Do firms mitigate climate impact on employment? Evidence from US heat shocks

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Motivation

"Heat stress is projected to reduce total working hours worldwide by 2.2 per cent and global GDP by US$2,400 billion in 2030. For workers and businesses to be able to cope with heat stress, appropriate policies, technological investments and behavioural change are required."

– International Labor Organization Report (2019)

Research questions

1. Do firms mitigate the impact of heat shocks on employment?
2. Does mitigation occur by (a) hiring new workers at unaffected locations, or (b) moving existing employees to unaffected locations?
3. What factors (firm-specific, region-specific, industry-specific) affect mitigation activity?
   - Hypotheses to understand mechanisms and costs/benefits for firms (next slide)
4. What are the implications for local economies?

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Answering these questions is challenging because:

- Measuring heat exposure and within-firm employment reallocation is difficult without granular data
- Employment changes can be firm-driven or worker-driven
  - Firm-driven response depends on constraints and governance
  - Worker-driven response can be within-region or across-regions

Hypotheses (heterogeneity of mitigation)

1. Understanding the mechanisms:
   - Is the mitigating response stronger in the case of
     - Heat-exposed firms?
     - (Towards) Counties less exposed to heat stress?
     - Industries with workers at risk of injuries or fatalities due to heat stress?
   - Primary alternative candidate: Employee-, rather than Employer-, level mitigation
     - Is mitigation stronger for larger firms vis-à-vis smaller firms, within-county vs across-counties?
     - Is there inward migration of workers to benefiting counties?

Hypotheses (heterogeneity of mitigation)

2 Understanding costs and benefits to firms from mitigation:

- Is the mitigating response stronger in the case of
  - Firms with management/shareholders keen/incentivized to address climate change?
  - Less-leveraged firms as they focus on long-term resilience rather than short-term gains?
  - (Towards) Counties with more competitive rather than concentrated labor markets?
  - (Towards) Nearby counties due to the cost of breaking firm relationships with clients and customers?
  - Economic times when resilience costs easier to incur?

3 Descriptive inquiries:

- Acute, chronic heat stress; Other physical climate risks; Compound physical climate risks

Related literature

1. Extreme heat and firm performance
   - Addoum et al. (2020), Jin et al. (2021), Addoum et al. (2023), Pankratz et al. (2023), Ponticelli et al. (2023)
   - Extreme heat adversely impacts establishment revenue and costs
2. Firm response to climate shocks
   - Lin et al. (2020), Pankratz and Schiller (2021), Bartram et al. (2022), Castro-Vincenzi (2023)
   - Firms terminate supplier relationships and increase investments in flexible production technologies in response to climate shocks
3. Firms' establishment networks
   - Gabaix (2011), Tate and Yang (2015), Giroud and Mueller (2015, 2019), Gumpert et al. (2022)
   - Establishment networks can propagate economic shock across distant regions

This paper: Firms respond to heat-related profitability shocks by relocating operations

▸ Heat anecdotes

Overview

1. Data
2. Results
    2.1 Impact of heat shocks: Single vs. multi-location firms
    2.2 Firm mitigation: Reallocation to unaffected counties
        2.2.1 Mitigation across firms
        2.2.2 Mitigation across regions
        2.2.3 Mitigation across industries
    2.3 Does mitigation vary by type of shock (acute, spells, chronic)?
    2.4 Other and compound climate hazards
    2.5 Impact of heat shocks on county-level outcomes
    2.6 Does employee-level mitigation and migration explain our results?

1. Data: Sources

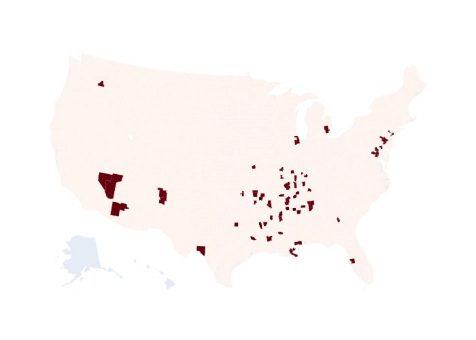
1. Dun & Bradstreet Global Archive Files
   - Establishment-level data on employment
   - 50,000 multi-establishment firms across 3,000 counties
   - Time period is 2009 to 2020
   - Drop very small firms (average employment below 100)

2. Spatial Hazard Events and Losses Database for the United States (SHELDUS) – County-level data on heat-related hazards

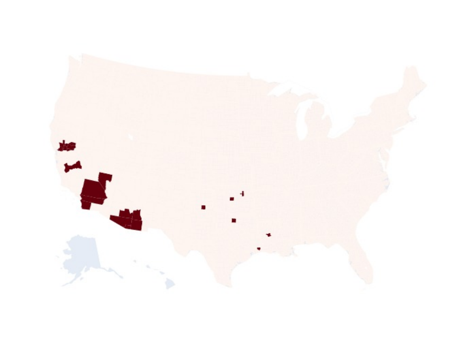
3. Other datasets: Current Population Survey (for migration), Compustat (for firm financials), PRISM (for daily temperature data), CRA Analytics (for bank presence)

1. Data: Realized heat shocks across the U.S.

Figure: Highlighted counties experienced ≥1 hot days



(a) Year: 2010



(b) Year: 2020

Definition: Hot Days are days when a loss (property, crop, injury, or fatality) occurred from a heat hazard according to SHELDUS

