

# Food Policy in a Warming World

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December 7, 2023



# 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 Quantitative model: empirical estimates → 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: $\lambda^G \gg \lambda^C, \lambda^P$

- $\alpha^*$  increases in  $\omega$ , decreases in  $\omega'$
- Shock  $\uparrow$ , imports  $\uparrow$ , subsidy cost  $\uparrow$ , tax benefit  $\uparrow$  (terms-of-trade)

## ② Constituent focus: $\lambda^C \gg \lambda^G$ or $\lambda^P \gg \lambda^G$

- $\alpha^*$  decreases in  $\omega$ , increases in  $\omega'$
- 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)

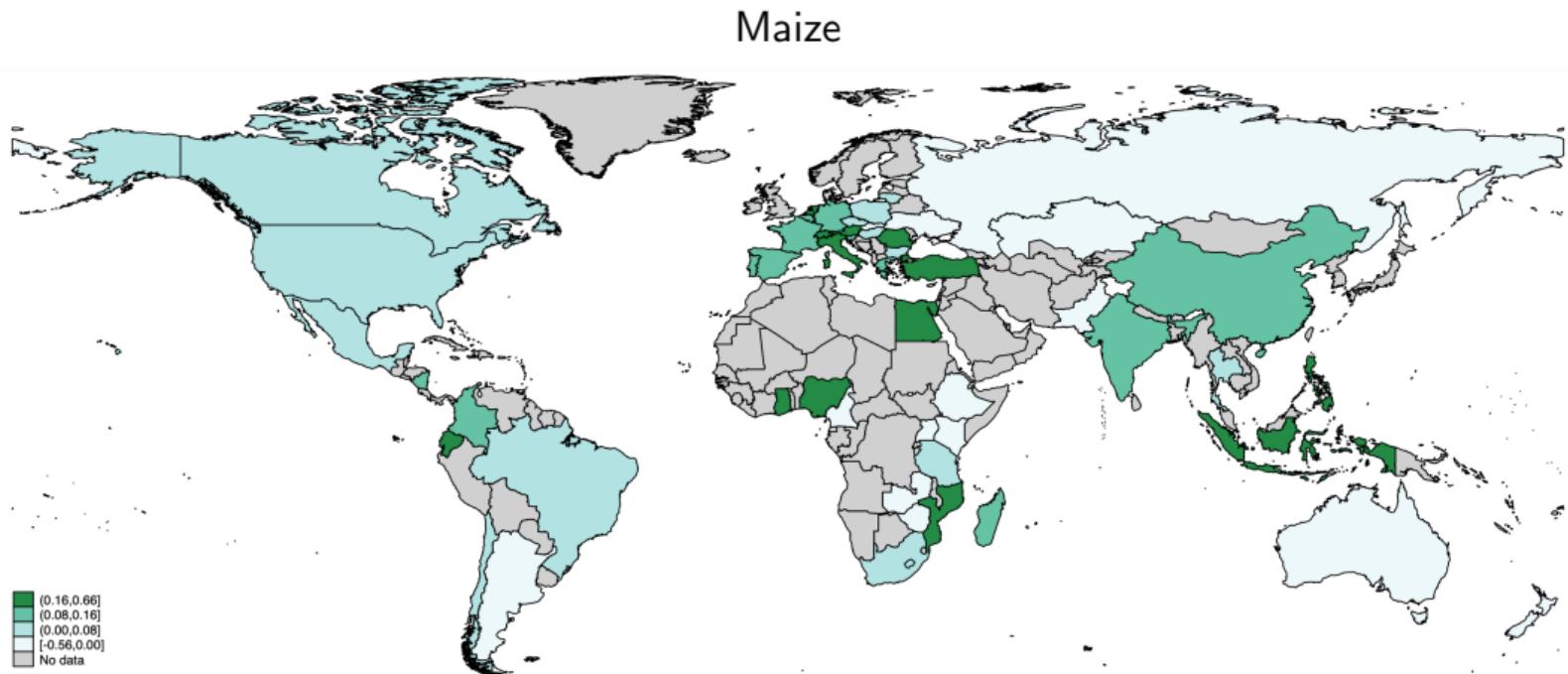
- Agricultural policy, production, trade
  - World Bank: nominal rate of assistance (price distortions)
  - FAO: production, exports, imports
  - Covering 85% of global agricultural production
- Extreme heat exposure
  - ERA-5: temperatures
  - FAO EcoCrop: crop-specific temperature sensitivity
  - Earthstat: global geography of agricultural production
- Politics
  - Database of Political Institutions: national election years

