Food Policy in a Warming World

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Three perspectives on India's export ban

Indian Ministry of Commerce & Industry
May 13 statement

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Farmer Ranbeer Singh Sirsa of Punjab
May 14 *New York Times*

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Questions

1. **How do governments intervene in response to agricultural shocks?**
2. **What are the aggregate and distributional consequences?**

This paper

1. **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, possibly offsetting consumer aid
   - Persistent effects, including for longer-run changes

2. **Theory:** model of agricultural policy and trade
   - To rationalize observed policy responses
   - Government considers redistribution and revenues

3. **Quantification:** how policy responses affect incidence of climate damages
   - Policy responses shield domestic consumers by stabilizing prices

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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

Data and Measurement

Shocks: extreme heat exposure

- Capture that extreme heat drives yield variability (Schlenker & Roberts 2009)
  - ERA-5 re-analysis data on temperatures
  - EarthStat data on geography of crop production (Monfreda et al. 2008)
  - ECOCROP data on crop-specific temperature sensitivity (Moscona & Sastry 2022)

- Exposure by country ℓ, crop k, year t, aggregating over cells c

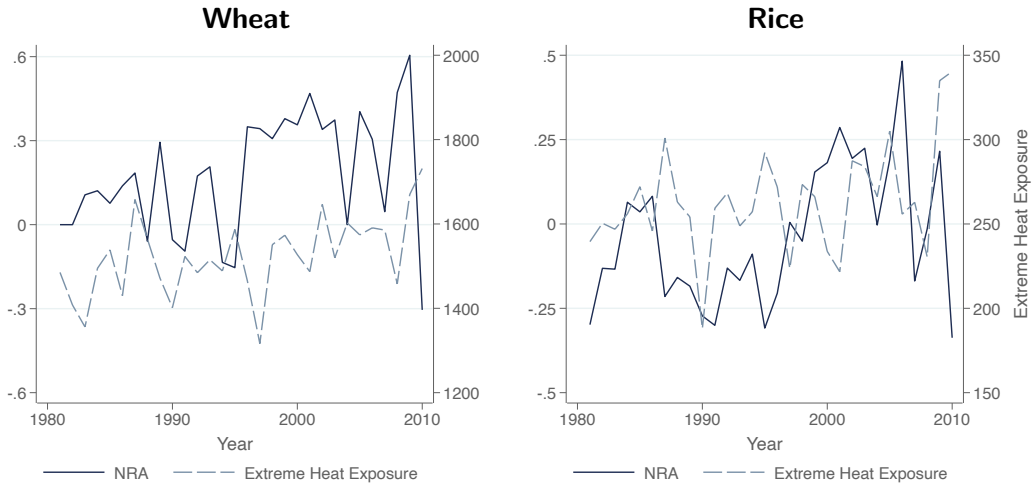
$$\text{ExtremeHeat}_{\ell kt} = \sum_{c \in \ell} \frac{\text{Area}_{ck}}{\sum_{c' \in \ell} \text{Area}_{c'k}} \cdot \text{DegreeDays}_{ct}(T_k^{\max})$$

Policy: nominal rate of assistance

- "Distortions to Agricultural Incentives" project (Anderson & Valenzuela 2008)
  - 80 products, 82 countries, 85% of global production (1955-2011)
  - Wedge between domestic and international prices
  - "Pro-consumer" if $NRA_{\ell kt} < 0$

- Captures multiple dimensions of policy
  - Quantity instruments, input-market interventions, temporary measures
  - But some subjectivity in measurement