1. Data: Key variables

Definition: For firm f, county c, and year t, we define:

$$\text{Own Shock}_{c,t} = \text{Log}(1 + \#\text{Hot Days}_{c,t})$$

$$\text{Peer Shock}_{f,c,t} = \text{Log}(1 + \#\text{Hot Days, Other}_{f,c,t})$$

$$\text{where, } \#\text{Hot Days, Other}_{f,c,t} = \sum_{c' \neq c} \frac{\text{Employment}_{f,c',t-2}}{\text{Employment}_{f,c,t-2}} \times \#\text{Hot Days}_{c',t}$$

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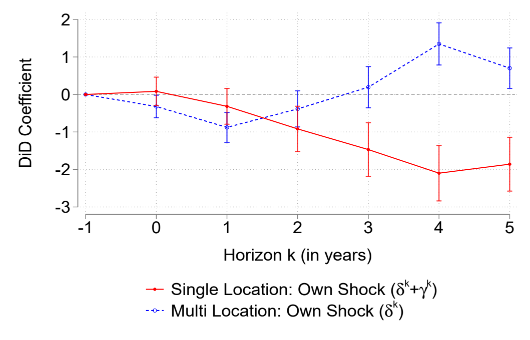
Summary Statistics (Firm-County-Year Panel):

	Mean	SD	5%tile	Median	95%tile
Employment	106	644	2	20	350
# Establishments	2.2	5.5	1	1	6
#Hot Days	.47	3	0	0	2
#Hot Days, Other	1,092	14,710	0	.69	2,776
Own Shock	.12	.47	0	0	1.1
Peer Shock	2.4	2.9	0	.52	7.9

2.1 Impact of heat shocks: single vs. multi-location firms

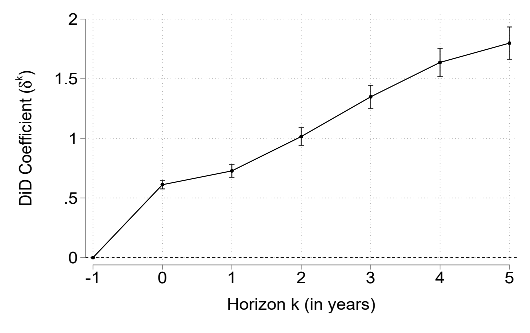
$$\Delta\text{Log(Employment)}_{f,t-1\rightarrow t+k} = \gamma^k \times \text{Firm Shock}_{f,t} \times \text{Single Location}_f + \delta^k \times \text{Firm Shock}_{f,t} + \alpha_f + \alpha_t + \varepsilon_{f,t}$$

ΔLog(Employment)



2.2. Firm mitigation: Reallocation to unaffected counties

$$\Delta \text{Log(Employment)}_{f,c,t-1\to t+k} = \delta^k \times \text{Peer Shock}_{f,c,t} + \alpha_f + \alpha_{c,t} + \varepsilon_{f,c,t}$$



Key Result: Consider a firm with equal employment in two counties (c and c'). Over a 3-year horizon,

- **1 hot day in c'** $\implies$ 0.7% $\uparrow$ in employment growth in c
- Mean employment growth in the sample is 2.4%

▸ Robustness - Alternative measures ▸ Robustness - Alternative FE ▸ Robustness - Extensive margin

2.2.1. Mitigation across firms

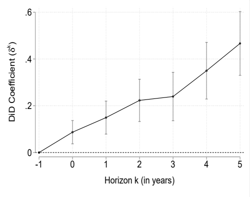
Mitigation is higher when:

- Climate Change Exposure, Risk, and Sentiment is higher

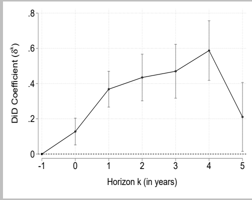
Definitions: Following Sautner et al. (2023),

- Exposure is the overall frequency of climate change bi-grams in earnings call transcript
- Risk corresponds to bi-grams associated with risk-related words
- Sentiment corresponds to bi-grams associated with positive/negative tone words

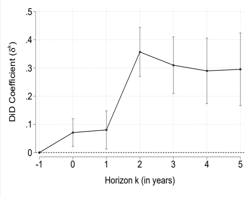
Exposure



Risk



Sentiment



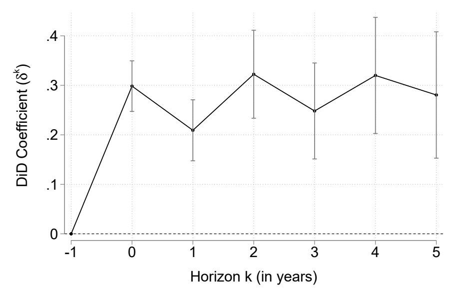
Key Result: Employment reallocation to unaffected counties is higher in firms more exposed and sensitive to climate change factors

2.2.1. Mitigation across firms (contd.)

Mitigation is higher when:

- Shareholding of ESG-classified mutual funds is higher
- We follow ESG classification of Cohen et al. (2021)

MF Share - ESG



Key Result: Employment reallocation to unaffected counties is higher if firm's mutual fund investors are ESG-oriented

