

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

Spike in wheat prices
threatens “**food security**
of India”

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

“If the price wants to go
up ... who are they trying
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“These measures could
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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

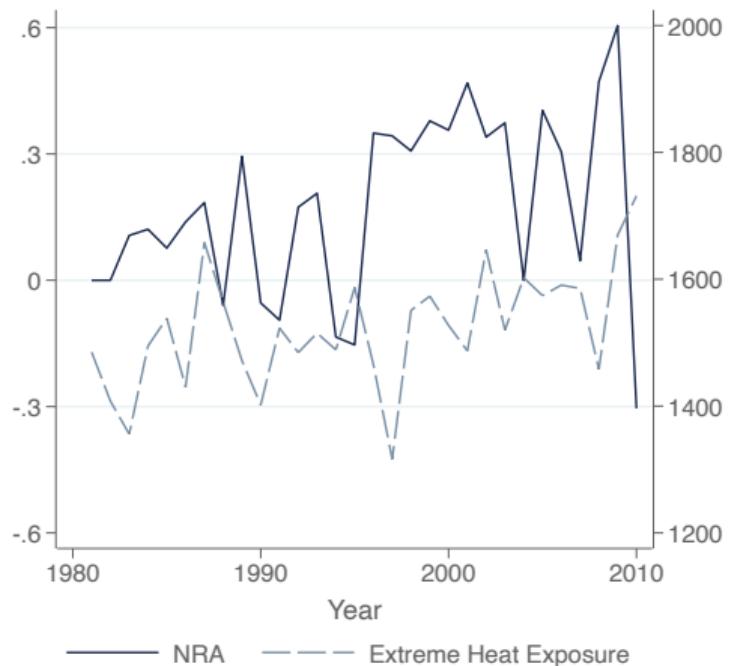
$$\text{ExtremeHeat}_{\ell k t} = \sum_{c \in \ell} \frac{\text{Area}_{ck}}{\sum_{c' \in \ell} \text{Area}_{c'k}} \cdot \text{DegreeDays}_{ct}(T_k^{\max})$$

Policy: nominal rate of assistance

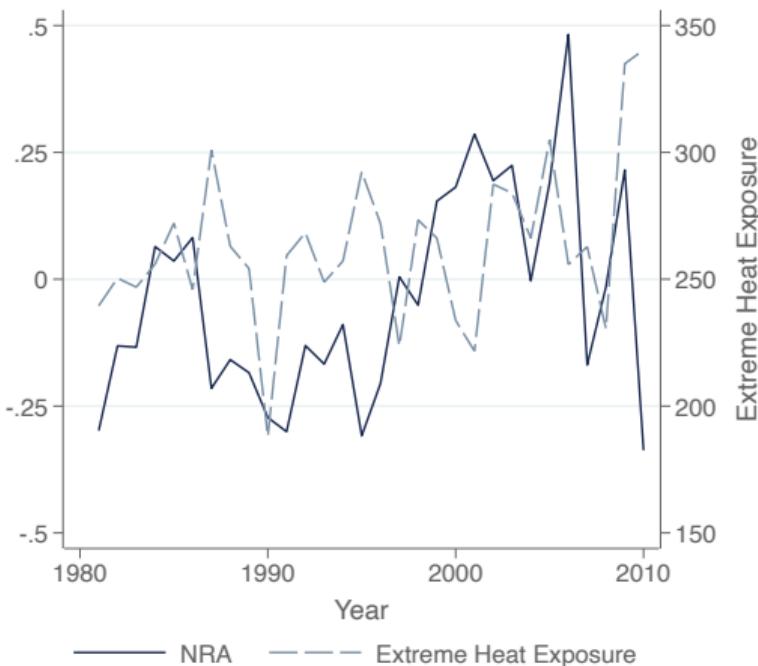
- “Distortions to Agricultural Incentives” project (Anderson & Valenzuela 2008)
 - 80 products, 82 countries, 85% of global production (1955-2011)
 - Wedge between domestic and international prices
 - “Pro-consumer” if $NRA_{\ell kt} < 0$
- Captures multiple dimensions of policy
 - Quantity instruments, input-market interventions, temporary measures
 - But some subjectivity in measurement