Example: staples in India



Empirical Results

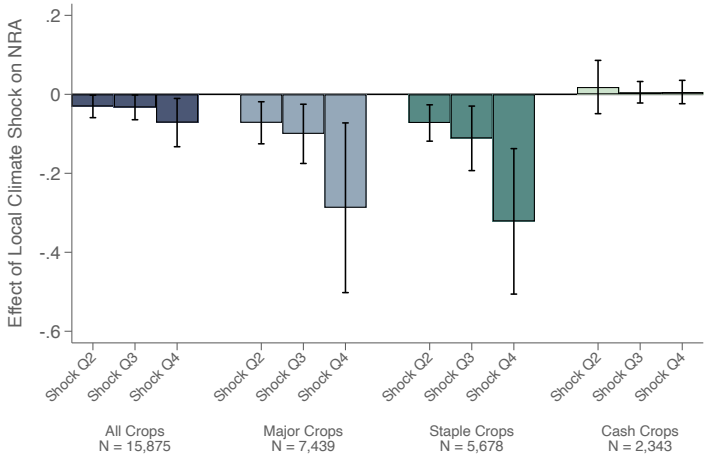
1. How does extreme heat affect trade policy?

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

- Country ℓ, crop k, year t, quartile dummies $g(\cdot)$
- Fixed effects by country-year, crop-year, country-crop

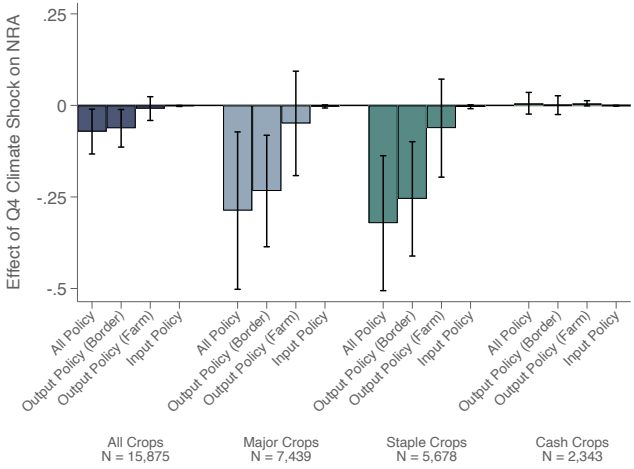
- **Identification:** some crops get worse shocks due to physiology, geography

Extreme heat induces pro-consumer policy



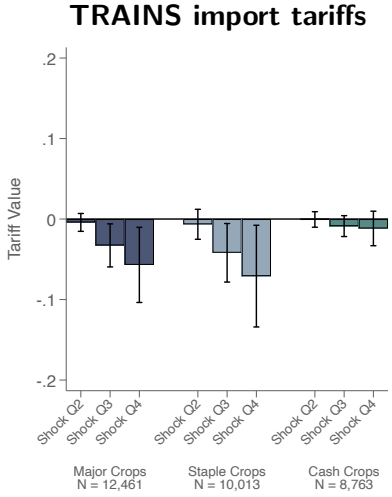
$$\text{NRA}_{\ell kt} = g(\text{ExtremeHeat}_{\ell kt}) + \gamma_{\ell t} + \delta_{kt} + \mu_{\ell k} + \varepsilon_{\ell kt}$$

