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)

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.

SUSTAINABLE BUSINESS

Biden Administration Announces Rules to Protect Workers From Extreme Heat

The proposed regulation is likely to face legal challenges if implemented

Research questions

Given the adverse impact of heat shocks on labor productivity...

1. Do heat shocks cause employment reallocation across- and within-firms?
2. What are the implications for local economies?
3. What are the underlying mechanisms?
   - Labor productivity vs. energy expenditures vs. local demand
   - What factors (firm-specific, region-specific, industry-specific) affect mitigation activity?

Main Results

1. After experiencing heat shocks:
   - Single-location firms:
     - lose workers to multi-location firms, increase job postings, especially in industries where workers have high climate exposure

     $\Longrightarrow$ within-county reallocation is driven by labor supply
   - Multi-location firms:
     - experience within-county worker rotation in their favor, driven by industries where workers have low climate exposure
     - increase employment and job postings in unaffected peer locations, driven by industries with high worker exposure

     $\Longrightarrow$ spatial reallocation is driven by labor demand

Takeaway: Multi-location firms mitigate impact of heat shocks on aggregate employment but induce spatial redistribution of economic activity

Main Results

2. **Aggregate effects (county-level)**: After a heat shock, employment growth, wage growth and labor force participation rate:
   - Decrease in the affected county (weakly so for labor force participation rate)
   - Increase in peer counties (i.e., connected by firm networks)

Takeaways:

- Heat shocks cause positive spillover across counties through firm networks
- Multi-location firms can be considered "heat insulators" for an economy's employment

Main Results

3. **Mechanism**: Reallocation is driven by labor productivity channel. Effects are stronger:
   - Among occupations and industries where workers are more exposed to extreme temperatures
   - Towards locations that are less exposed to future heat damage
   - Among firms with high climate exposure and more ESG-oriented investors
   - When heat shocks are more acute, chronic, and compounded with other disasters
   - **Extensive margin**: Multi-location firms open establishments in new locations, particularly in locations with low climate exposure

Takeaways:

- Firms reallocate workforce to prevent heat-related decline in labor productivity
- Rule out energy expenditure and local demand channel
  - Both predict negative spillover across locations – inconsistent with our results

Data: Sources

1. Establishment-level data: Dun & Bradstreet Global Archive Files (2009 to 2020)
   - Detailed employment data for 50,000 multi-establishment firms across 3,000 counties
   - Drop firms having fewer than 100 employees on average during the sample period

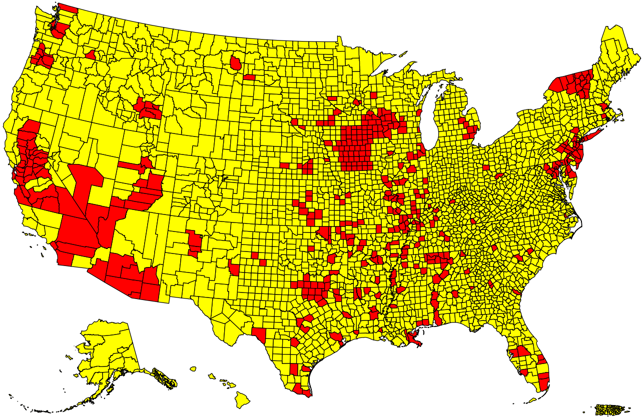
2. Heat shocks: Spatial Hazard Events and Losses Database for United States (SHELDUS)
   - County-level data on heat and other climate hazards

3. Lightcast (formerly Burning Glass) job postings database: firm-county-occupation-year data on job postings (2010 to 2020)

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

Data: Realized heat shocks across the U.S.