Example: staples in India

Wheat



Rice



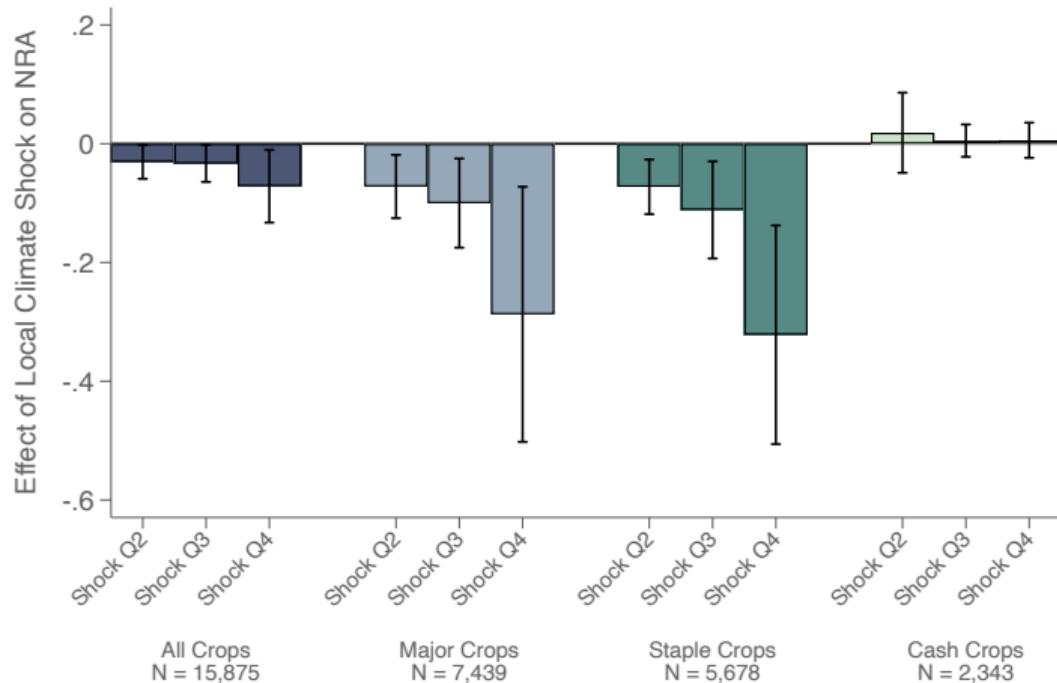
Empirical Results

1. How does extreme heat affect trade policy?

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

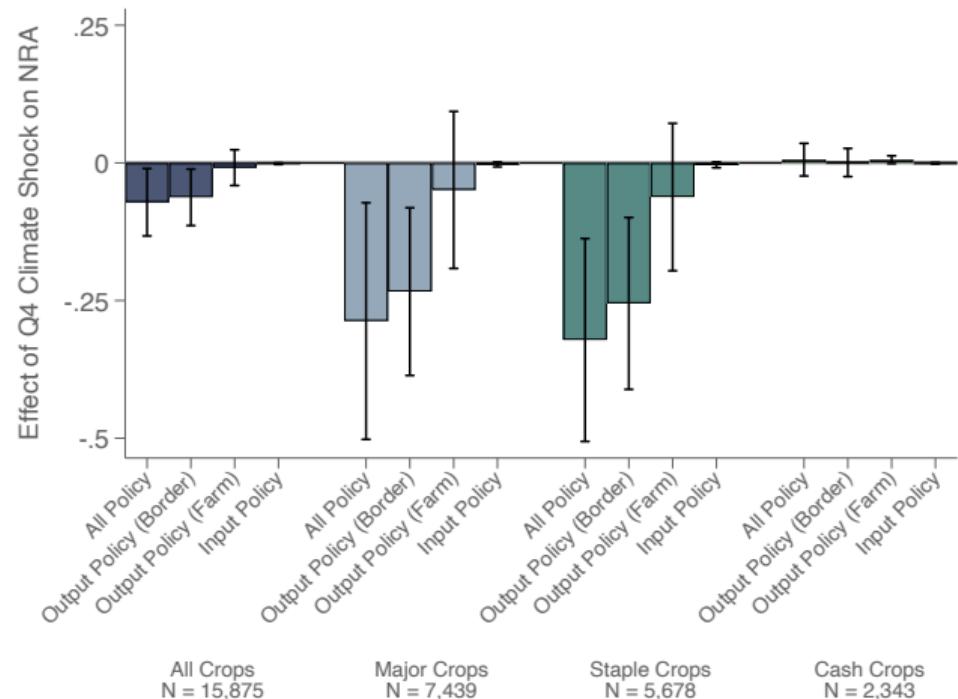
- Country ℓ , crop k , year t , quartile dummies $g(\cdot)$
- Fixed effects by country-year, crop-year, country-crop
- **Identification:** some crops get worse shocks due to physiology, geography