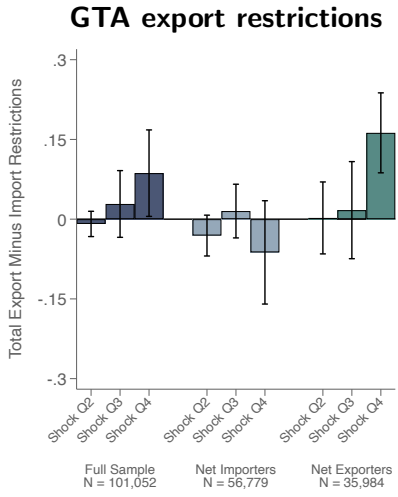
Effects concentrated in border policies



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

With lower import tariffs and more export restrictions





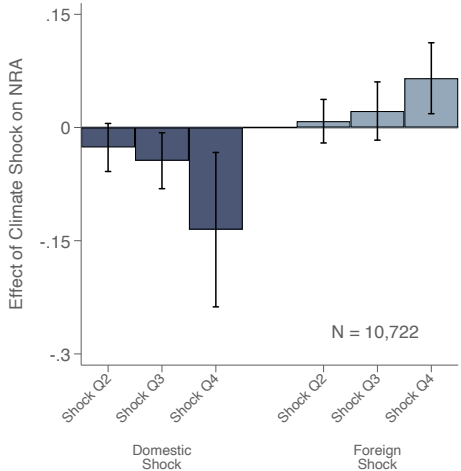
$$\text{Policy}_{\ell kt} = g(\text{ExtremeHeat}_{\ell kt}) + \gamma_{\ell t} + \delta_{kt} + \mu_{\ell k} + \varepsilon_{\ell kt}$$

2. How do foreign shocks affect trade policy?

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

- Country ℓ, crop k, year t, quartile dummies $g(\cdot)$ and $h(\cdot)$
- Fixed effects by country-year, crop-year, country-crop
- ForeignExtremeHeat: trade partner shocks, weighted by pre-period trade shares

Foreign shocks induce pro-producer policy



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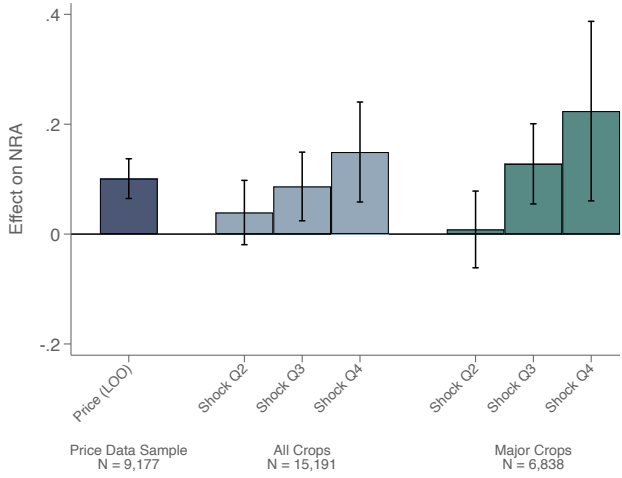
Global shocks also induce pro-producer policy



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

3. How does extreme heat affect longer-run policy?

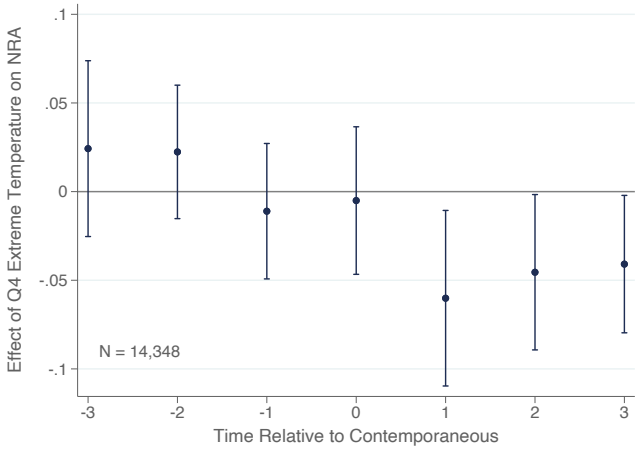
- Longer-run policy: country ℓ, crop k, years $t+s$

$$\text{NRA}_{\ell kt} = \sum_{s=-3}^{3} \text{ExtremeHeat}^{\text{Q4}}_{\ell kt+s} + \gamma_{\ell t} + \delta_{kt} + \mu_{\ell k} + \varepsilon_{\ell kt}$$

- Longer-run shocks: country ℓ, crop k, decade $\bar{t}$

$$\text{NRA}_{\ell k\bar{t}} = \beta\, \text{YearsHeat}^{\text{Q4}}_{\ell k\bar{t}} + \alpha\, \text{YearsForeignHeat}^{\text{Q4}}_{\ell k\bar{t}} + \gamma_{\ell\bar{t}} + \delta_{k\bar{t}} + \mu_{\ell k} + \varepsilon_{\ell k\bar{t}}$$

