953, Putnam 1988, Bagwell & Staiger 1999, Grossman & Helpman 1995, Ossa 2014
   - Johnson 1991, Anderson 2009, Anderson & Masters 2009, Anderson et al. 2013, Bates 2014

Theory: trade policy with shocks

- Consumption = production + imports

$$Q(p^*) = Y(p^*, \omega) + M(p^* - \tau, \omega')$$

- Government chooses import tax τ to maximize

$$\lambda^C \int_{p^*}^{\infty} Q(p)dp + \lambda^P \int_0^{p^*} Y(p,\omega)dp + \lambda^G \tau M(p^* - \tau, \omega')$$

Optimal trade policy $\alpha = \frac{\tau}{p^* - \tau}$

$$\alpha_1^* = \frac{1}{\epsilon_m}, \quad \alpha_2^* \propto -\lambda^C + \lambda^P(1 - s_m) + \lambda^G s_m \quad \left[s_m = \frac{m}{q} \right]$$

1. Domestic/foreign redistribution (terms-of-trade)
   - Isolated when $\lambda^C = \lambda^P = \lambda^G$, which yields Ramsey rule

2. Consumer/producer redistribution
   - Isolated when $\epsilon_m \to \infty$, which yields cutoff rule
   - Consumer aid involves subsidies with shadow cost λ^G

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Trade policy in response to shocks (ω, ω')

$$F = \epsilon_S(\lambda^C - \lambda^G) - \epsilon_D(\lambda^P - \lambda^G)$$

1. Revenue focus ($F < 0$): α^* increases in ω, decreases in ω'
   - Shock $\uparrow$, imports $\uparrow$, subsidy cost $\uparrow$, tax benefit $\uparrow$ (terms-of-trade)

2. Constituent focus ($F > 0$): α^* decreases in ω, increases in ω'
   - Import subsidy helps (C, P'), hurts (P, C')
   - Shock $\uparrow$, imports $\uparrow$, hurt $P \downarrow$, hurt $C' \uparrow$

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Annual data for 80 crops, 81 countries (1980-2011)

- Agricultural policy, production, trade
  - World Bank: NRA price distortions (negative = pro-consumer)
  - FAO: production, exports, imports
  - Covering 85% of global agricultural production

- Extreme heat exposure
  - ERA-5: temperatures
  - FAO EcoCrop: crop-specific temperature sensitivity (T_k^{max})
  - Earthstat: global geography of agricultural production

- Politics
  - DPI: national election years

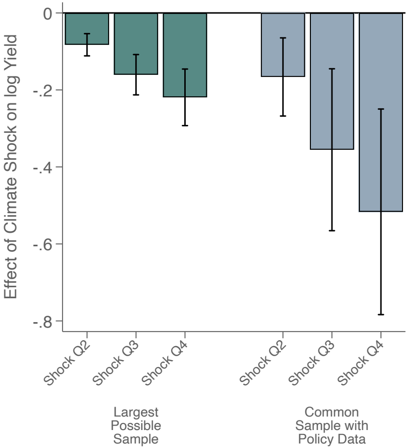
Measurement (country ℓ, crop k, year t, cell c)

$$\text{NRA}_{\ell kt} = \frac{P^d_{\ell kt} - P^m_{\ell kt}}{P^m_{\ell kt}}$$

$$\text{ExtremeHeat}_{\ell kt} = \sum_{c \in \ell} \frac{\text{Area}_{ck}}{\sum_{c' \in \ell} \text{Area}_{c'k}} \cdot \text{DegreeDays}_{ct}(T^{\text{max}}_k)$$

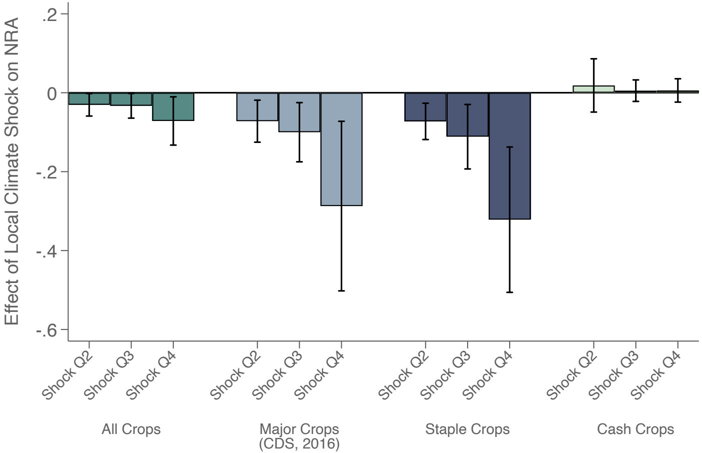
$$\text{ForeignExtremeHeat}_{\ell kt} = \sum_{\ell' \neq \ell} \text{ImportShare}_{\ell' \to \ell k} \cdot \text{ExtremeHeat}_{\ell' kt}$$

Extreme heat lowers yields



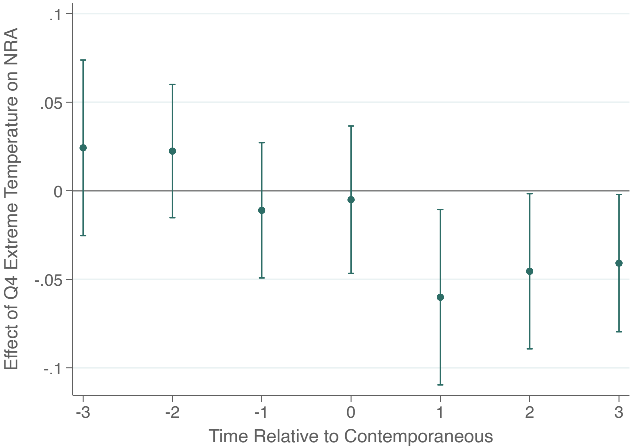
$$\log(\text{yield}_{\ell kt}) = f(\text{ExtremeHeat}_{\ell kt}) + \gamma_{\ell t} + \delta_{kt} + \mu_{\ell k} + \varepsilon_{\ell kt}$$

