Food Policy in a Warming World

Allan Hsiao
Princeton University

Jacob Moscona
Harvard University

Karthik Sastry
Princeton University

January 7, 2023


CBOT wheat ($ per bushel)
Source: FT, Refinitiv
14
12
10
8
Q1 21
Q2 21
Q3 21
Q4 21
Q1 22
Q2 22

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. **Quantitative model:** empirical estimates $\rightarrow$ climate damages
   - Endogenous trade policy increases 2100 damages by 14%

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

$$\underbrace{Q(p^*)}_{\text{consumption}} = \underbrace{Y(p^*, \omega)}_{\text{production}} + \underbrace{M(\alpha, p^*, \omega')}_{\text{imports}}$$

$$\alpha^* = \arg\max \left\{ \lambda^C CS(p^*) + \lambda^P PS(p^*, \omega) + \lambda^G G(\alpha, p^*, \omega') \right\}$$

1. Domestic/foreign redistribution (terms-of-trade)
2. Consumer/producer redistribution

Trade policy in response to shocks

1. Revenue focus: $\lambda^G \gg \lambda^C, \lambda^P$
   - α^* increases in ω, decreases in ω'
   - Shock $\uparrow$, imports $\uparrow$, subsidy cost $\uparrow$, tax benefit $\uparrow$ (terms-of-trade)
2. Constituent focus: $\lambda^C \gg \lambda^G$ or $\lambda^P \gg \lambda^G$
   - α^* decreases in ω, increases in ω'
   - Import subsidy helps (C, P'), hurts (P, C')
   - Shock $\uparrow$, imports $\uparrow$, hurt $P \downarrow$, hurt $C' \uparrow$

Data

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

- Agricultural policy, production, trade
  - World Bank: nominal rate of assistance (price distortions)
  - FAO: production, exports, imports
  - Covering 85% of global agricultural production

- Extreme heat exposure
  - ERA-5: temperatures
  - FAO EcoCrop: crop-specific temperature sensitivity
  - Earthstat: global geography of agricultural production

- Politics
  - Database of Political Institutions: national election years

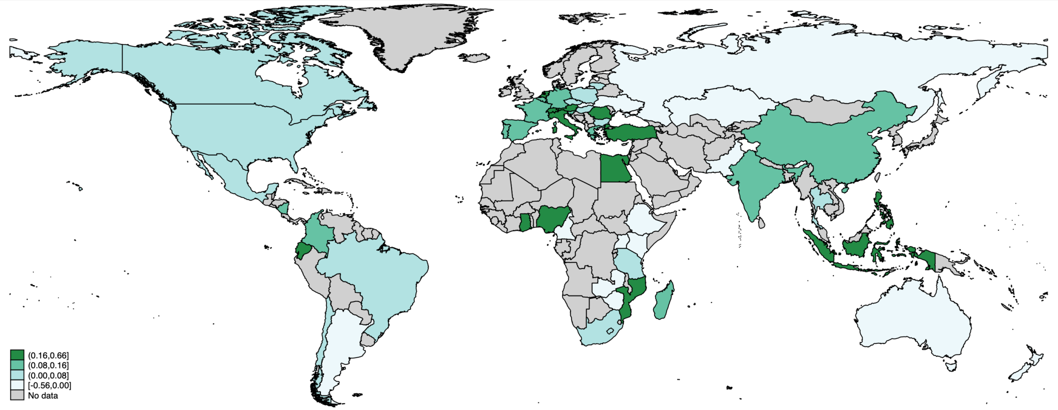
Measuring agricultural policy

$$\mathsf{NRA}_{\ell kt} = \frac{P^d_{\ell kt} - P^w_{\ell kt}}{P^w_{\ell kt}}$$

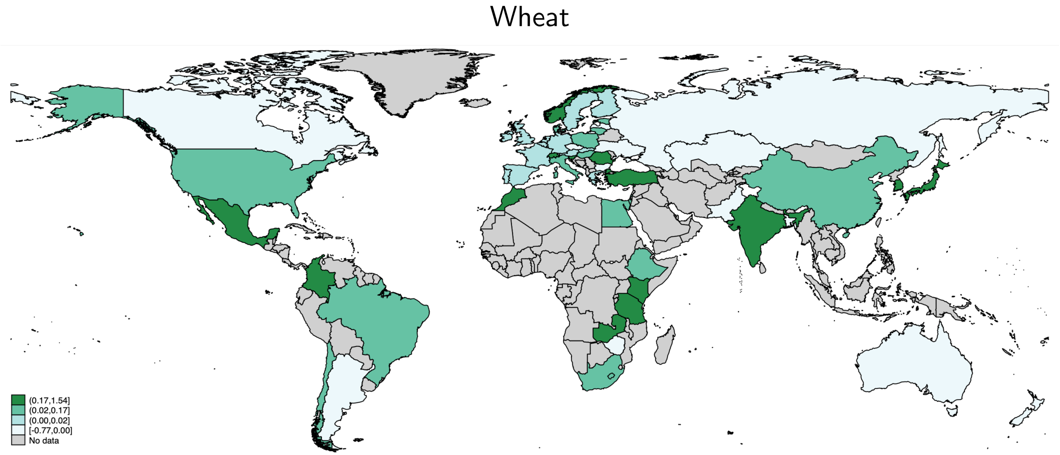
- Domestic vs. world price by country ℓ, crop k, year t
  - "Distortions to Agricultural Incentives" (Anderson & Valenzuela 2008)
  - 82 countries, 80 crops, 85% of production (1955-2011)