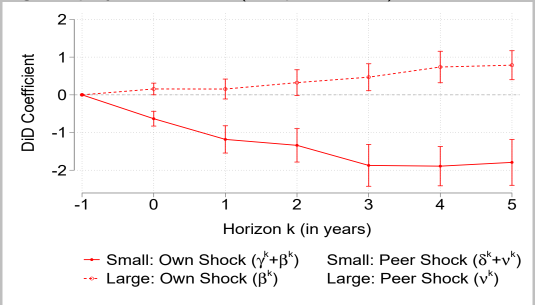
2.2.1. Heterogeneity across firms: Firm financials

	ΔLog(Employment)$_{t-1,t+k} \times 100$				
	k=+2	k=+2	k=+2	k=+2	k=+2
Peer Shock	0.263***	2.016***	1.972***	2.002***	0.672
	(0.066)	(0.083)	(0.087)	(0.095)	(0.856)
Large Firm	-11.377***				-12.162***
	(0.295)				(0.830)
Large Firm × Peer Shock	1.091***				1.401*
	(0.066)				(0.849)
Low Leverage		-0.275			-0.701
		(0.565)			(0.586)
Low Leverage × Peer Shock		0.533***			0.534***
		(0.091)			(0.094)
High Z-Score			0.525		-0.467
			(0.506)		(0.558)
High Z-Score × Peer Shock			0.305***		0.117
			(0.070)		(0.082)
High Profitability				6.645***	7.461***
				(0.563)	(0.595)
High Profitability × Peer Shock				0.176**	0.047
				(0.080)	(0.091)
Firm FE	✓	✓	✓	✓	✓
County × Year FE	✓	✓	✓	✓	✓
Sample	Full D&B	Compustat	Compustat	Compustat	Compustat
Observations	4,015,976	463,256	463,256	463,256	463,256
$\bar{y}$	2.424	4.206	4.206	4.206	4.206
Adj. R^2	0.043	0.035	0.035	0.036	0.036

2.2.1. Heterogeneity across firms: Firm size

$$\Delta \text{Log(Employment)}_{f,c,t-1\rightarrow t+k} = \gamma^k \times \text{Own Shock}_{c,t} \times \text{Small Firm}_f + \beta^k \times \text{Own Shock}_f$$
$$+ \delta^k \times \text{Peer Shock}_{f,c,t} \times \text{Small Firm}_f + \nu^k \times \text{Peer Shock}_f + \alpha_f + \alpha_t + \alpha_c + \varepsilon_{f,c,t}$$

Definition: Small firm: Average employment $\leq$ 250 (sample median)



Key Result: Consider a firm with equal employment in two counties – c and c'. Over 3-year horizon, **1 hot day in** c' $\Longrightarrow$ Employment growth

- in c': 0.9% ↓ in small firms and 0.2% ↑ in large firms
- Mean employment growth in the sample is 2.4%

▸ Table

2.2.1. Heterogeneity across firms: Firm size

$$\Delta\text{Log(Employment)}_{f,c,t-1\to t+k} = \gamma^k \times \text{Own Shock}_{c,t} \times \text{Small Firm}_f + \beta^k \times \text{Own Shock}_f$$
$$+ \delta^k \times \text{Peer Shock}_{f,c,t} \times \text{Small Firm}_f + \nu^k \times \text{Peer Shock}_f + \alpha_f + \alpha_t + \alpha_c + \varepsilon_{f,c,t}$$

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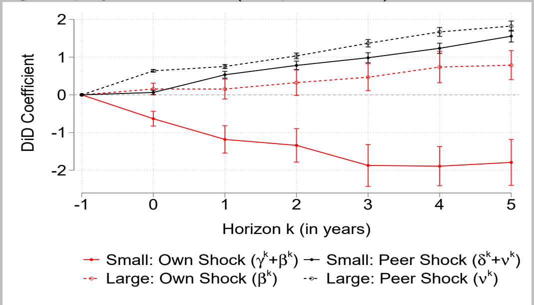


Key Result: Consider a firm with equal employment in two counties – c and c'. Over 3-year horizon, **1 hot day in** c' $\implies$ Employment growth

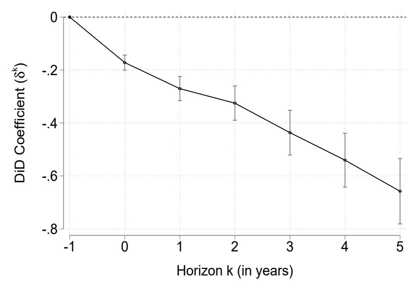
- in c': 0.9% ↓ in small firms and 0.2% ↑ in large firms
- in c: 0.5% ↑ in small firms and 0.7% ↑ in large firms
- Mean employment growth in the sample is 2.4%

▸ Table

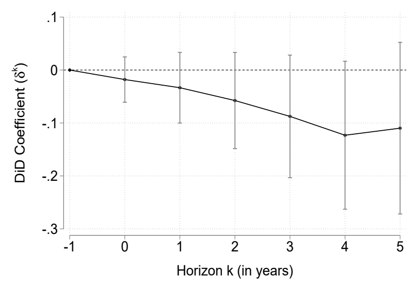
2.2.2. Mitigation across regions

$$\Delta\text{Log(Employment)}_{f,c,t-1\to t+k} = \delta^k \times \text{Peer Shock}_{f,c,t} \times \text{County Characteristic}_{c,t} + \gamma^k \text{Peer Shock}_{f,c,t} + \alpha_f + \alpha_{c,t} + \varepsilon_{f,c,t}$$