# Measuring agricultural policy

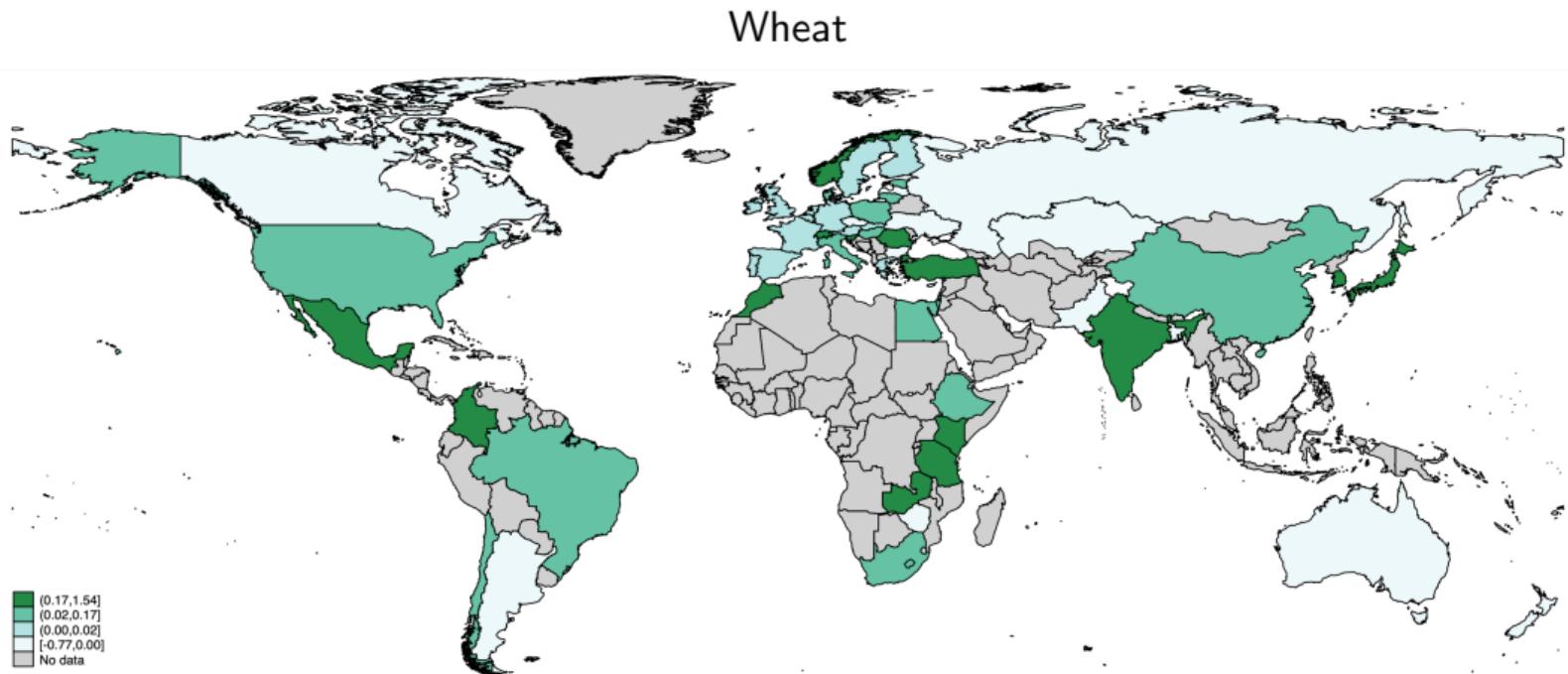
$$\text{NRA}_{\ellkt} = \frac{P_{\ellkt}^d - P_{\ellkt}^w}{P_{\ellkt}^w}$$