Figure: Highlighted counties experienced $\geq$1 hot days



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

▸ Relation to High Temperatures

Definiting Heat Shocks

Establishment-Level: For firm f, county c, and year t, we define:

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

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

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

County-Level: For county c and year t, we define:

$$\text{Peer Shock}_{c,t} = \text{Log}\left(1 + \sum_{f} \frac{\text{Employment}_{f,c,t-2}}{\text{Employment}_{c,t-2}} \times \#\text{ Hot Days, Other}_{f,c,t}\right)$$

Summary Statistics

Summary Statistics (Firm-county-year Panel):

	Mean	SD	1%tile	5%tile	25%tile	Median	75%tile	95%tile	99%tile
Employment	118	659	1	2	7	21	79	405	1,521
# Establishments	2.3	5.7	1	1	1	1	2	7	18
# Hot Days	.47	3	0	0	0	0	0	2	11
# Hot Days, Other	1,092	14,693	0	0	0	.74	123	2,780	17,928
Δ Log(Employment) (%)	.8	29	-69	0	0	0	0	0	88
Own Shock	.12	.47	0	0	0	0	0	1.1	2.5
Peer Shock	2.4	2.9	0	0	0	.55	4.8	7.9	9.8
Total Postings/L.Employment	7	27	0	0	0	0	0	40	200

Summary Statistics (cont'd)

Summary Statistics (Firm-Year Panel):

	Mean	SD	1%tile	5%tile	25%tile	Median	75%tile	95%tile	99%tile
Single Location	.3	.46	0	0	0	0	1	1	1
Employment	1,074	8,526	27	93	140	232	514	3,032	14,538
# Establishments	21	196	1	1	3	5	11	50	271
# Hot Days, Firm	.59	3	0	0	0	0	0	3	11
Δ Log(Employment) (%)	2.1	38	-88	-12	0	0	0	30	113
Firm Shock	.19	.52	0	0	0	0	0	1.4	2.5
Entry In New County	.12	.32	0	0	0	0	0	1	1

County-Year Panel

Research questions

Given the adverse impact of heat shocks on labor productivity...

1. Do heat shocks cause employment reallocation across- and within-firms?
2. What are the implications for local economies?
3. What are the underlying mechanisms?
   - Labor productivity vs. energy expenditures vs. local demand
   - What factors (firm-specific, region-specific, industry-specific) affect mitigation activity?

Employment reallocation across firms in heat-affected counties

$$\Delta\text{Log(Employment)}_{f,c,t-1\to t+k} = \gamma_1^k \times \text{Own Shock}_{c,t} + \gamma_2^k \times \text{Single-Location}_f \times \text{Own Shock}_{c,t} + \alpha_f + \alpha_c + \alpha_t + \varepsilon_{f,c,t}$$

Definition: – Single-Location firm: Present in single county throughout the sample period of 2009 to 2020

	$\Delta\text{Log(Employment)}_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Own Shock	0.018	-0.076	0.057	0.150	0.396**	0.438***
	(0.058)	(0.102)	(0.130)	(0.133)	(0.160)	(0.146)
Single Location × Own Shock	0.152	-0.360	-1.508**	-2.850***	-3.586***	-2.575***
	(0.299)	(0.520)	(0.663)	(0.761)	(0.686)	(0.556)
Firm FE	✓	✓	✓	✓	✓	✓
County FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	5,664,113	4,826,630	4,106,215	3,460,396	2,868,812	2,330,678
$\bar{y}$	0.802	1.898	2.618	3.488	4.190	5.072

Key Result: Employment growth declines in establishments of single-location firms and increases in those of multi-location firms in the affected counties (Result similar to Ponticelli et al, 2023)

Split by firm size

Is employment reallocation stronger in climate-exposed sectors?

Definition: – Exposed Industry: Industry (SIC-2) with above-median job posting rate in climate-exposed occupations (i.e., those having climate exposure score above 50/100 in the O*NET Work Context database)