High Employment HHI



High Non-Compete Enforceability



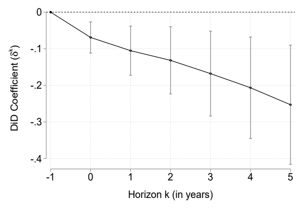
Key Result: Employment reallocation to unaffected counties is higher if their labor markets are competitive

2.2.2. Mitigation across regions (contd.)

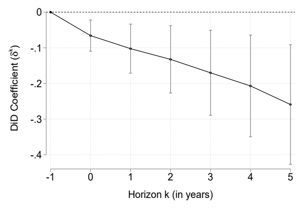
$$\Delta\text{Log(Employment)}_{f,c,t-1\to t+k} = \delta^k \times \text{Peer Shock}_{f,c,t} \times \text{County Characteristic}_{c,t} + \gamma^k \text{Peer Shock}_{f,c,t} + \alpha_f + \alpha_{c,t} + \varepsilon_{f,c,t}$$

Definitions: Exposure measures from SEAGLAS (Hsiang et al., 2017)

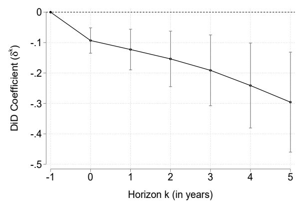
Heat Damage/GDP



Energy Damage/GDP



Labor Damage/GDP



Key Result: Employment reallocation to unaffected counties is higher if they have lower exposure to heat-related damage

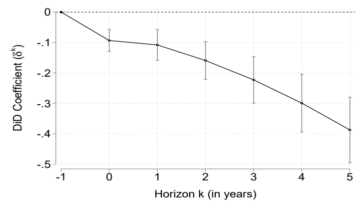
2.2.2. Mitigation across regions (contd.)

$$\Delta \text{Log(Employment)}_{f,c,t-1\to t+k} = \delta^k \times \text{Peer Shock}_{f,c,t} \times \text{High Economic Stress}_{c,t} + \gamma^k \text{Peer Shock}_{f,c,t} + \alpha_f + \alpha_{c,t} + \varepsilon_{f,c,t}$$

Definitions:

– High economic stress: Negative growth in real GDP during $t-1$

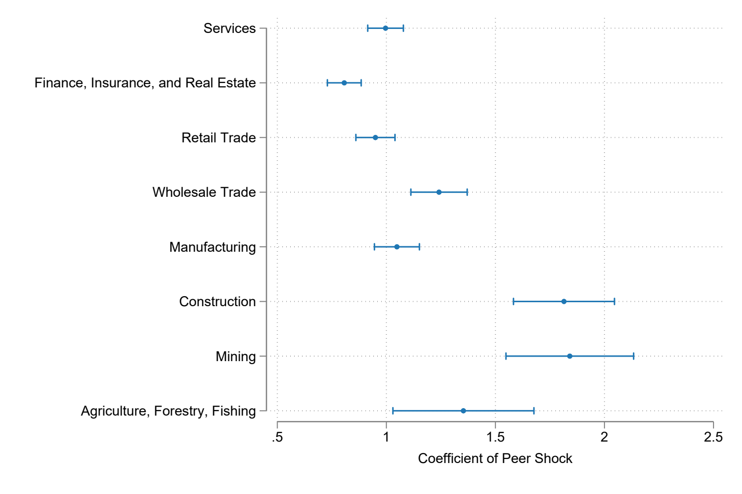
High economic stress



Key Result: Employment reallocation to unaffected counties is higher if they have lower economic stress

▸ Distance ▸ Bank presence

2.2.3. Mitigation across industries



Key Result: Employment reallocation to unaffected counties is higher if workers are more exposed to physical heat

2.2.3. Mitigation across industries

$$\Delta\text{Log(Employment)}_{f(i),c,t-1\rightarrow t+k} = \delta^k \times \text{Peer Shock}_{f(i),c,t} \times \text{Industry Characteristic}_{i,t-1} + \gamma^k \text{Peer Shock}_{f(i),c,t} + \alpha_{f(i)} + \alpha_{c,t} + \varepsilon_{f(i),c,t}$$

Definitions:

- Teleworking: Dingel and Neiman (2020) classification based on feasibility of remote work
- Tradable: geographical concentration-based classification of Mian and Sufi (2014)

	$\Delta\text{Log(Employment)}_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Peer Shock	0.451***	0.780***	1.097***	1.432***	1.756***	1.998***
	(0.023)	(0.032)	(0.044)	(0.056)	(0.069)	(0.078)
Telework × Peer Shock	0.224***	-0.075***	-0.116***	-0.118***	-0.164***	-0.272***
	(0.018)	(0.023)	(0.030)	(0.035)	(0.041)	(0.043)
Peer Shock	0.623***	0.710***	1.003***	1.330***	1.616***	1.774***
	(0.018)	(0.028)	(0.039)	(0.051)	(0.061)	(0.070)
Non-Tradable × Peer Shock	-0.079***	0.119***	0.087**	0.132***	0.149***	0.179***
	(0.020)	(0.029)	(0.038)	(0.047)	(0.055)	(0.060)
Firm FE	✓	✓	✓	✓	✓	✓
County FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓

2.3. Does mitigation vary by type of shock (acute)?

$$\Delta\text{Log(Employment)}_{f,c,t-1\to t+k} = \delta^k \times \text{Peer Shock (Type)}_{f,c,t} + \alpha_f + \alpha_{c,t} + \varepsilon_{f,c,t}$$