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

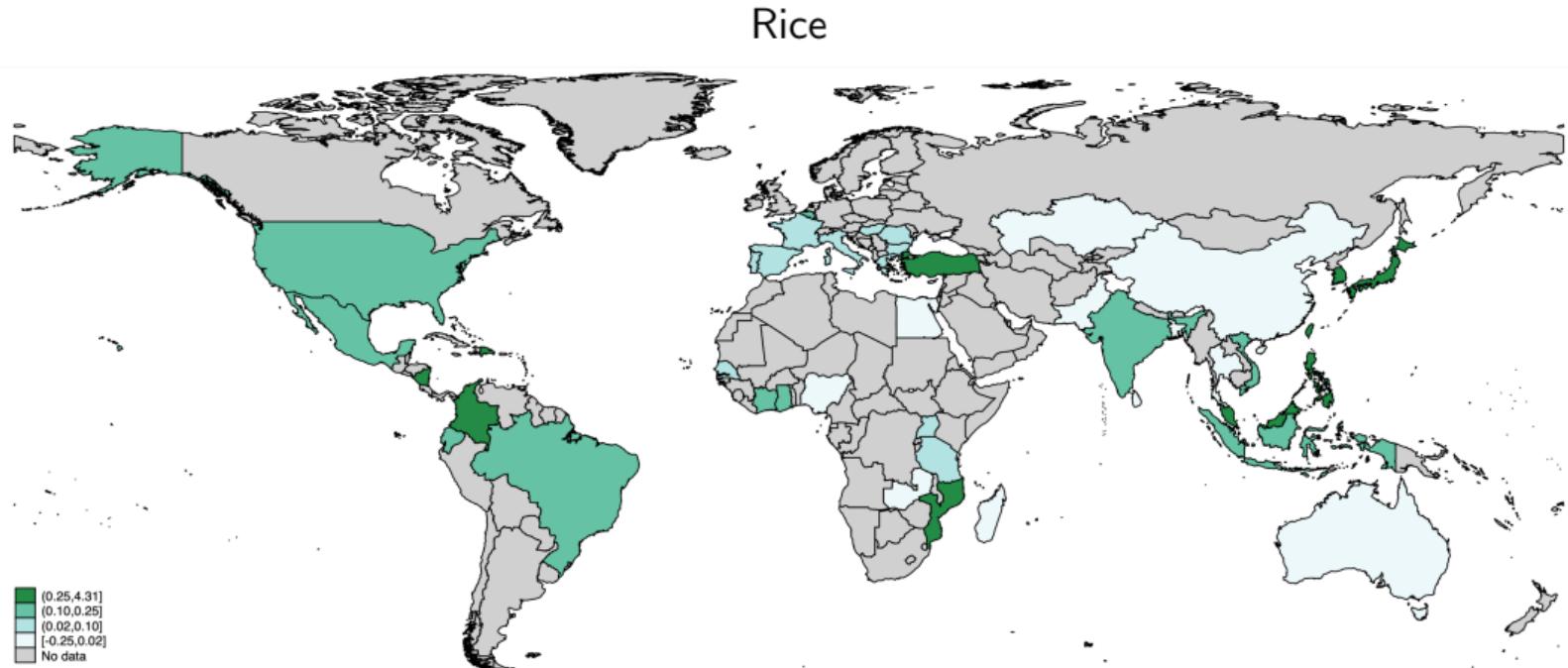
# Average nominal rate of assistance (2001-2010)