	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Own Shock	0.062	0.109	0.264**	0.369***	0.588***	0.570***
	(0.042)	(0.091)	(0.123)	(0.127)	(0.156)	(0.170)
Single Location × Own Shock	0.582**	0.014	-0.868*	-1.808***	-2.484***	-1.475***
	(0.234)	(0.325)	(0.464)	(0.609)	(0.534)	(0.502)
Exposed Industry × Own Shock	-0.102***	-0.272***	-0.366***	-0.408***	-0.457***	-0.358*
	(0.032)	(0.067)	(0.084)	(0.103)	(0.152)	(0.193)
Single Location × Exposed Industry × Own Shock	-0.832***	-0.790**	-0.967*	-1.381**	-1.356*	-1.448**
	(0.254)	(0.359)	(0.514)	(0.617)	(0.721)	(0.731)
Firm FE	✓	✓	✓	✓	✓	✓
County FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	5,627,939	4,796,281	4,080,582	3,438,803	2,850,940	2,316,286
$\bar{y}$	0.666	1.839	2.623	3.511	4.254	5.159
Adj. R^2	0.019	0.040	0.058	0.078	0.101	0.127

Key Result: Decline in employment growth of single-location firms is larger in climate-exposed industries

Separating worker-driven vs. firm-driven reallocation using job postings

$$\text{Total Postings/L.Employment}_{f,c,t+k} = \gamma_1^k \times \text{Own Shock}_{c,t} + \gamma_2^k \times \text{Single-Location}_f \times \text{Own Shock}_{c,t} + \alpha_f + \alpha_c + \alpha_t + \varepsilon_{f,c,t}$$

Definition: Total Postings/L.Employment (Job Posting rate): Total job postings scaled by lagged employment

	Total Postings/L.Employment$_{t+k}$ $\times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Own Shock	0.021	0.153	0.179	0.053	-0.265*	-0.290**
	(0.107)	(0.138)	(0.118)	(0.113)	(0.146)	(0.120)
Single Location $\times$ Own Shock	0.340	0.567**	0.760***	0.704***	0.865***	0.491**
	(0.223)	(0.262)	(0.244)	(0.258)	(0.192)	(0.222)
Firm FE	✓	✓	✓	✓	✓	✓
County FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	1,391,478	1,277,856	1,106,821	950,763	803,600	663,195
$\bar{y}$	7.027	7.334	7.623	8.016	8.292	8.587

Key Result: Single-location firms increase job postings whereas multi-location firms decrease job postings in the affected counties

▸ Split by firm size

Is job posting effect stronger in climate exposed occupations?

Definition: – Exposed Occupation: Occupations having climate exposure score above 50/100 in the O*NET Work Context database

	Total Postings/L.Employment$_{t+k}$ $\times$ 100					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Own Shock	-0.025	0.131	0.183	0.050	-0.234*	-0.291**
	(0.094)	(0.125)	(0.112)	(0.108)	(0.132)	(0.117)
Single Location $\times$ Own Shock	0.345	0.577**	0.756***	0.739***	0.897***	0.453*
	(0.217)	(0.255)	(0.244)	(0.247)	(0.189)	(0.234)
Exposed Occupation $\times$ Own Shock	-0.255	-0.049	-0.584	-1.045	-1.275**	-2.233**
	(0.788)	(0.981)	(0.795)	(0.766)	(0.611)	(0.938)
Single Location $\times$ Exposed Occupation $\times$ Own Shock	0.255	1.315	0.859	0.734	1.819**	4.250***
	(1.810)	(1.802)	(1.409)	(1.154)	(0.855)	(1.539)
Firm FE $\times$ Exposed Occupation	✓	✓	✓	✓	✓	✓
County FE $\times$ Exposed Occupation	✓	✓	✓	✓	✓	✓
Year FE $\times$ Exposed Occupation	✓	✓	✓	✓	✓	✓
Observations	2,782,956	2,555,712	2,213,642	1,901,526	1,607,200	1,326,390
$\bar{y}$	9.209	9.775	10.242	10.861	11.259	11.591
Adj. R^2	0.167	0.171	0.186	0.192	0.199	0.241

Key Result: Single-location firms increase job postings more in climate-exposed occupations

Reallocation to unaffected counties in multi-location firms

Specification similar to Giroud and Mueller (2019):