Definitions:

– Acute stress: peer shock calculated using hot days with non-zero property damage

	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Panel (a): Heat stress (baseline)						
Peer Shock	0.628***	0.744***	1.037***	1.376***	1.672***	1.836***
	(0.018)	(0.027)	(0.038)	(0.050)	(0.060)	(0.069)
Panel (b): Acute heat stress						
Peer Shock (Damages)	0.728***	0.943***	1.577***	1.855***	2.152***	2.055***
	(0.021)	(0.031)	(0.050)	(0.058)	(0.064)	(0.069)
Observations	5,437,792	4,626,456	3,930,617	3,308,011	2,739,695	2,221,750
$\bar{y}$	0.775	1.807	2.453	3.251	3.942	4.797
Firm FE	✓	✓	✓	✓	✓	✓
County $\times$ Year FE	✓	✓	✓	✓	✓	✓

2.3. Does mitigation vary by type of shock (spells)?

$$\Delta\text{Log(Employment)}_{f,c,t-1\rightarrow t+k} = \delta^k \times \text{Peer Shock (Type)}_{f,c,t} + \alpha_f + \alpha_{c,t} + \varepsilon_{f,c,t}$$

Definitions:

- Heat spells: peer shock calculated using hot days that occurred in a consecutive spell of three or more days

	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Panel (a): Heat stress (baseline)						
Peer Shock	0.628***	0.744***	1.037***	1.376***	1.672***	1.836***
	(0.018)	(0.027)	(0.038)	(0.050)	(0.060)	(0.069)
Panel (c): Heat spells						
Peer Shock (Spells)	0.610***	0.691***	0.956***	1.279***	1.568***	1.705***
	(0.017)	(0.026)	(0.036)	(0.046)	(0.055)	(0.063)
Observations	5,437,792	4,626,456	3,930,617	3,308,011	2,739,695	2,221,750
$\bar{y}$	0.775	1.807	2.453	3.251	3.942	4.797
Firm FE	✓	✓	✓	✓	✓	✓
County × Year FE	✓	✓	✓	✓	✓	✓

2.3. Does mitigation vary by type of shock (chronic)?

$$\Delta\text{Log(Employment)}_{f,c,t-1\rightarrow t+k} = \delta^k \times \text{Peer Shock (Type)}_{f,c,t} + \alpha_f + \alpha_{c,t} + \varepsilon_{f,c,t}$$

Definitions:

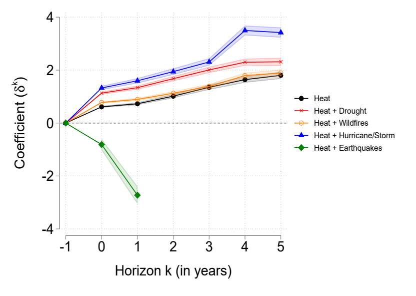
– Chronic stress: peer shock calculated using hot days occurring in counties s in the top quintile of the distribution of the number of hot days during the 1960-2008 period

	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Panel (a): Heat stress (baseline)						
Peer Shock	0.628***	0.744***	1.037***	1.376***	1.672***	1.836***
	(0.018)	(0.027)	(0.038)	(0.050)	(0.060)	(0.069)
Panel (d): Chronic heat stress						
Peer Shock (Chronic)	0.789***	0.904***	1.219***	1.583***	1.858***	2.049***
	(0.021)	(0.030)	(0.042)	(0.053)	(0.064)	(0.074)
Observations	5,437,792	4,626,456	3,930,617	3,308,011	2,739,695	2,221,750
$\bar{y}$	0.775	1.807	2.453	3.251	3.942	4.797
Firm FE	✓	✓	✓	✓	✓	✓
County × Year FE	✓	✓	✓	✓	✓	✓

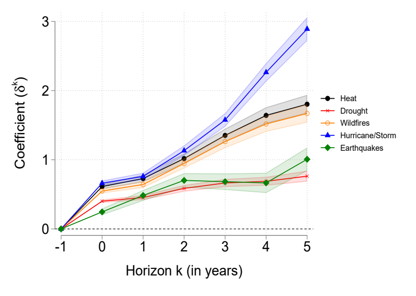
2.4. Other and compound climate hazards

$$\Delta \text{Log(Employment)}_{f,c,t-1\to t+k} = \delta^k \times \text{Peer Shock (Type)}_{f,c,t} + \alpha_f + \alpha_{c,t} + \varepsilon_{f,c,t}$$

Combined with heat hazard



Single hazard

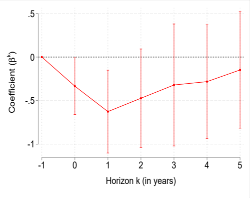


Key Result: Employment reallocation is stronger in response to compound shocks. Firms handle all forms of climate risks.