Annual shocks have persistent effects



$$\text{NRA}_{\ell kt} = \sum_{s=-3}^{3} \text{ExtremeHeat}^{\text{Q4}}_{\ell kt+s} + \gamma_{\ell t} + \delta_{kt} + \mu_{\ell k} + \varepsilon_{\ell kt}$$

Decadal shocks have similar effects

	All Policy	Output Policy	Output Policy (Border)	Output Policy (Farm)
Years of Extreme Heat (Local)	-0.0252**	-0.0251**	-0.0204**	-0.00468
	(0.0110)	(0.0111)	(0.00897)	(0.00471)
Years of Extreme Heat (Foreign)	0.0179*	0.0180*	0.0131***	0.00491
	(0.00969)	(0.00968)	(0.00463)	(0.00727)
Observations	1,951	1,951	1,951	1,951

$$\text{NRA}_{\ell k \bar{t}} = \beta \, \text{YearsHeat}^{\text{Q4}}_{\ell k \bar{t}} + \alpha \, \text{YearsForeignHeat}^{\text{Q4}}_{\ell k \bar{t}} + \gamma_{\ell \bar{t}} + \delta_{k \bar{t}} + \mu_{\ell k} + \varepsilon_{\ell k \bar{t}}$$

4. Does political economy drive policy effects?

$$\text{NRA}_{\ell kt} = g(\text{Heat}_{\ell kt} \times \text{No Election}_{\ell kt}) + h(\text{Heat}_{\ell kt} \times \text{Election}_{\ell t}) + \gamma_{\ell t} + \delta_{kt} + \mu_{\ell k} + \varepsilon_{\ell kt}$$

- Country ℓ, crop k, year t, $g(\cdot)$ and $h(\cdot)$ quartile dummies
- Fixed effects by country-year, crop-year, country-crop
- $\text{Election}_{\ell t}$: election year or one year before (Database for Political Institutions)

- Elections erode fiscal responsibility $\Rightarrow$ negative interaction coefficients
  - Political cycles, e.g. Alesina & Roubini 1992, Akhmedov & Zhuravskaya 2004

Stronger effects before elections

	Full sample		Major crops	
	Estim	SE	Estim	SE
Q2 Extreme Heat × No Election	-0.0249	(0.0299)	-0.0541	(0.0375)
Q3 Extreme Heat × No Election	-0.0114	(0.0387)	-0.0853	(0.0661)
Q4 Extreme Heat × No Election	-0.0996	(0.0698)	-0.155	(0.0974)
Q2 Extreme Heat × Election	-0.0234	(0.0196)	-0.0908***	(0.0280)
Q3 Extreme Heat × Election	-0.0576**	(0.0258)	-0.0991**	(0.0377)
Q4 Extreme Heat × Election	-0.145**	(0.0695)	-0.340**	(0.163)
Observations	10,711		5,580	

$$\text{NRA}_{\ell kt} = g(\text{Heat}_{\ell kt} \times \text{No Election}_{\ell kt}) + h(\text{Heat}_{\ell kt} \times \text{Election}_{\ell t}) + \gamma_{\ell t} + \delta_{kt} + \mu_{\ell k} + \varepsilon_{\ell kt}$$

Theory

Model

- Prices: redistributive motives (Grossman & Helpman 1994; Bates 2014)
- Revenue: terms-of-trade manipulation (Johnson 1951)

- Market clearing $q = y + m$

$$\underbrace{q = p^{-\epsilon_d}}_{\text{Domestic demand}} \qquad \underbrace{y = \omega p^{\epsilon_s}}_{\text{Domestic supply}} \qquad \underbrace{x = \omega' p^{-\epsilon_x}}_{\text{Foreign net demand}}$$