Extreme heat induces pro-consumer policy



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

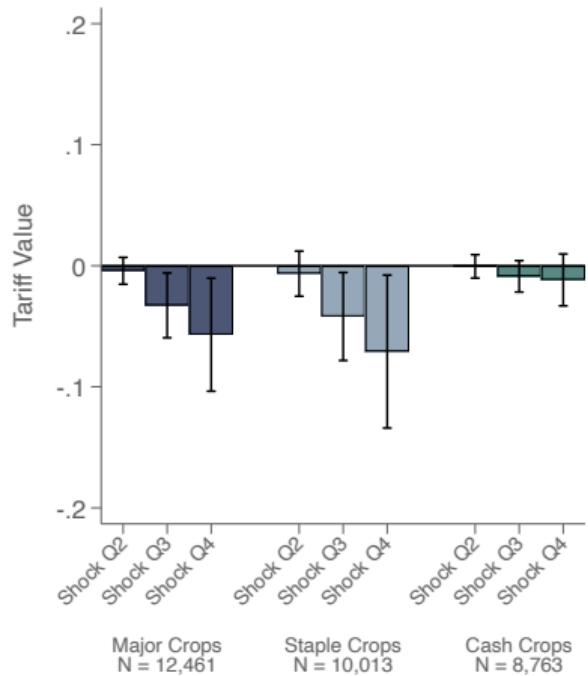
Effects concentrated in border policies



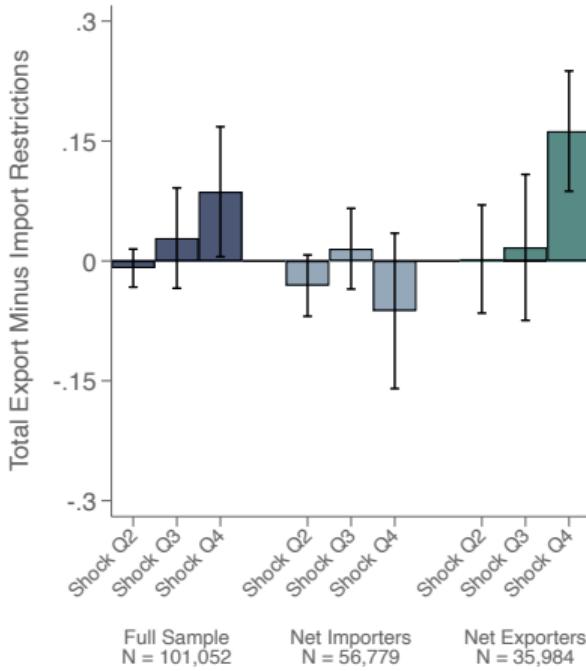
$$\text{NRA}_{\ellkt}^{\text{type}} = g(\text{ExtremeHeat}_{\ellkt}) + \gamma_{\ell t} + \delta_{kt} + \mu_{\ell k} + \varepsilon_{\ellkt}$$

With lower import tariffs and more export restrictions

TRAINs import tariffs



GTA export restrictions



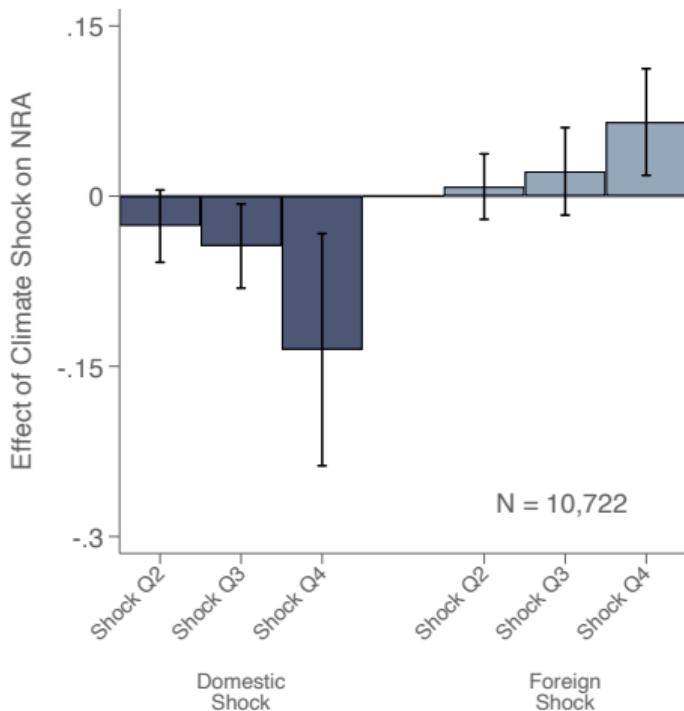
$$\text{Policy}_{\ell k t} = g(\text{ExtremeHeat}_{\ell k t}) + \gamma_{\ell t} + \delta_{k t} + \mu_{\ell k} + \varepsilon_{\ell k t}$$

2. How do foreign shocks affect trade policy?

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

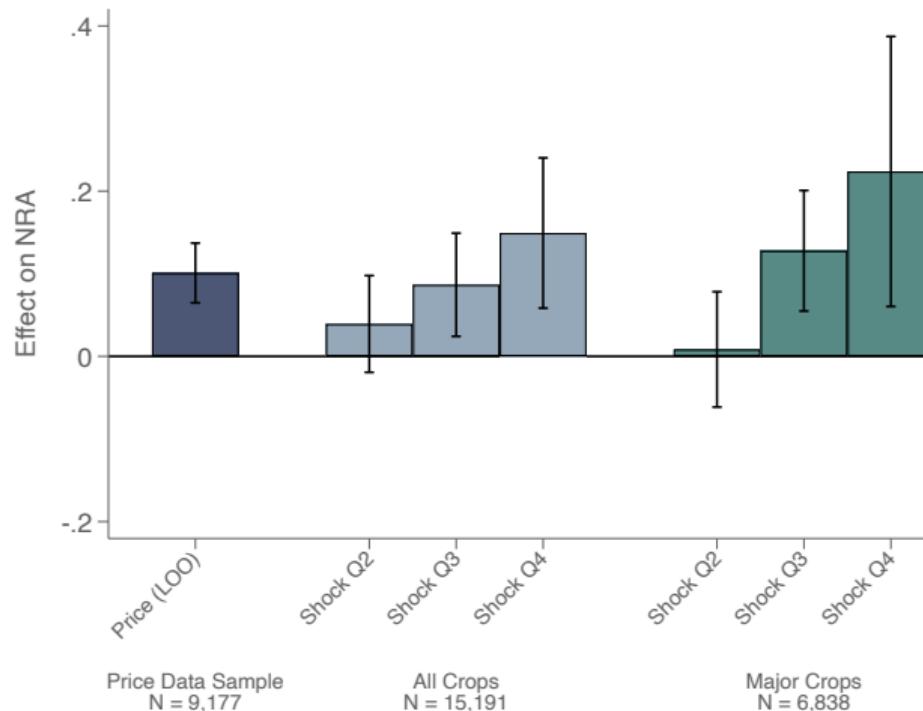
- Country ℓ , crop k , year t , quartile dummies $g(\cdot)$ and $h(\cdot)$
- Fixed effects by country-year, crop-year, country-crop
- ForeignExtremeHeat: trade partner shocks, weighted by pre-period trade shares