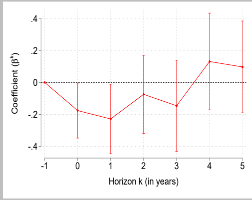
2.5. Impact of heat shocks on county-level outcomes (Own Shock)

$$\Delta Y_{c,t-1\rightarrow t+k} = \beta \times \text{Own Shock}_{c,t} + \alpha_c + \alpha_t + \varepsilon_{c,t}$$

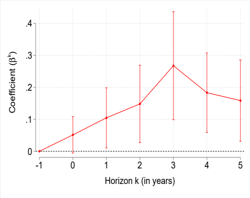
ΔLog(Employment)



ΔLog(# Establishments)



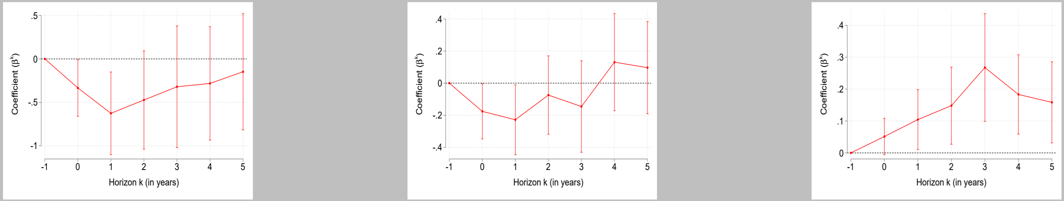
ΔEmployment HHI



2.5. Impact of heat shocks on county-level outcomes (Own Shock)

$$\Delta Y_{c,t-1\rightarrow t+k} = \beta \times \text{Own Shock}_{c,t} + \alpha_c + \alpha_t + \varepsilon_{c,t}$$

ΔLog(Employment) ΔLog(# Establishments) ΔEmployment HHI



Economic Magnitudes (3 year period):

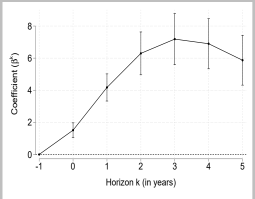
- 1% ↑ in Own Shock $\implies$ 0.7% ↓ in employment growth, 0.3% ↓ in establishment growth, 0.13% ↑ in HHI growth
- 1% ↑ in Peer Shock $\implies$ 6.9% ↑ in employment growth, 1.2% ↑ in establishment growth, 0.4% ↑ in HHI growth

Key Result: Heat shocks lead to lower employment and establishment growth, higher concentration

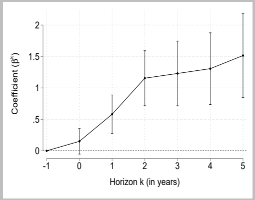
2.5. Impact of heat shocks on county-level outcomes (Peer Shock)

$$\Delta Y_{c,t-1\rightarrow t+k} = \beta \times \text{Peer Shock}_{c,t} + \alpha_c + \alpha_t + \varepsilon_{c,t}$$

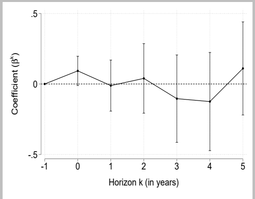
ΔLog(Employment)



ΔLog(# Establishments)



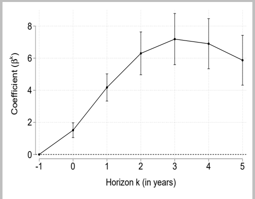
ΔEmployment HHI



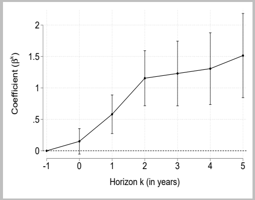
2.5. Impact of heat shocks on county-level outcomes (Peer Shock)

$$\Delta Y_{c,t-1\to t+k} = \beta \times \text{Peer Shock}_{c,t} + \alpha_c + \alpha_t + \varepsilon_{c,t}$$

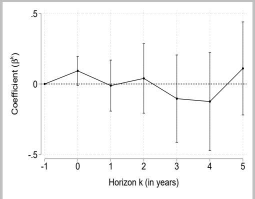
ΔLog(Employment)



ΔLog(# Establishments)



ΔEmployment HHI



Economic Magnitudes (3 year period):

- 1% ↑ in Own Shock $\Longrightarrow$ 0.7% ↓ in employment growth, 0.3% ↓ in establishment growth, 0.13% ↑ in HHI growth
- 1% ↑ in Peer Shock $\Longrightarrow$ 6.9% ↑ in employment growth, 1.2% ↑ in establishment growth, 0.4% ↑ in HHI growth

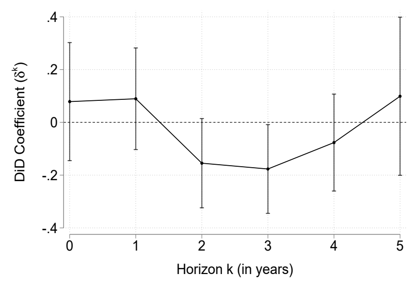
Key Result: Heat shocks lead to higher employment and establishment growth

2.6. Does employee-level mitigation and migration explain our results?

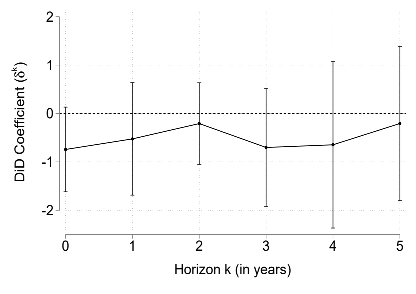
$$\text{In-Migration}_{h,c,t} = \gamma^k \times \text{Shock}_{c,t-k} + \alpha_D + \alpha_c + \alpha_t + \epsilon_{w,c,t}$$