- Tax wedge α between domestic price p^* and international price $\frac{p^*}{1+\alpha}$
- Government maximizes weighted sum of surplus

$$\max_{\alpha \in [-1,\infty)} \left\{ \lambda^C CS + \lambda^P PS + \lambda^G G \right\}$$

Policy responses depend on redistribution vs. revenue concerns

The government is **redistribution-focused** if

$$\frac{\epsilon_s \lambda^C + \epsilon_d \lambda^P}{\epsilon_s + \epsilon_d} > \lambda^G$$

revenue-focused if the opposite holds strictly, and **neutral** at equality.

Proposition: Food Policy and Climate Shocks

1. Under redistribution focus, adverse shock $\rightarrow$ consumer assistance (lower α)
2. Under revenue focus, adverse shock $\rightarrow$ producer assistance (higher α)
3. In the neutral case, policy is invariant to shock ω.

Intuition for both cases

- **Revenue focus:** lower export share $\Rightarrow$ less profitable to tax exports
- **Redistribution focus:** lower export share $\Rightarrow$ best time to tax exports
  - Bigger gains for domestic consumers, smaller losses for domestic producers
  - Different initial levels, but same changes
- Corollary: opposite policy responses to foreign production shocks
  - Domestic and foreign shocks have opposite effects on export share
  - Distinguish this model from price stabilization, helping the poor

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Counterfactuals

Quantitative model

- Many countries + estimated impacts of heat shocks on production and policy
  - Goals: equilibrium welfare impacts, characterize incidence, isolate policy effects

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

$$\text{equilibrium} \quad \sum_\ell q_{\ell k} = \sum_\ell y_{\ell k} \quad \forall k$$

How does trade policy affect global adaptation to climate shocks?

1. "Baseline" of minimum observed heat (1991-2019)
   - In-sample shocks as observed heat
   - Out-of-sample shocks as projected heat (2090-2100 from GFDL-ESM4)
2. Apply shocks to baseline data, then compute
   - Equilibrium prices, quantities, trade, and welfare
3. Compare outcomes to baseline
   - Under responsive vs. fixed trade policy

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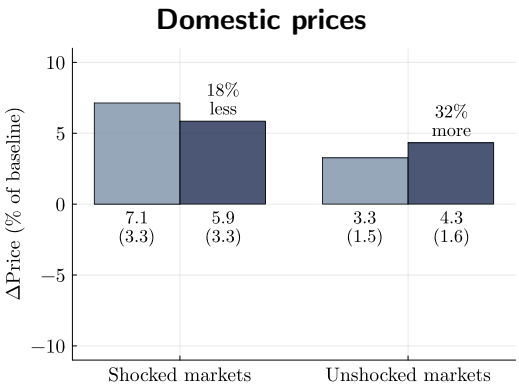
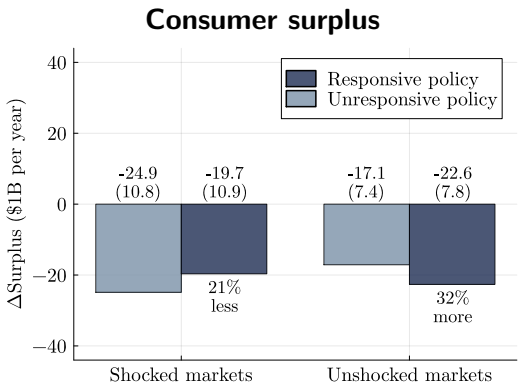
In shocked markets, policy responses stabilize prices