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

	$\Delta\text{Log(Employment)}_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Peer Shock	0.612***	0.728***	1.016***	1.351***	1.640***	1.802***
	(0.018)	(0.027)	(0.038)	(0.049)	(0.060)	(0.069)
Firm FE	✓	✓	✓	✓	✓	✓
County × Year FE	✓	✓	✓	✓	✓	✓
Observations	5,555,947	4,726,836	4,015,440	3,378,682	2,797,336	2,267,285
$\bar{y}$	0.770	1.785	2.424	3.214	3.899	4.748
Adj. R^2	0.012	0.027	0.041	0.057	0.075	0.092

Key Result: Firms experiencing heat shocks increase employment in unaffected peer locations

– Consider a firm with equal employment in two counties (c and c'):

– 1 hot day in c' $\Longrightarrow$ 0.7% $\uparrow$ in employment growth in c (over a 3-year horizon)

▸ Robustness - Alternative measures ▸ Robustness - Alternative FE ▸ Robustness - Alternative outcomes ▸ Robustness: Matched Sample ▸ Split by firm size

Is reallocation to peer counties stronger in climate exposed industries?

	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Peer Shock	0.607***	0.633***	0.901***	1.216***	1.458***	1.684***
	(0.019)	(0.030)	(0.041)	(0.052)	(0.063)	(0.068)
Exposed Industry × Peer Shock	0.004	0.146***	0.180***	0.208***	0.285***	0.170***
	(0.016)	(0.021)	(0.027)	(0.032)	(0.037)	(0.041)
Firm FE	✓	✓	✓	✓	✓	✓
County × Year FE	✓	✓	✓	✓	✓	✓
Observations	5,519,005	4,695,887	3,989,329	3,356,710	2,779,181	2,252,672
$\bar{y}$	0.779	1.800	2.445	3.242	3.934	4.793
Adj. R^2	0.012	0.027	0.042	0.057	0.075	0.093

Key Result: Employment growth in response to the peer shock is higher in climate exposed industries

Separating worker-driven vs. firm-driven reallocation using job postings

Specification:

$$\text{Total Postings/L.Employment}_{f,c,t+k} = \delta^k \times \text{Peer Shock}_{f,c,t} + \alpha_f + \alpha_{c,t} + \varepsilon_{f,c,t}$$

	Total Postings/L.Employment$_{t+k}$ × 100					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Peer Shock	0.803***	0.663***	0.591***	0.577***	0.480***	0.415***
	(0.036)	(0.033)	(0.034)	(0.033)	(0.033)	(0.029)
Firm FE	✓	✓	✓	✓	✓	✓
County × Year FE	✓	✓	✓	✓	✓	✓
Observations	1,352,263	1,243,747	1,076,981	924,851	781,349	644,505
$\bar{y}$	7.048	7.342	7.632	8.032	8.312	8.610
Adj. R^2	0.317	0.325	0.346	0.369	0.379	0.384

Key Result: Firms experiencing heat shocks increase job postings in unaffected peer locations

- Consider a firm with equal employment in two counties (c and c'):
- 1 hot day in c' $\Longrightarrow$ 0.6% ↑ in job posting rate in c (over a 3-year horizon)

Is job posting effect stronger in climate exposed occupations?

	Total Postings/L.Employment$_{t+k}$ $\times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Peer Shock	0.841***	0.714***	0.643***	0.621***	0.516***	0.464***
	(0.036)	(0.032)	(0.034)	(0.032)	(0.033)	(0.030)
Exposed Occupation × Peer Shock	1.571***	1.446***	1.589***	1.291***	0.697***	0.428*
	(0.267)	(0.288)	(0.403)	(0.337)	(0.236)	(0.232)
Firm FE × Exposed Occupation	✓	✓	✓	✓	✓	✓
County × Year FE × Exposed Occupation	✓	✓	✓	✓	✓	✓
Observations	2,704,526	2,487,494	2,153,962	1,849,702	1,562,698	1,289,010
$\bar{y}$	9.301	9.853	10.331	10.992	11.429	11.771
Adj. R^2	0.140	0.146	0.158	0.171	0.190	0.231

Key Result: Increase in job postings in response to the peer shock is higher in climate exposed occupations

Research questions

Given the adverse impact of heat shocks on labor productivity...