Average nominal rate of assistance (2001-2010)

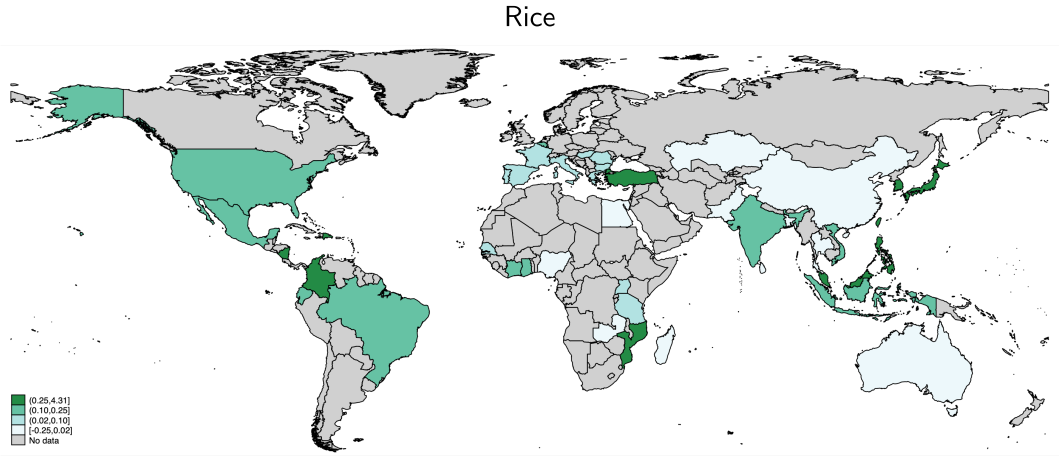
Maize



Average nominal rate of assistance (2001-2010)



Average nominal rate of assistance (2001-2010)



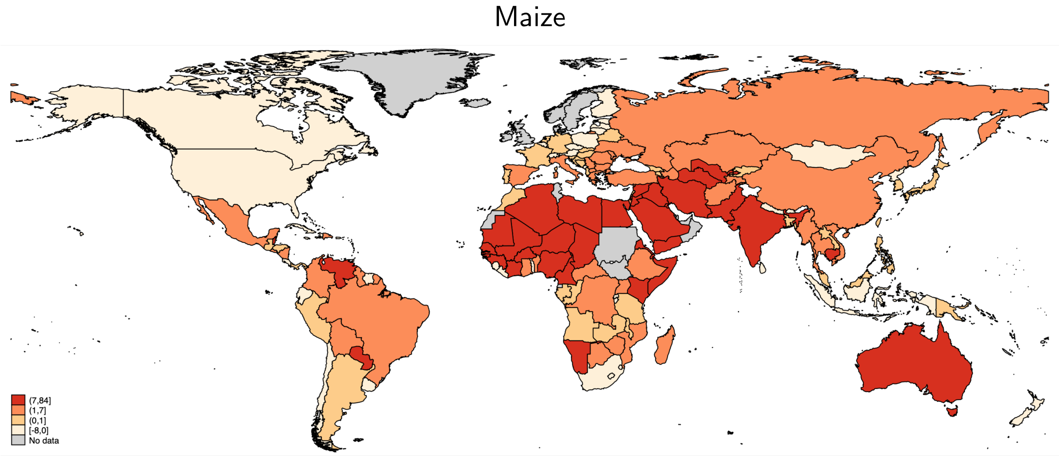
Measuring extreme heat exposure

$$\text{ExtremeHeat}_{\ell kt} = \sum_{c \in \ell} \frac{\text{Area}_{ck}}{\sum_{c' \in \ell} \text{Area}_{c'k}} \cdot \text{DegreeDays}_{ct}(T_k^{\text{max}})$$