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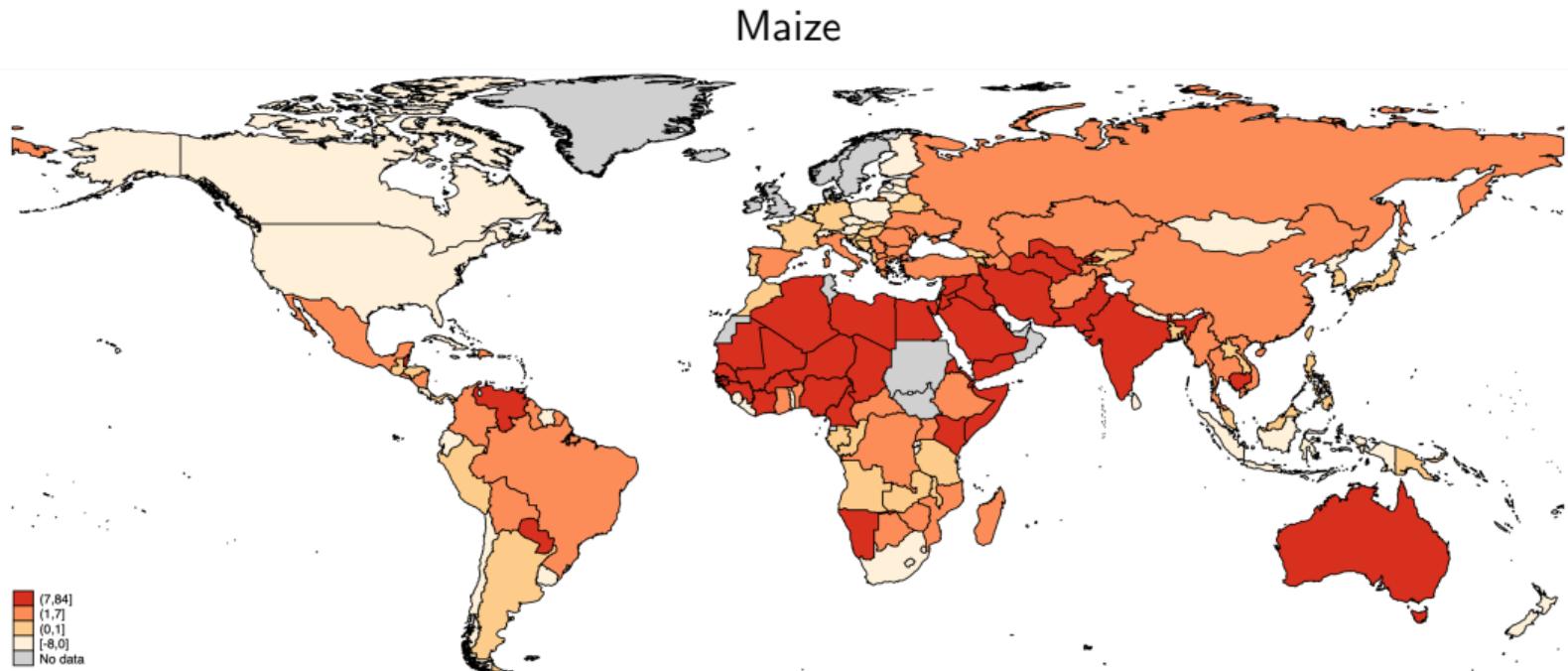
## Measuring extreme heat exposure