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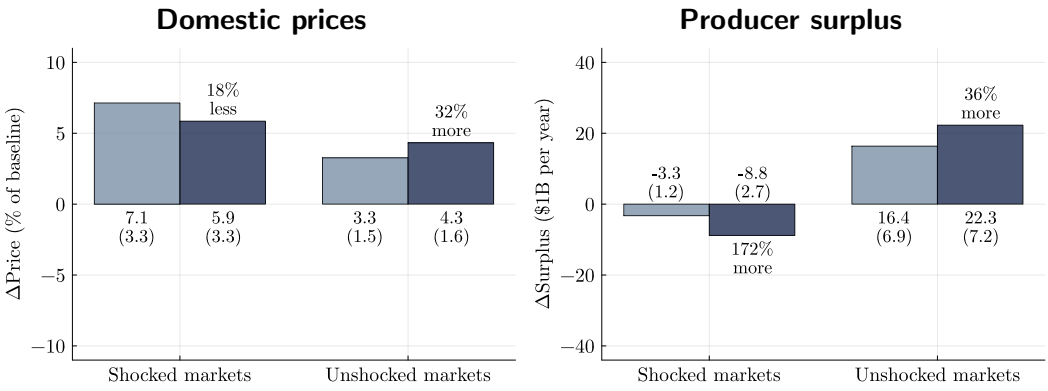

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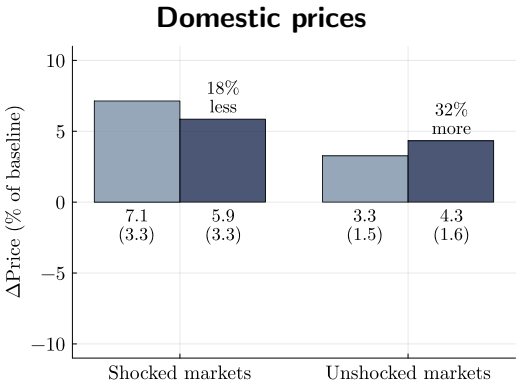
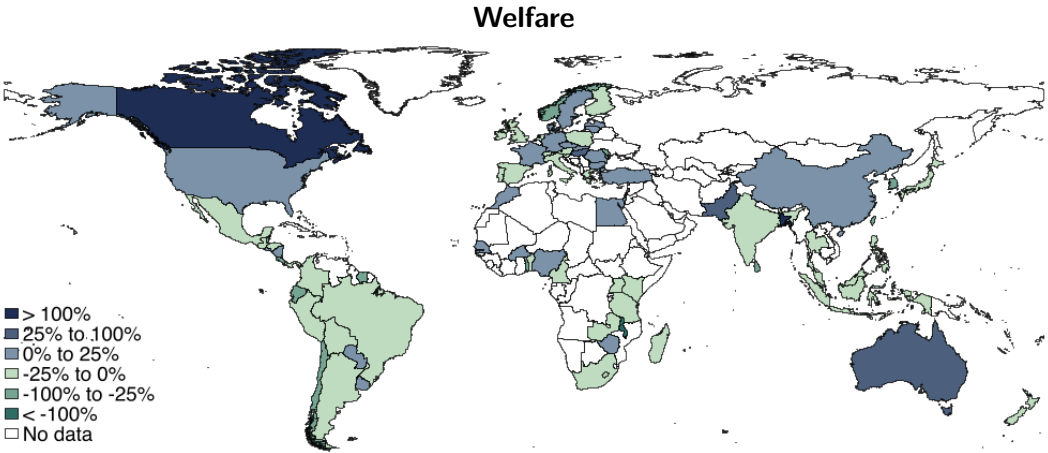