Foreign shocks induce pro-producer policy



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

Global shocks also induce pro-producer policy



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

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

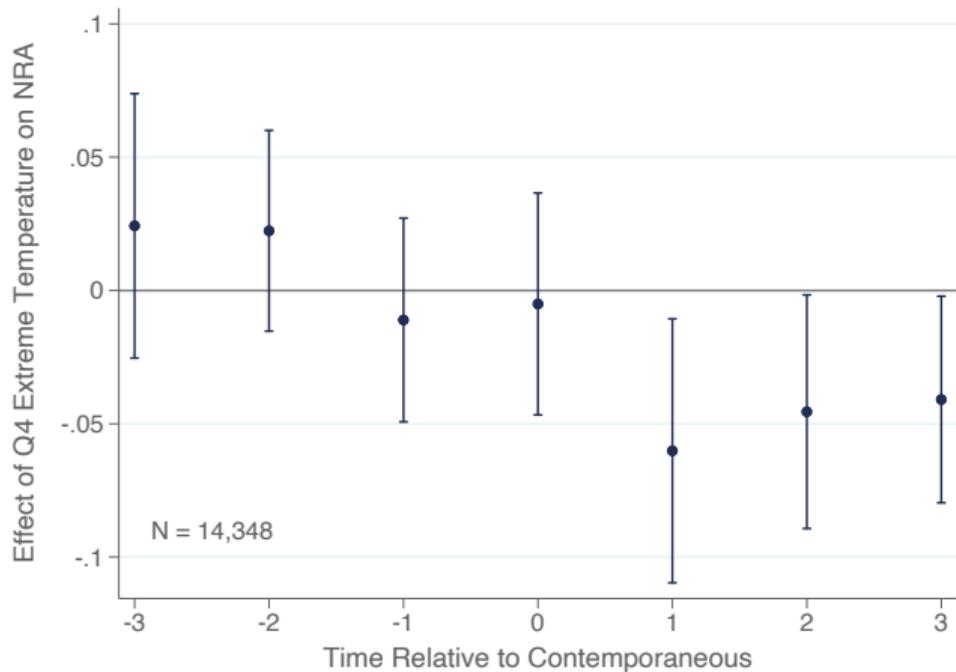
- Longer-run policy: country ℓ , crop k , years $t + s$