1. Do heat shocks cause employment reallocation across- and within-firms?
2. What are the implications for local economies?
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   - Labor productivity vs. energy expenditures vs. local demand
   - What factors (firm-specific, region-specific, industry-specific) affect mitigation activity?

Effect of heat shocks on county-level employment

Data: Dun & Bradstreet data aggregated at the county-year level

Employment growth

	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Own Shock	-0.380**	-0.753***	-0.641**	-0.611	-0.493	-0.544
	(0.179)	(0.265)	(0.326)	(0.415)	(0.399)	(0.407)
Peer Shock	1.614***	4.363***	6.576***	7.481***	7.228***	6.230***
	(0.253)	(0.469)	(0.752)	(0.900)	(0.886)	(0.889)
County FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	28,310	25,505	22,680	19,853	17,006	14,169
$\bar{y}$	1.376	2.258	3.366	4.655	5.826	7.030

Key Result: Employment growth decreases in affected counties and increases in unaffected counties linked to affected ones through firms' establishment network. One SD increase in

– Own Shock: Decreases employment growth by 0.26 pp

– Peer Shock: Increases employment growth by 2.4 pp

▸ Robustness: Evidence using Census data ▸ Migration Results

Impact of county-level wages

Data: – Wage growth: Calculated using Quarterly Census of Employment and Wages (QCEW) data

	ΔLog(Wage)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Own Shock	-0.400***	-0.473**	-0.589**	-0.617***	-0.624**	-0.514**
	(0.139)	(0.205)	(0.231)	(0.228)	(0.266)	(0.247)
Peer Shock	-0.020	0.504***	0.606**	1.016***	0.869**	0.348
	(0.104)	(0.170)	(0.251)	(0.261)	(0.339)	(0.292)
County FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	27,441	24,682	21,907	19,103	16,325	13,496
$\bar{y}$	2.972	5.607	8.176	10.700	13.062	15.651

Key Result: Wage growth decreases in affected counties and increases in unaffected counties linked to affected ones through firms' establishment networks. One SD increase in

- Own Shock: Decreases wage growth by 0.14 pp
- Peer Shock: Increases wage growth by 0.9 pp

Impact of county-level labor force participation rate

Data: – Labor force participation rate: Calculated using Bureau of Labor Statistics (BLS) data

	ΔLabor force participation rate$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Own Shock	0.007	-0.038	-0.087	-0.068	-0.003	-0.035
	(0.037)	(0.052)	(0.056)	(0.061)	(0.066)	(0.071)
Peer Shock	0.022	0.070	0.122*	0.197***	0.135*	0.140
	(0.028)	(0.053)	(0.066)	(0.074)	(0.082)	(0.102)
County FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	27,505	25,033	22,203	19,416	16,622	13,834
$\bar{y}$	-0.127	-0.283	-0.427	-0.576	-0.739	-0.899

Key Result: Labor force participation rate increases in unaffected counties linked to affected ones through firms' establishment networks. One SD increase in peer shock increases change in participation rate by 0.2 pp

Research questions

Given the adverse impact of heat shocks on labor productivity...

1. Do heat shocks cause employment reallocation across- and within-firms?
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   - Labor productivity vs. energy expenditures vs. local demand
   - What factors (firm-specific, region-specific, industry-specific) affect mitigation activity?

Mechanism

Employment reallocation is driven by the labor productivity channel

- Heat shocks can reduce labor productivity, causing worker absenteeism and workplace incidents in extreme cases (Somanathan et al., 2021)
- Firms can diversify spatially and hire more workers in unaffected peer locations

Evidence: Consistent with positive spillover across establishments. Response is stronger:

- Among occupations and industries where workers are more exposed to extreme temperatures (shown before). Smaller response in tele-working industries
- Towards locations that are less exposed to future heat damage
- Among firms with high climate exposure and more ESG-oriented investors
- When heat shocks are more acute, chronic, and compound (i.e., accompanied by other disasters)

Smaller reallocation response in tele-working industries

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

Definitions: – Telework: Dingel and Neiman (2020) classification based on feasibility of remote work