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

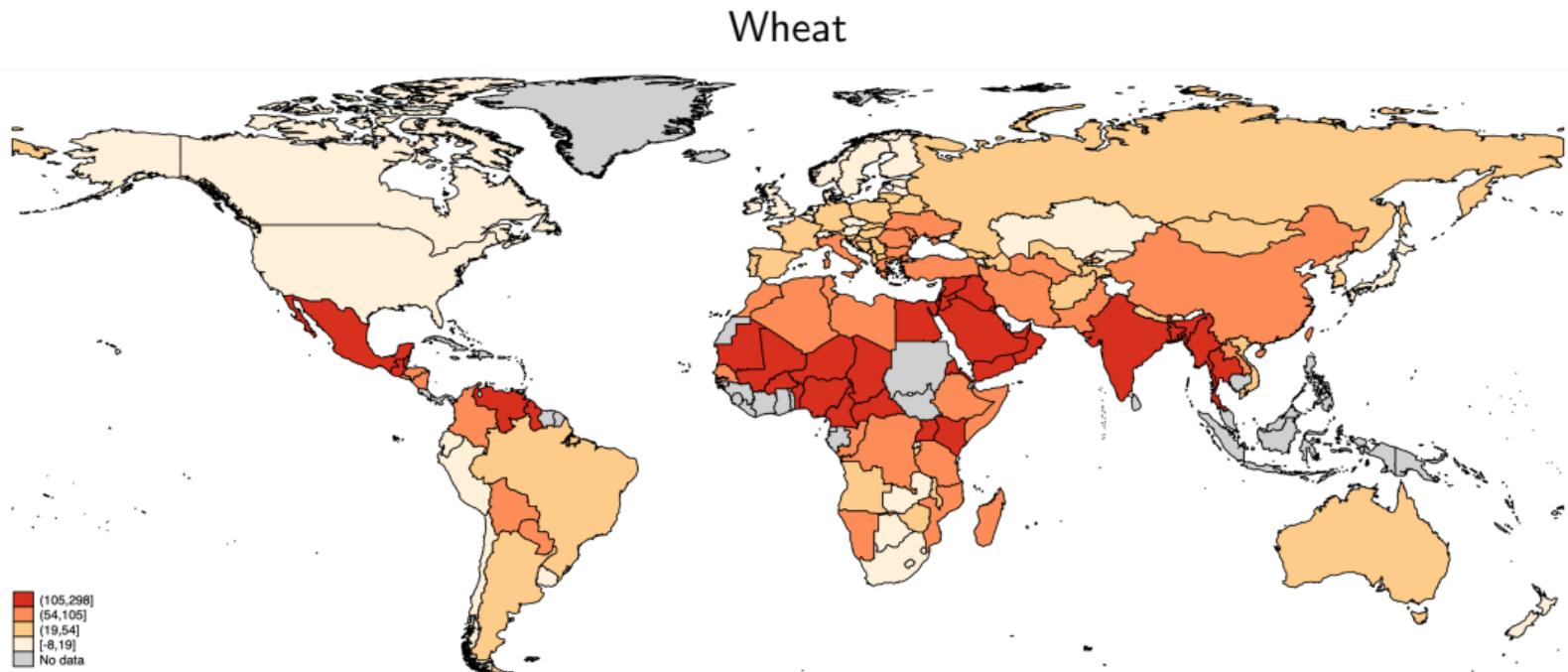
$$\text{ForeignExtremeHeat}_{\ell kt} = \sum_{\ell' \neq \ell} \text{ImportShare}_{\ell' \rightarrow \ell k} \cdot \text{ExtremeHeat}_{\ell' kt}$$