Extreme heat induces pro-consumer policy



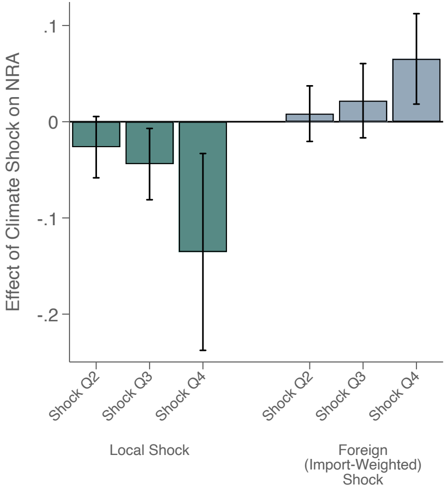
$$\log(\mathsf{NRA}_{\ell kt}) = g(\mathsf{ExtremeHeat}_{\ell kt}) + \gamma_{\ell t} + \delta_{kt} + \mu_{\ell k} + \varepsilon_{\ell kt}$$

Extreme heat induces persistent pro-consumer policy



$$\log(\mathsf{NRA}_{\ell kt}) = \sum_{s=-3}^{3} g(\mathsf{ExtremeHeat}_{\ell kt+s}) + \gamma_{\ell t} + \delta_{kt} + \mu_{\ell k} + \varepsilon_{\ell kt}$$

Foreign exposure has offsetting effects



$$\log(\mathsf{NRA}_{\ell kt}) = g(\mathsf{ExtremeHeat}_{\ell kt}) + h(\mathsf{ForeignExtremeHeat}_{\ell kt}) + \gamma_{\ell t} + \delta_{kt} + \mu_{\ell k} + \varepsilon_{\ell kt}$$

Effects strongest before elections $(N_{\text{full}} = 15,860)$

	Full Sample	Major Crops	Staple Crops	Cash Crops
Q2 Extreme Heat Exposure x No Election	-0.0429*	-0.0724	-0.0509	-0.0259
	(0.0222)	(0.0445)	(0.0390)	(0.0486)
Q3 Extreme Heat Exposure x No Election	-0.0138	-0.0788	-0.0561	-0.0182
	(0.0236)	(0.0654)	(0.0719)	(0.0163)
Q4 Extreme Heat Exposure x No Election	-0.0172	-0.0948	-0.104	-0.0126
	(0.0374)	(0.101)	(0.0946)	(0.0216)
Q2 Extreme Heat Exposure x Election	-0.0120	-0.0689**	-0.0820**	0.0680
	(0.0172)	(0.0315)	(0.0316)	(0.0600)
Q3 Extreme Heat Exposure x Election	-0.0363	-0.110**	-0.145**	0.0217
	(0.0230)	(0.0543)	(0.0627)	(0.0223)
Q4 Extreme Heat Exposure x Election	-0.108**	-0.382**	-0.436***	0.0203
	(0.0490)	(0.149)	(0.142)	(0.0246)

$$\log(\mathsf{NRA}_{\ell kt}) = g(\mathsf{ExtremeHeat}_{\ell kt}) + g^{\mathsf{E}}(\mathsf{ExtremeHeat}_{\ell kt} \times \mathsf{Election}_{\ell t}) + \gamma_{\ell t} + \delta_{kt} + \mu_{\ell k} + \varepsilon_{\ell kt}$$

Simulating climate change

$$\begin{aligned}
\log q_{\ell k} &= \log q^0_{\ell k} - \epsilon_d \log p_{\ell k} \\
\log y_{\ell k} &= \log y^0_{\ell k} + \epsilon_s \log p_{\ell k} + f(\text{ExtremeHeat}_{\ell k}) \\
\alpha_{\ell k} &= \alpha^0_{\ell k} + g(\text{ExtremeHeat}_{\ell k}) + h(\text{ForeignExtremeHeat}_{\ell k})
\end{aligned}$$

- Demand $q_{\ell k}$, supply $y_{\ell k}$, NRA $\alpha_{\ell k}$, prices $p_{\ell k} = (1 + \alpha_{\ell k})p_k$
- World prices p_k clear markets
- Climate change via (f, g, h)

$$\text{ExtremeHeat}^{\text{CC}}_{\ell k} = \text{ExtremeHeat}_{\ell k} + 100$$

Total welfare losses 9% bigger under endogenous trade policy

Trade policy	Total	CS	PS	G
Endogenous	-3.89	-3.36	-3.13	-48.72
Endogenous, domestic only	-4.19	-3.80	-3.04	-52.47
Endogenous, foreign only	-3.15	-3.25	-4.03	24.26
Exogenous	-3.55	-3.67	-3.81	8.68

- Government shields consumers and producers, but very costly
- Losses 6% bigger for high-income countries, 12% for low-income

Summary

- Extreme heat prompts pro-consumer trade policy
- Endogenous trade policy complicates global adaptation
  - Important distributional effects both within and across countries
- Next: richer quantitative model
  - Global vs. local shocks
  - Global vs. local policy responses

Crops

Major	Staple	Cash
maize	maize	cocoa
soy	soy	coffee
rice	rice	cotton
wheat	wheat	palm
potato	potato	sugar
tomato	tomato	tobacco
banana	onion	
cotton		
palm		
sugar		