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

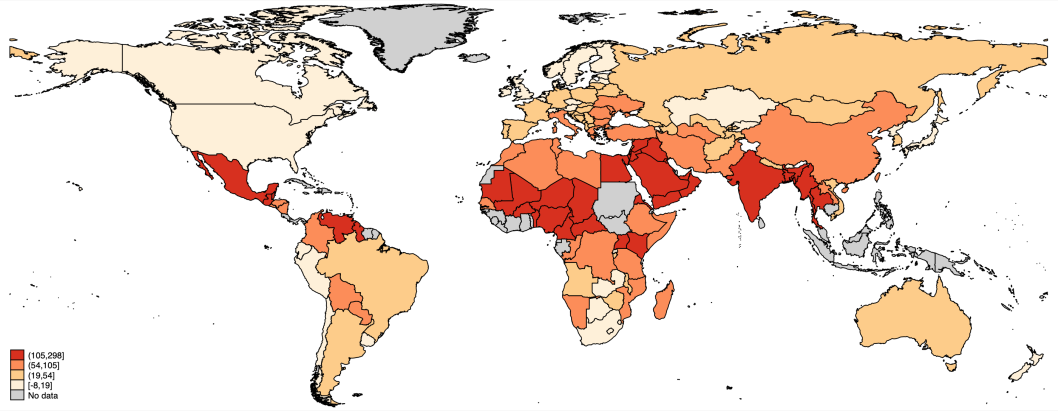
- Growing degree days by country ℓ, crop k, year t, cell c

Change in growing degree days (1980-2010)

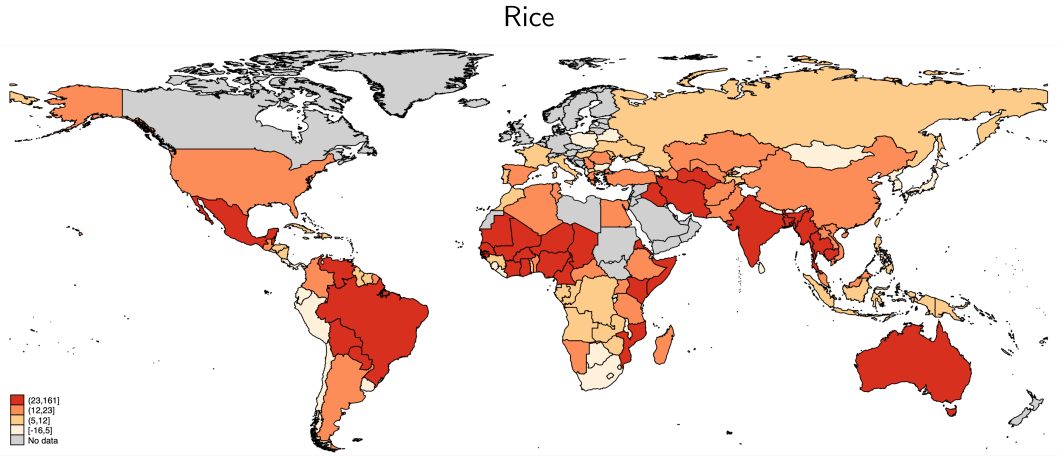


Change in growing degree days (1980-2010)

Wheat

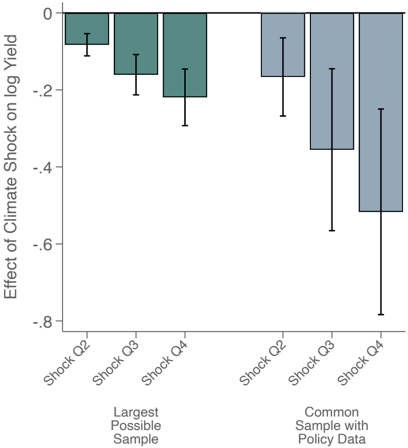


Change in growing degree days (1980-2010)



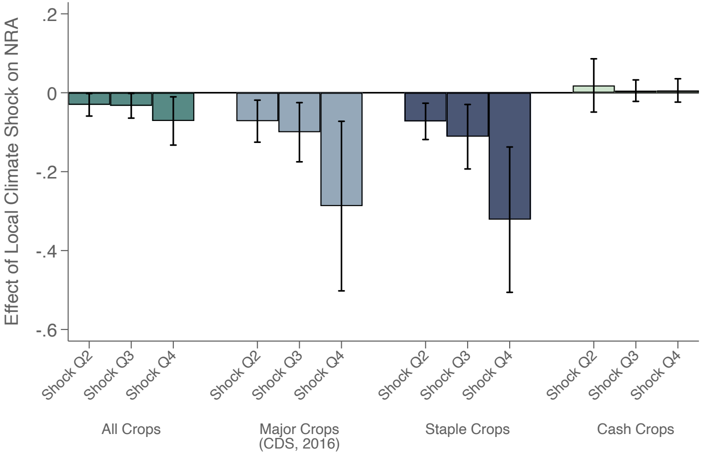
Empirical results

Extreme heat lowers yields (quartile effects)