- Growing degree days by country  $\ell$ , crop  $k$ , year  $t$ , cell  $c$

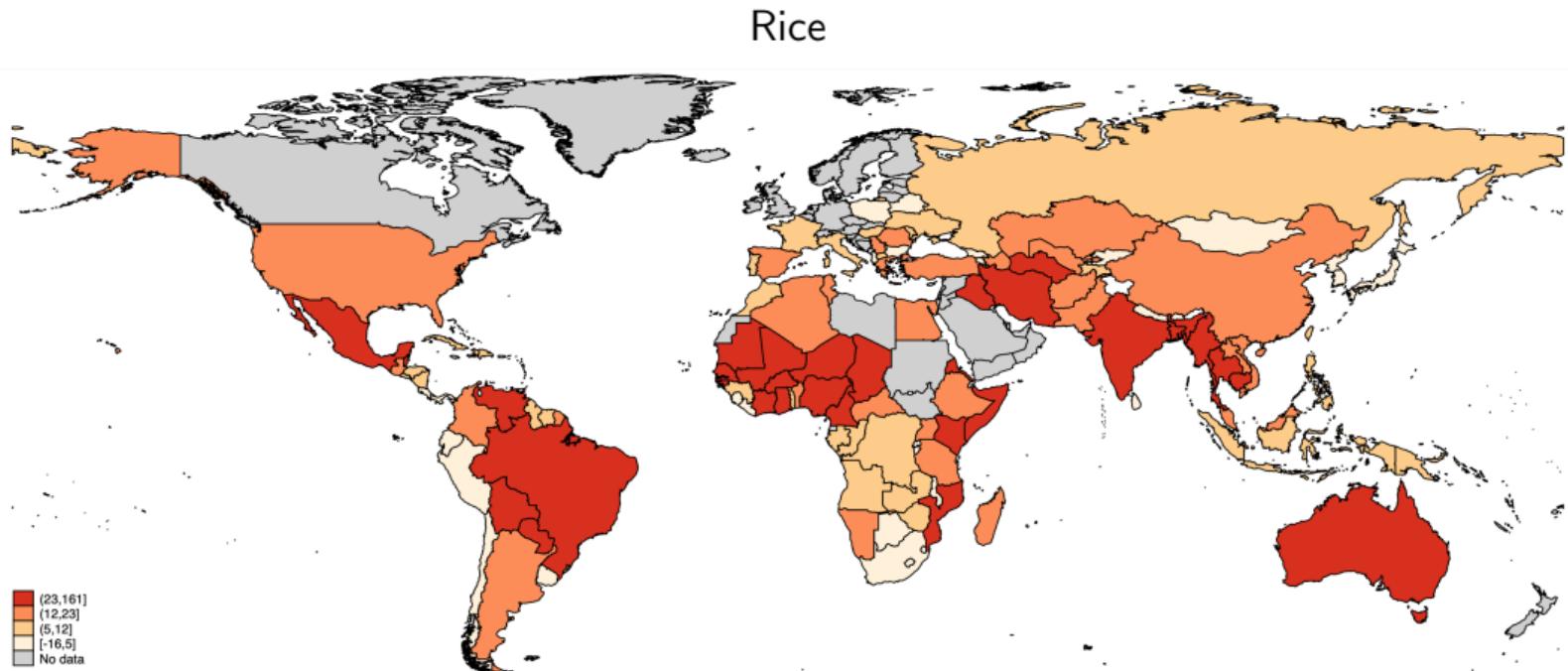
# Change in growing degree days (1980-2010)



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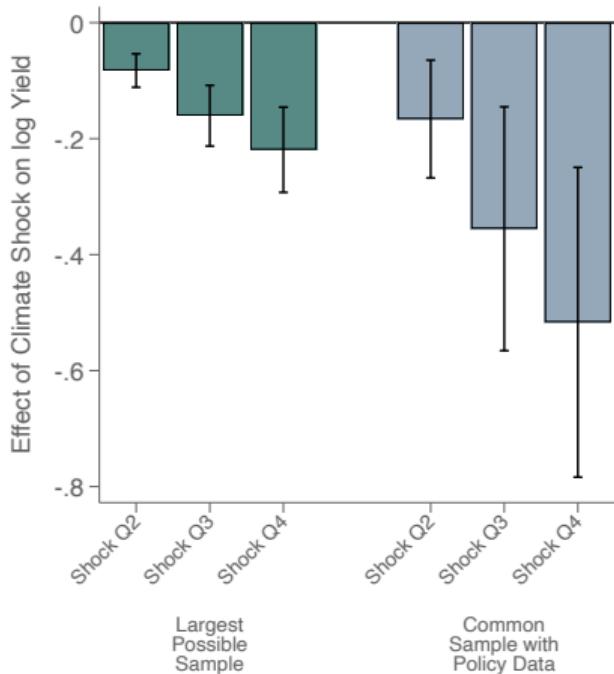