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

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

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

Annual shocks have persistent effects



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

Decadal shocks have similar effects

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

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

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 $q = y + m$

$$\underbrace{q = p^{-\epsilon_d}}_{\text{Domestic demand}}$$

$$\underbrace{y = \omega p^{\epsilon_s}}_{\text{Domestic supply}}$$

$$\underbrace{x = \omega' p^{-\epsilon_x}}_{\text{Foreign net demand}}$$

- 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

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

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

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

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

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

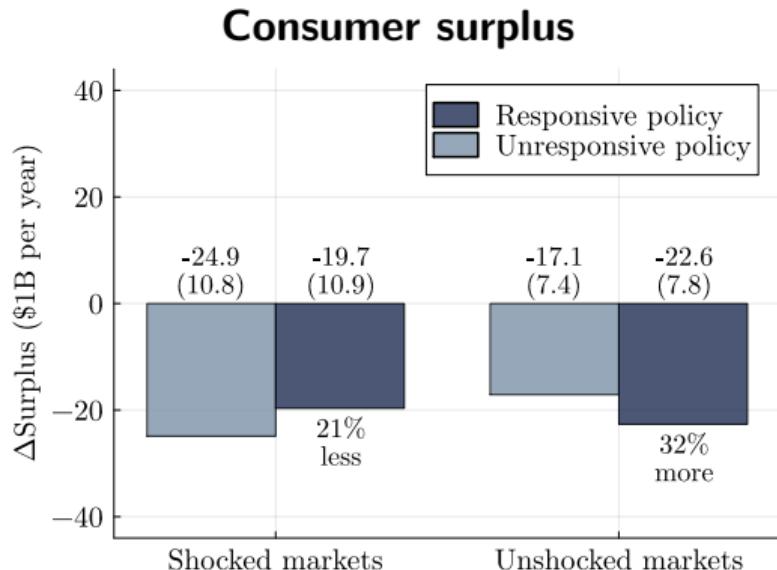
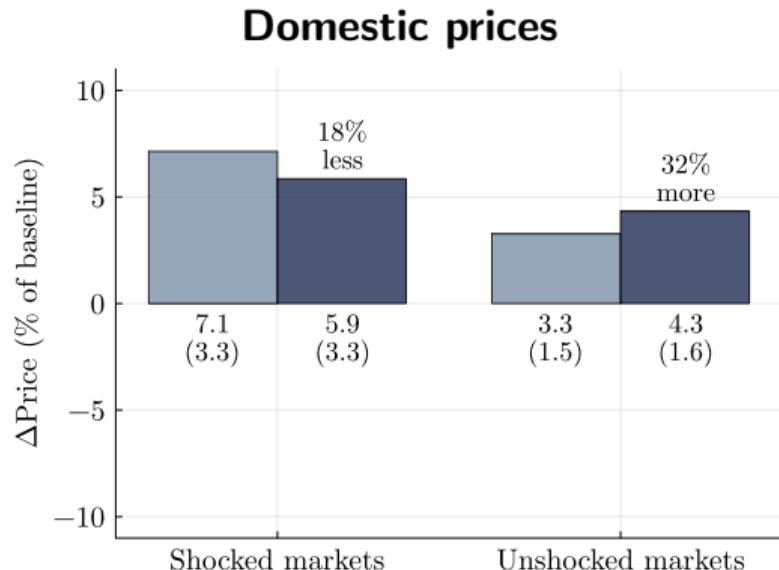
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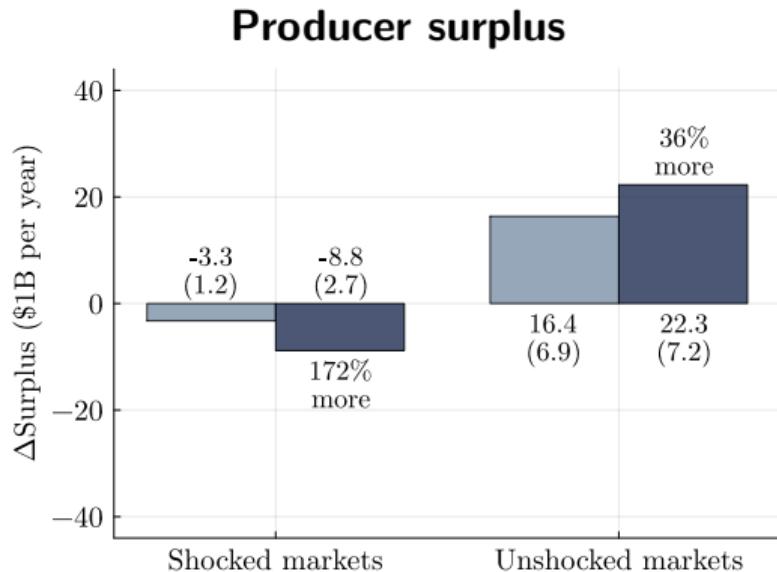
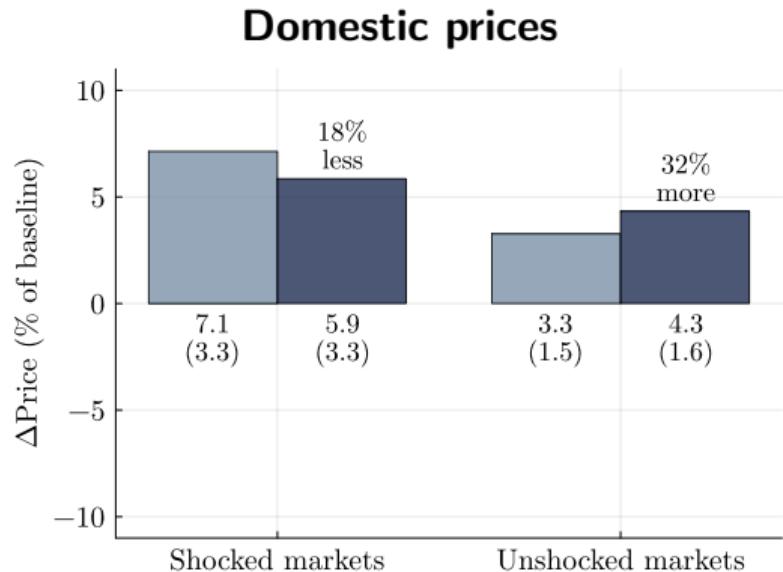
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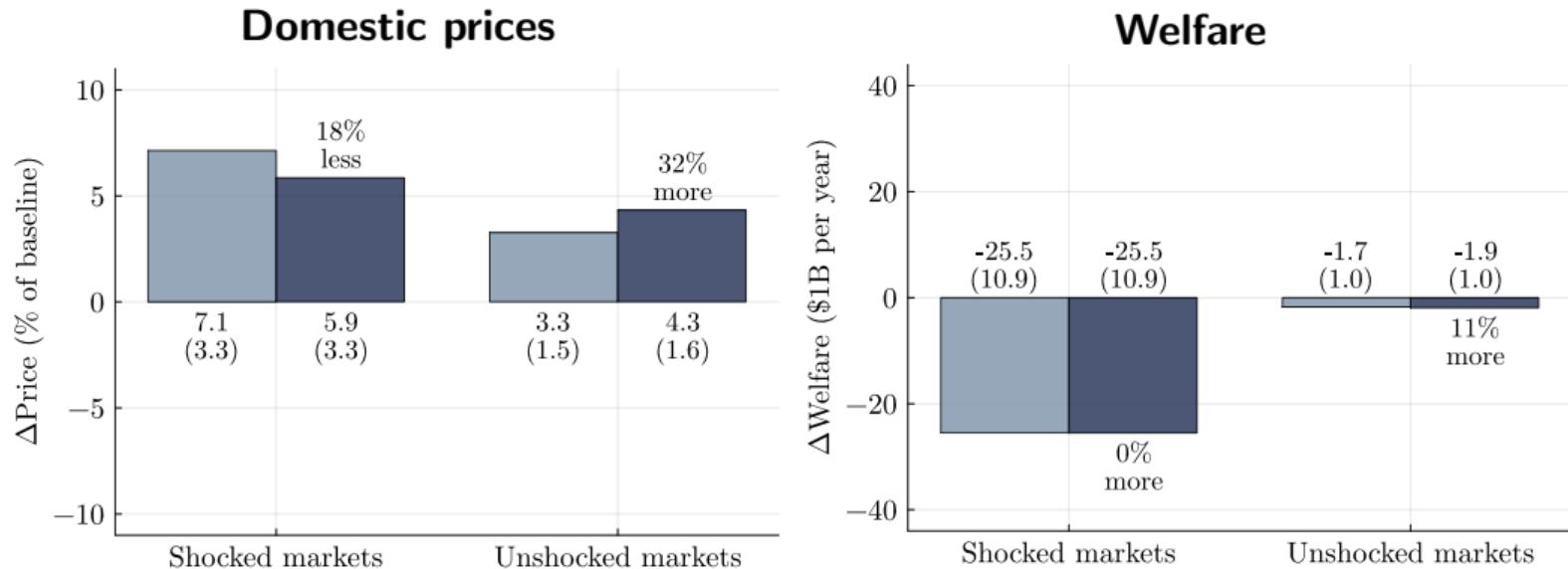
In shocked markets, policy responses stabilize prices