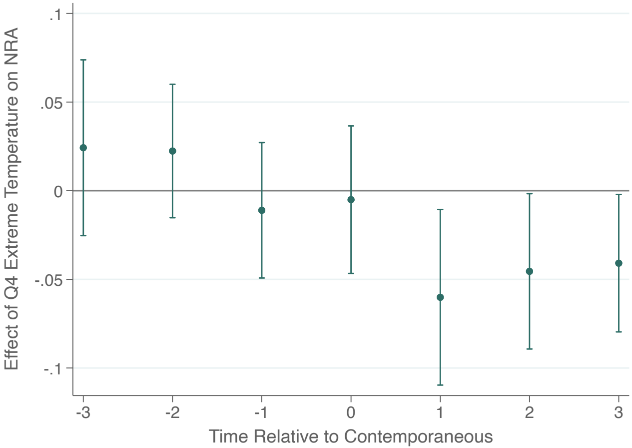
$$\log(\text{yield}_{\ell kt}) = f(\text{ExtremeHeat}_{\ell kt}) + \gamma_{\ell t} + \delta_{kt} + \mu_{\ell k} + \varepsilon_{\ell kt}$$

Extreme heat induces pro-consumer policy



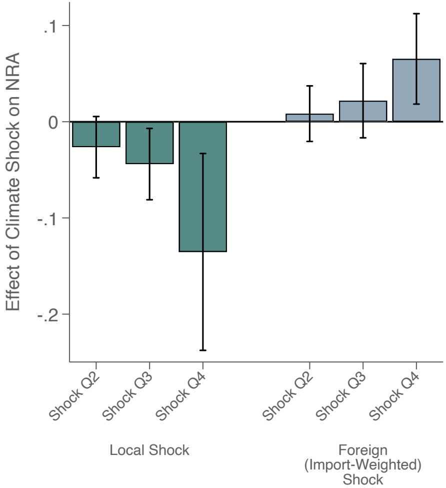
$$\mathrm{NRA}_{\ell kt} = g(\mathrm{ExtremeHeat}_{\ell kt}) + \gamma_{\ell t} + \delta_{kt} + \mu_{\ell k} + \varepsilon_{\ell kt}$$

Extreme heat induces persistent pro-consumer policy



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

Foreign exposure has offsetting effects



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

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)
p-value, Q4 x Election - Q4 x No Election	*0.08*	*0.03*	*0.04*	*0.34*

Welfare effects

Simulating climate change

$$\text{ExtremeHeat}_{\ell k}^{\text{2000s}} \to \text{ExtremeHeat}_{\ell k}^{\text{2090s}}$$

$$\begin{aligned}
\text{demand} \quad & \log q_{\ell k} = \log q_{\ell k}^0 - \epsilon_d \log[(1+\alpha_{\ell k})p_k] \\
\text{supply} \quad & \log y_{\ell k} = \log y_{\ell k}^0 + \epsilon_s \log[(1+\alpha_{\ell k})p_k] - f(\text{ExtremeHeat}_{\ell k}) \\
\text{NRA} \quad & \alpha_{\ell k} = \alpha_{\ell k}^0 - g(\text{ExtremeHeat}_{\ell k}) + h(\text{ForeignExtremeHeat}_{\ell k})
\end{aligned}$$

$$\text{equilibrium} \quad Q_k(p_k^*) = Y_k(p_k^*)$$

Global welfare losses 14% bigger under endogenous trade policy

Full sample	W	CS	PS	G
Endogenous	-2.96	-1.48	-0.37	-1.11
Exogenous	-2.55	-1.72	-0.81	-0.02
Difference (%)	-14	16	123	-98

- Governments shield consumers and producers, but at great cost

Driven by country-crops with biggest production losses

Most impacted	W	CS	PS	G
Endogenous	-2.41	0.63	-2.13	-0.92
Exogenous	-1.73	-0.64	-1.15	0.06
Difference (%)	-28	201	-46	-107

- Governments aid domestic consumers, but hurt domestic producers

Opposite distributional effects elsewhere

Less impacted	Total	CS	PS	G
Endogenous	-0.55	-2.11	1.76	-0.19
Exogenous	-0.82	-1.08	0.34	-0.08
Difference (%)	51	-49	81	-59

- Losses for foreign consumers, gains for foreign producers

Summary

- Extreme heat prompts pro-consumer trade policy
- Endogenous trade policy complicates global adaptation
    - Important distributional effects both within and across countries

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		