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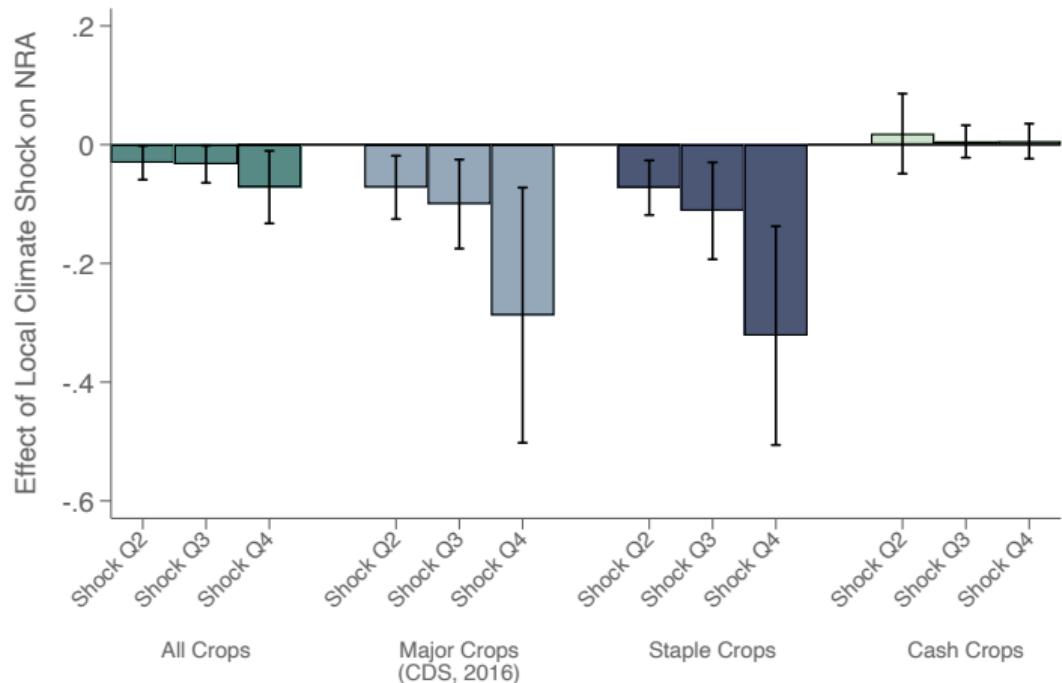
## Empirical results

## Extreme heat lowers yields (quartile effects)



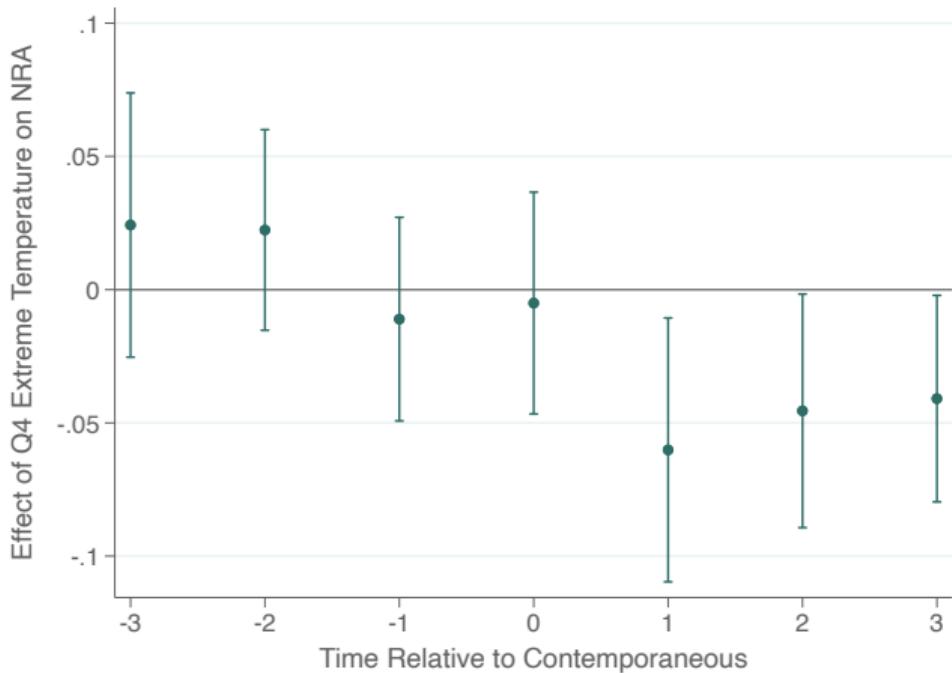
$$\log(\text{yield}_{\ell k t}) = f(\text{ExtremeHeat}_{\ell k t}) + \gamma_{\ell t} + \delta_{k t} + \mu_{\ell k} + \varepsilon_{\ell k t}$$