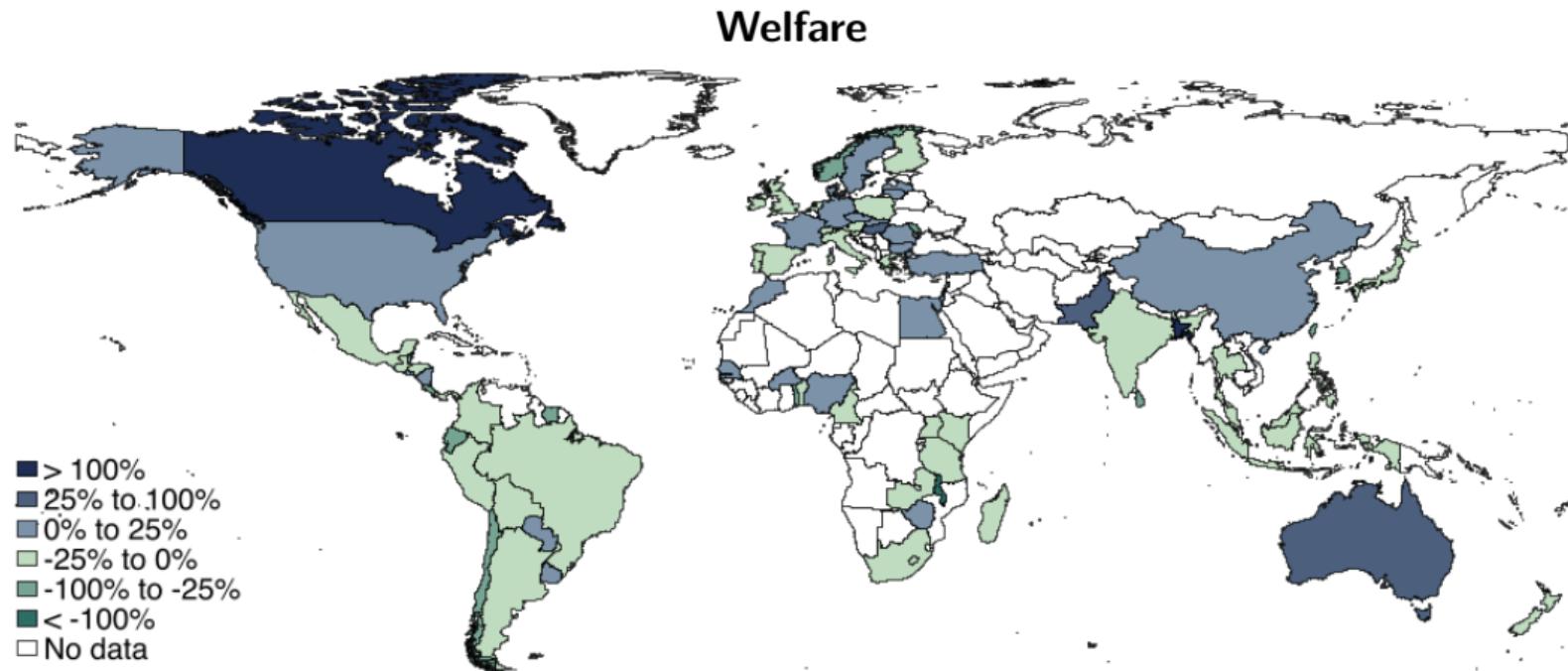
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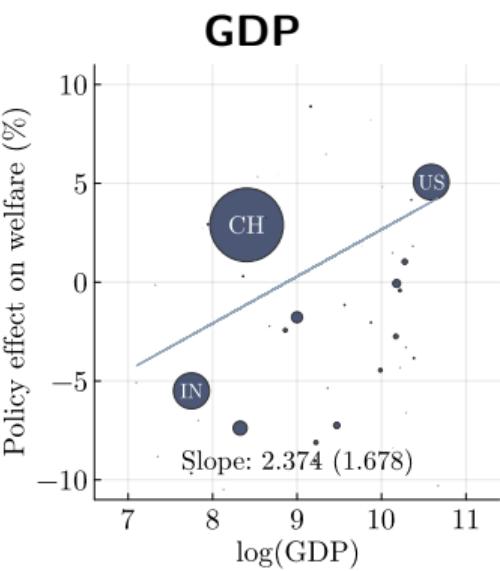
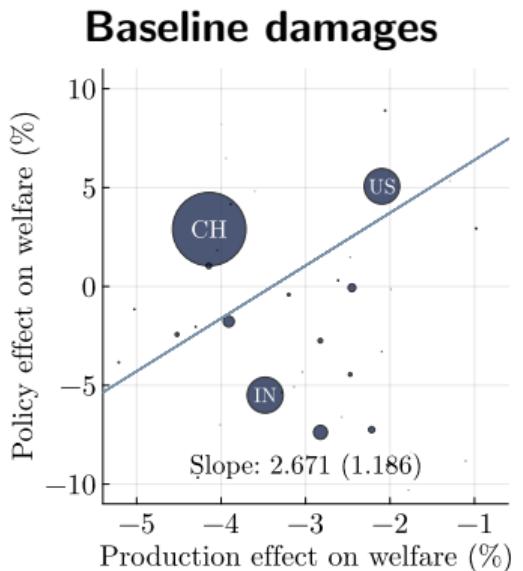
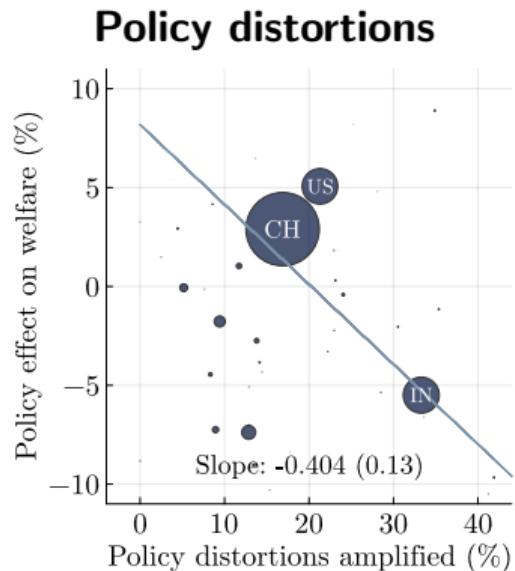
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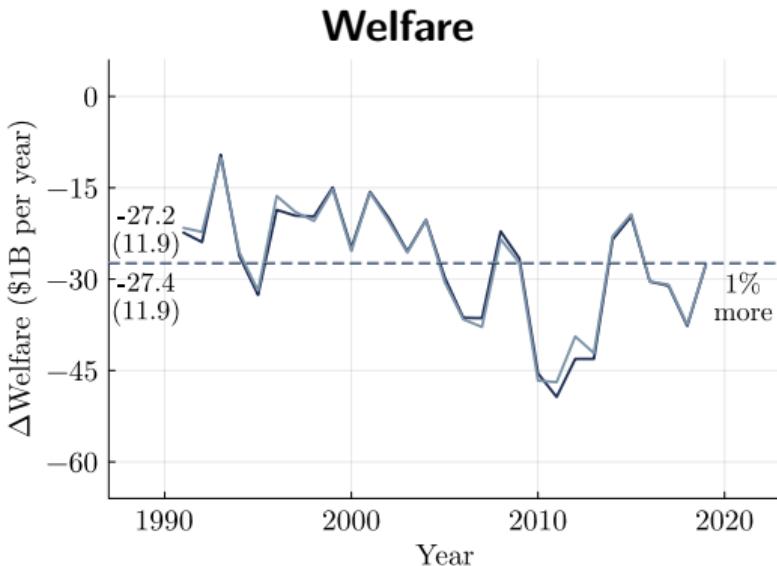
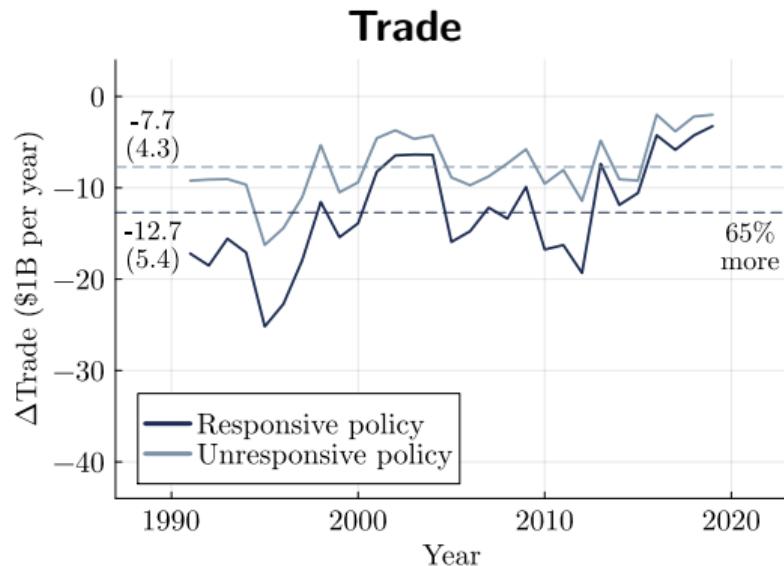
Across countries, policy responses affect pre-existing distortions