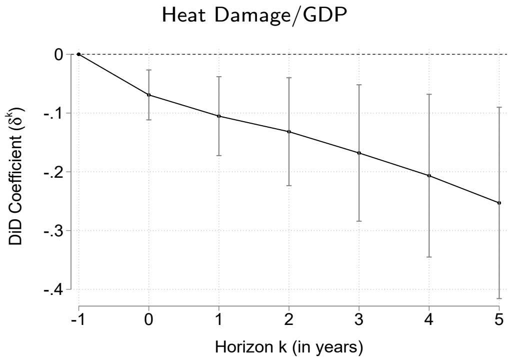
	$\Delta\text{Log(Employment)}_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Peer Shock	0.453***	0.783***	1.099***	1.436***	1.760***	2.002***
	(0.023)	(0.032)	(0.044)	(0.055)	(0.068)	(0.077)
Telework × Peer Shock	0.222***	-0.078***	-0.116***	-0.119***	-0.164***	-0.271***
	(0.018)	(0.023)	(0.030)	(0.035)	(0.041)	(0.043)
Firm FE	✓	✓	✓	✓	✓	✓
County × Year FE	✓	✓	✓	✓	✓	✓
Observations	5,545,208	4,717,622	4,007,575	3,372,004	2,791,784	2,262,784
$\bar{y}$	0.771	1.786	2.423	3.212	3.898	4.746
Adj. R^2	0.012	0.027	0.041	0.057	0.075	0.092

Key Result: Firm response is lower in industries with more remote-working capabilities

Firms reallocate to counties with lower projected heat damage

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

Definitions: Heat Damage/GDP: Exposure measures from SEAGLAS (Hsiang et al., 2017)



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

Reallocation is stronger in climate exposed firms

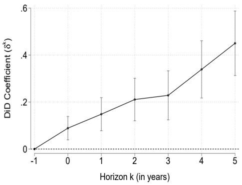
Mitigation is higher when:

- Exposure, Risk, and Sentiment towards climate change is higher

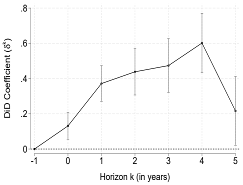
Definitions: Following Sautner et al. (2023),

- 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

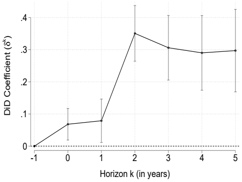
Exposure



Risk



Sentiment

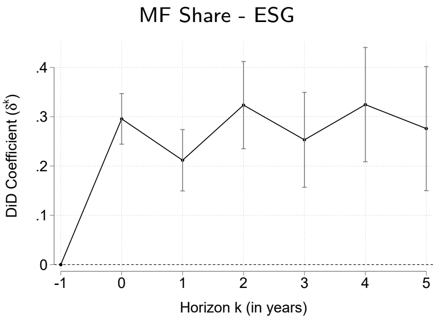


Key Result: Employment reallocation to unaffected counties is higher in firms more exposed and sensitive to climate change factors

Role of ESG-oriented investors

Mitigation is higher when:

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



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

Does mitigation vary by type of shock?

Definitions:

- Acute stress: peer shock calculated using hot days with non-zero property damage
- Heat spells: peer shock calculated using hot days that occurred in a consecutive spell of three or more days
- 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