Across countries, policy responses affect pre-existing distortions



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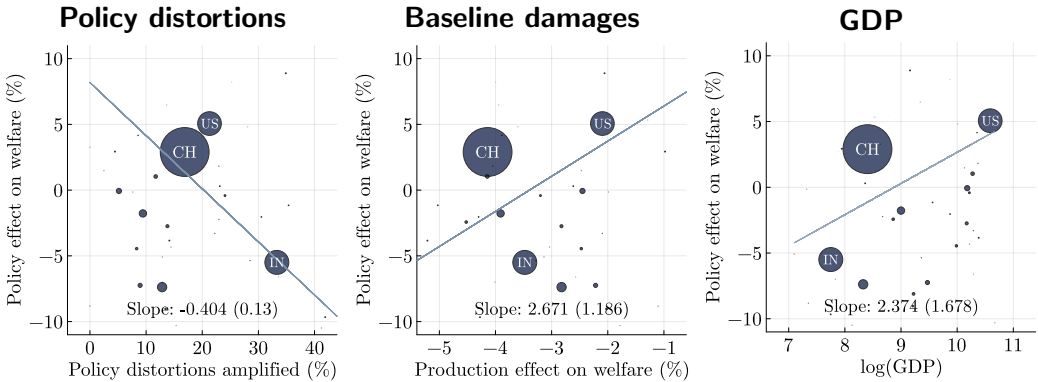
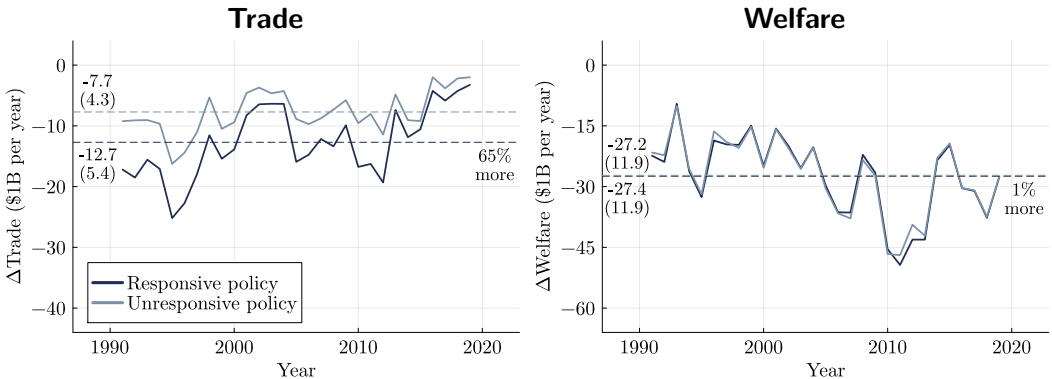
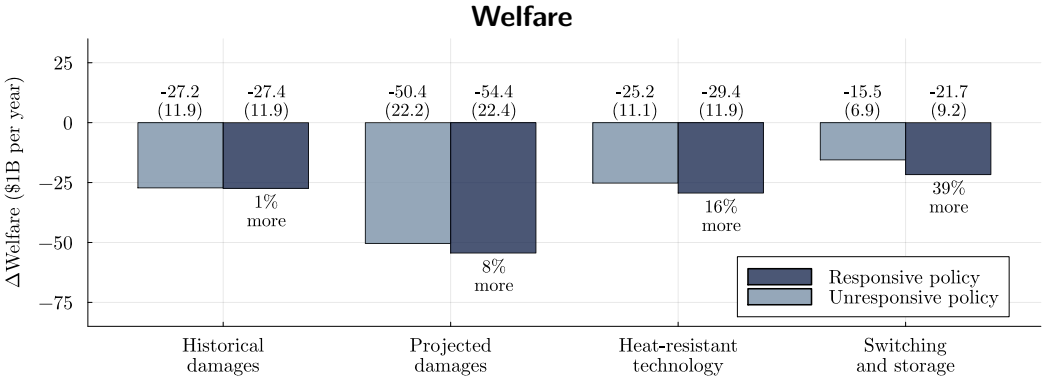


Over time, policy responses reduce trade



In projections, policy responses worsen climate damages



Conclusion

Summary

- **Policy responses** complicates global adaptation
  - Domestic agricultural shocks induce pro-consumer policy
  - Redistributes losses and can intensify pre-existing distortions
- Broader implications
  - For global trade liberalization
  - And other adaptation mechanisms