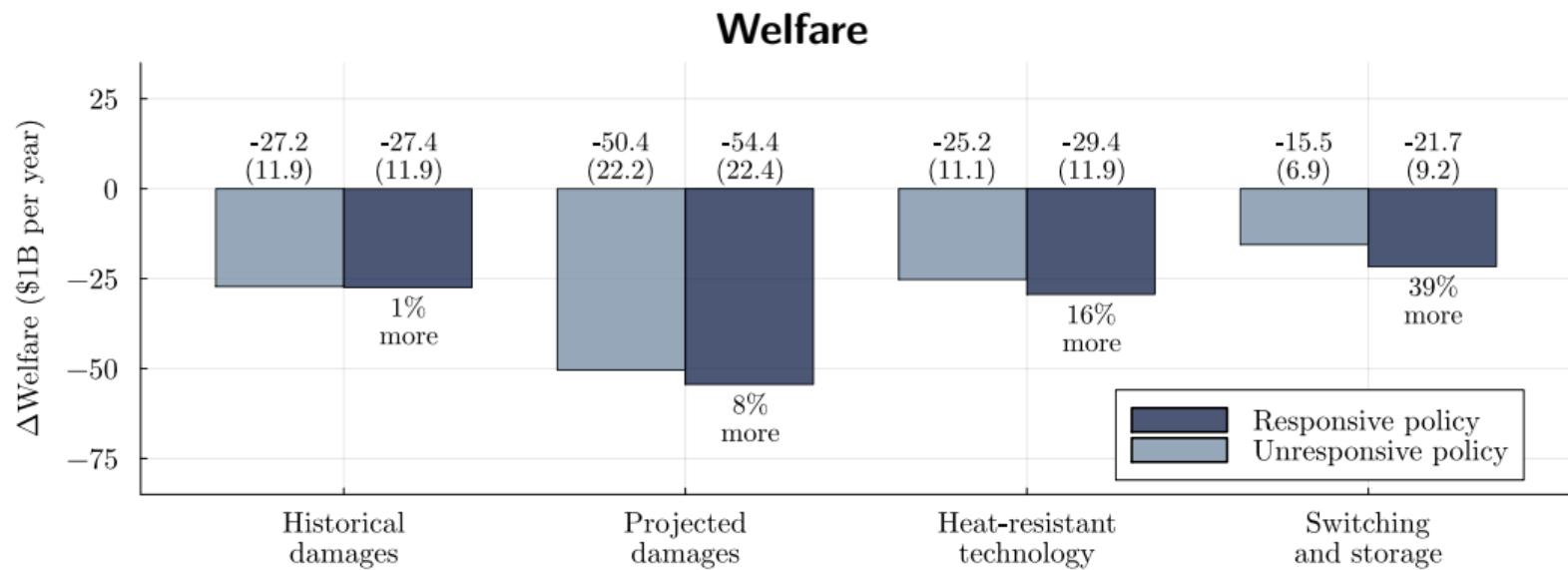
Across countries, policy responses affect pre-existing distortions



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
 - Redistributions losses and can intensify pre-existing distortions
- Broader implications
 - For global trade liberalization
 - And other adaptation mechanisms