# Extreme heat induces pro-consumer policy



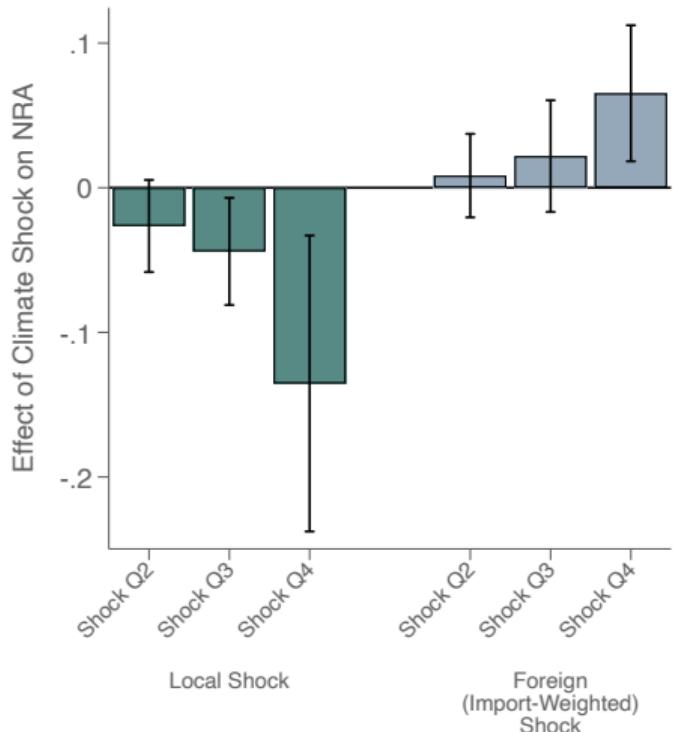
$$\text{NRA}_{\ell kt} = g(\text{ExtremeHeat}_{\ell kt}) + \gamma_{\ell t} + \delta_{kt} + \mu_{\ell k} + \varepsilon_{\ell kt}$$

# Extreme heat induces persistent pro-consumer policy



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

## Foreign exposure has offsetting effects



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

## 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* (0.0222)	-0.0724 (0.0445)	-0.0509 (0.0390)	-0.0259 (0.0486)
Q3 Extreme Heat Exposure x No Election	-0.0138 (0.0236)	-0.0788 (0.0654)	-0.0561 (0.0719)	-0.0182 (0.0163)
Q4 Extreme Heat Exposure x No Election	-0.0172 (0.0374)	-0.0948 (0.101)	-0.104 (0.0946)	-0.0126 (0.0216)
Q2 Extreme Heat Exposure x Election	-0.0120 (0.0172)	-0.0689** (0.0315)	-0.0820** (0.0316)	0.0680 (0.0600)
Q3 Extreme Heat Exposure x Election	-0.0363 (0.0230)	-0.110** (0.0543)	-0.145** (0.0627)	0.0217 (0.0223)
Q4 Extreme Heat Exposure x Election	-0.108** (0.0490)	-0.382** (0.149)	-0.436*** (0.142)	0.0203 (0.0246)
<i>p-value, Q4 x Election - Q4 x No Election</i>	0.08	0.03	0.04	0.34

## Welfare effects

# Simulating climate change

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

supply

$$\log q_{\ell k} = \log q_{\ell k}^0 - \epsilon_d \log[(1 + \alpha_{\ell k}) p_k]$$

demand

$$\log y_{\ell k} = \log y_{\ell k}^0 + \epsilon_s \log[(1 + \alpha_{\ell k}) p_k] - f(\text{ExtremeHeat}_{\ell k})$$

NRA

$$\alpha_{\ell k} = \alpha_{\ell k}^0 - g(\text{ExtremeHeat}_{\ell k}) + h(\text{ForeignExtremeHeat}_{\ell k})$$

equilibrium

$$Q_k(p_k^*) = Y_k(p_k^*)$$

## 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		