Definition: In-Migration$_{w,c,t}$ is an indicator that equals one if any member of the household h residing in county c in year t migrated into their current location for a work-related reason during the previous year

Own shock



Peer shock



Conclusion

- Evidence suggests that
  - Heat shocks impact local counties and small firms

    BUT

  - Multi-establishment firms relocate workers away from impacted locations to their unaffected, less exposed, locations
  - In a manner consistent with firm-level costs and benefits of mitigation
  - Particularly for acute, chronic and compound climate stress
- Open questions
  - Are mitigating firms more resilient to FUTURE stress?
  - How much does mitigation help in the aggregate to insulate economy against climate change?
- Next steps
  - Further disentangle worker-driven and firm-driven reallocation (job postings)
  - Within-firm mitigation across occupational groups

Heat Is Costing the U.S. Economy Billions in Lost Productivity

From meatpackers to home health aides, workers are struggling in sweltering temperatures and productivity is taking a hit.

NYT (7/31/2023)

ECONOMY

Weeks of Extreme Heat Strain Small Businesses and Economy

Infrastructure holds up but risk of failure rises as hot weather persists

WSJ (7/15/2023)

Heat Wave Intensifies Energy Crisis in Europe

Natural-gas prices surge to a record, and electricity prices rally as high temperatures spur bidding war for the fuel

WSJ (8/16/2022)

China's worst heatwave in 60 years is forcing factories to close

CNN (8/16/2022)

We ask: do firms respond to these heat-related profitability shocks by relocating?

Back

Robustness: Different measures

$$\Delta\text{Log(Employment)}_{f,c,t-1\to t+k} = \delta^k \times \text{Peer Shock}_{f,c,t} + \alpha_f + \alpha_{c,t} + \varepsilon_{f,c,t}$$

Definition: Peer Shock, $\text{Alt}_{f,c,t}$ is the lagged-employment-weighted number of hot days across all the peer counties of c where firm f has employment in year t

	$\Delta\text{Log(Employment)}_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Panel (a)						
Peer Shock, Alt	0.703***	0.446***	0.323***	0.731***	1.130***	1.092***
	(0.058)	(0.073)	(0.090)	(0.111)	(0.136)	(0.151)
Firm FE	✓	✓	✓	✓	✓	✓
County × Year FE	✓	✓	✓	✓	✓	✓
Observations	5,521,381	4,697,477	3,990,510	3,357,697	2,779,954	2,253,138
$\bar{y}$	0.769	1.782	2.420	3.208	3.892	4.740
Adj. R^2	0.010	0.026	0.040	0.055	0.072	0.090

Back

Robustness: Different measures (contd.)

$$\Delta \text{Log(Employment)}_{f,c,t-1\to t+k} = \delta^k \times \text{Peer Shock}_{f,c,t} + \alpha_f + \alpha_{c,t} + \varepsilon_{f,c,t}$$

Definition: Peer Shock, $(\text{Est-Wt})_{f,c,t}$ is the total number of peer hot days weighted by the number of establishments in the peer county (relative to those in county c)

	$\Delta \text{Log(Employment)}_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Panel (b)						
Peer Shock, (Est-Wt)	0.304***	0.031*	0.080***	0.229***	0.378***	0.388***
	(0.014)	(0.017)	(0.022)	(0.028)	(0.034)	(0.038)
Firm FE	✓	✓	✓	✓	✓	✓
County × Year FE	✓	✓	✓	✓	✓	✓
Observations	5,556,578	4,727,432	4,015,976	3,379,161	2,797,759	2,267,637
$\bar{y}$	0.770	1.785	2.424	3.213	3.899	4.748
Adj. R^2	0.010	0.026	0.040	0.055	0.072	0.090

Back

Robustness: Different measures (contd.)

$$\Delta\text{Log(Employment)}_{f,c,t-1\to t+k} = \delta^k \times \text{Peer Shock}_{f,c,t} + \alpha_f + \alpha_{c,t} + \varepsilon_{f,c,t}$$

Definition: Peer Shock, $(\text{Eq-Wt})_{f,c,t}$ is the equal-weighted average of hot days in peer counties. We employ firm and county-year fixed effects in each specification and cluster standard errors at the county level

	$\Delta\text{Log(Employment)}_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Panel (c)						
Peer Shock, (Eq-Wt)	0.154**	0.518***	0.903***	0.899***	0.947***	0.645***
	(0.068)	(0.095)	(0.109)	(0.131)	(0.146)	(0.136)
Firm FE	✓	✓	✓	✓	✓	✓
County × Year FE	✓	✓	✓	✓	✓	✓
Observations	5,556,578	4,727,432	4,015,976	3,379,161	2,797,759	2,267,637
$\bar{y}$	0.770	1.785	2.424	3.213	3.899	4.748
Adj. R^2	0.010	0.026	0.040	0.055	0.072	0.090

Back

Robustness: Different fixed-effects

$$\Delta\text{Log(Employment)}_{f,c,t-1\to t+k} = \delta^k \times \text{Peer Shock}_{f,c,t} + \alpha_f + \alpha_{c,t} + \varepsilon_{f,c,t}$$

	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Panel (a)						
Peer Shock	1.172***	2.096***	2.895***	3.600***	4.170***	4.783***
	(0.030)	(0.051)	(0.072)	(0.092)	(0.112)	(0.130)
Firm × Year FE	✓	✓	✓	✓	✓	✓
County × Year FE	✓	✓	✓	✓	✓	✓
Observations	5,514,632	4,688,481	3,980,139	3,346,619	2,768,822	2,242,546
$\bar{y}$	0.763	1.777	2.413	3.199	3.880	4.724
Adj. R^2	0.087	0.091	0.093	0.095	0.099	0.101
Panel (b)						
Peer Shock	0.806***	1.070***	1.494***	1.992***	2.355***	2.637***
	(0.026)	(0.039)	(0.055)	(0.071)	(0.089)	(0.105)
Firm FE	✓	✓	✓	✓	✓	✓
County × Industry × Year FE	✓	✓	✓	✓	✓	✓
Observations	3,543,500	2,958,823	2,471,510	2,046,260	1,668,440	1,329,900
$\bar{y}$	0.880	2.009	2.759	3.666	4.459	5.453
Adj. R^2	-0.014	0.012	0.036	0.060	0.088	0.117

Back

Robustness: Different outcome

$$\Delta\text{Log(Employment)}_{f,c,t-1\to t+k} = \delta^k \times \text{Peer Shock}_{f,c,t} + \alpha_f + \alpha_{c,t} + \varepsilon_{f,c,t}$$

	ΔLog(# Establishments)$_{t-1,t+k}$ $\times$ 100					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Peer Shock	0.133***	0.022***	0.039***	0.110***	0.178***	0.198***
	(0.006)	(0.007)	(0.009)	(0.012)	(0.016)	(0.018)
Firm FE	✓	✓	✓	✓	✓	✓
County $\times$ Year FE	✓	✓	✓	✓	✓	✓
Observations	5,556,578	4,727,432	4,015,976	3,379,161	2,797,759	2,267,637
$\bar{y}$	0.554	1.211	1.520	1.918	2.305	2.759
Adj. R^2	0.021	0.044	0.064	0.086	0.114	0.144

Back

Heterogeneity across firms: Firm size

$$\Delta \text{Log(Employment)}_{f,c,t-1\to t+k} = \gamma^k \times \text{Own Shock}_{c,t} \times \text{Small Firm}_f + \beta^k \times \text{Own Shock}_{c,t} + \text{FE} + \varepsilon_{f,c,t}$$

	ΔLog(Employment)$_{t-1,t+k}$ $\times$ 100		
	k=+2	k=+2	k=+2
Own Shock	0.067	0.385**	
	(0.132)	(0.179)	
Small Firm $\times$ Own Shock		-1.706***	-1.717***
		(0.350)	(0.357)
Firm FE	✓	✓	✓
County FE	✓	✓	
Year FE	✓	✓	
County $\times$ Year FE			✓
Observations	3,930,760	3,930,760	3,930,617
$\bar{y}$	2.452	2.452	2.453
Adj. R^2	0.042	0.042	0.040

▸ Back

2.2.2. Mitigation across varying distance from the shock

$$\Delta\text{Log(Employment)}_{f,c,t-1\to t+k} = \sum_{(d_1,d_2)} \delta^k_{(d_1,d_2)} \times \text{Peer Shock}_{f,c,t,(d_1,d_2)} + \alpha_f + \alpha_{c,t} + \varepsilon_{f,c,t}$$

	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Peer Shock≤100	0.485***	0.682***	0.911***	1.075***	1.186***	1.332***
	(0.038)	(0.054)	(0.069)	(0.085)	(0.094)	(0.108)
Peer Shock∈(100,250]	0.361***	0.451***	0.588***	0.738***	0.832***	0.842***
	(0.027)	(0.037)	(0.047)	(0.060)	(0.074)	(0.087)
Peer Shock∈(250,500]	0.253***	0.261***	0.368***	0.480***	0.537***	0.545***
	(0.018)	(0.026)	(0.035)	(0.046)	(0.055)	(0.065)
Peer Shock∈(500,750]	0.385***	0.430***	0.592***	0.784***	0.903***	0.970***
	(0.018)	(0.027)	(0.037)	(0.051)	(0.061)	(0.071)
Firm FE	✓	✓	✓	✓	✓	✓
County × Year FE	✓	✓	✓	✓	✓	✓
Observations	5,527,471	4,698,487	3,988,344	3,353,575	2,774,744	2,247,523
$\bar{y}$	0.763	1.776	2.413	3.200	3.882	4.731
Adj. R^2	0.011	0.027	0.040	0.055	0.071	0.088

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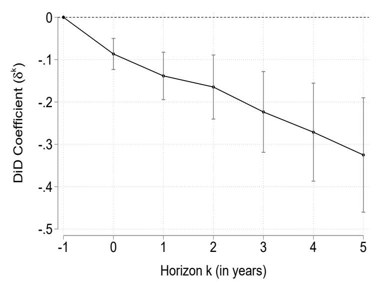
2.2.2. Mitigation across regions

$$\Delta\text{Log(Employment)}_{f,c,t-1\rightarrow t+k} = \delta^k \times \text{Peer Shock}_{f,c,t} \times \text{Low bank presence}_{c,t} + \gamma^k \text{Peer Shock}_{f,c,t} + \alpha_f + \alpha_{c,t} + \varepsilon_{f,c,t}$$

Definitions:

- Low bank presence: below median credit availability

Low bank presence



Key Result: Employment reallocation to unaffected counties is lower if they have weaker credit availability

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