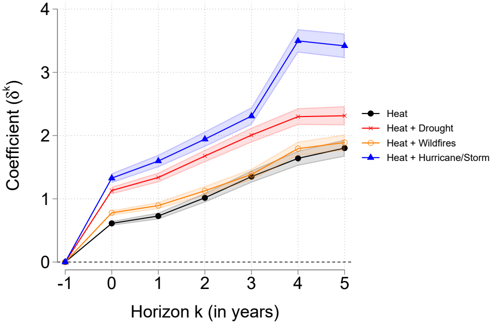
	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Panel (a): Heat stress (baseline)						
Peer Shock	0.612***	0.728***	1.017***	1.352***	1.640***	1.803***
	(0.018)	(0.027)	(0.038)	(0.049)	(0.060)	(0.069)
Panel (b): Acute heat stress						
Peer Shock (Damages)	0.708***	0.920***	1.546***	1.822***	2.113***	2.014***
	(0.021)	(0.031)	(0.049)	(0.057)	(0.063)	(0.068)
Panel (c): Heat spells						
Peer Shock (Temporal)	0.594***	0.675***	0.937***	1.257***	1.540***	1.674***
	(0.017)	(0.025)	(0.035)	(0.045)	(0.054)	(0.062)
Panel (d): Chronic heat stress						
Peer Shock (Chronic)	0.771***	0.885***	1.196***	1.555***	1.824***	2.012***
	(0.021)	(0.030)	(0.041)	(0.053)	(0.063)	(0.074)

Key Result: Employment reallocation is stronger when shocks are acute and hit chronically-stressed counties

Compound climate hazards

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

Figure: Combined with heat hazard



Key Result: Employment reallocation is stronger when heat shocks are compounded by other disasters

Alternative explanations

Reallocation to peer counties can also be driven by:

1. Energy cost shocks
   - Extreme temperatures can increase energy expenditures, cause structural damage, etc. (Ponticelli et al., 2023)
   - Firms may "spread" a sudden increase in operating cost across all its establishments
2. Local demand shocks
   - Heat shocks can reduce local demand (Addoum et al., 2023)
   - Lower demand at one establishment can reduce employment in unaffected establishments (Giroud and Mueller, 2019)

- 1 and 2 predict negative externalities across locations – inconsistent with our results
- No differential response across high- and low-energy intensive industries

Role of energy expenditure

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

Definitions: – High Energy Intensity: Above-median industry-level estimate of energy expense per employee

	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Peer Shock	0.642***	0.719***	1.012***	1.353***	1.676***	1.803***
	(0.019)	(0.029)	(0.041)	(0.052)	(0.063)	(0.072)
Energy Intensive × Peer Shock	-0.083***	0.031	0.015	-0.006	-0.096**	-0.017
	(0.016)	(0.023)	(0.029)	(0.032)	(0.039)	(0.040)
Firm FE	✓	✓	✓	✓	✓	✓
County × Year FE	✓	✓	✓	✓	✓	✓
Observations	5,346,537	4,549,533	3,865,066	3,252,902	2,693,914	2,183,975
$\bar{y}$	0.775	1.795	2.448	3.248	3.932	4.778
Adj. R^2	0.011	0.026	0.041	0.057	0.075	0.092

Key Result: No differential response in high energy intensity (rules out energy cost channel)

▸ Across industry groups ▸ Tradability

Additional Results

1. Extensive margin results: Multi-location firms open establishments in new locations, particularly in locations with low climate exposure
2. Other results: Other firm- and county-level factors that affect reallocation activity
3. Related literature

Extensive margin: Reallocation to new counties

$$\text{Entry In New County}_{f,t} = \gamma \times \text{Firm Shock}_{f,t-1} + \alpha_f + \alpha_t + \varepsilon_{f,t}$$

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

$$\text{Firm Shock}_{f,t} = \text{Log}\left(1 + \sum_c \frac{\text{Employment}_{f,c,t-2}}{\text{Employment}_{f,t-2}} \times \#\ \text{Hot Days}_{c,t}\right)$$

	Entry In New County $\times$ 100					
	Overall	Low Heat damage/GDP	Low Energy damage/GDP	Low Labor damage/GDP (high-risk)	Low Labor damage/GDP (low-risk)	Low Chronic Heat Stress
Firm Shock	0.177*	0.252***	0.241***	0.201**	0.284***	0.169*
	(0.092)	(0.077)	(0.077)	(0.079)	(0.075)	(0.086)
Firm FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	540,874	540,874	540,874	540,874	540,874	540,874
$\bar{y}$	8.833	6.411	6.329	6.415	5.873	7.328
Adj. R^2	0.270	0.244	0.245	0.243	0.236	0.251

Key Result: Firms are more likely to open new establishments in unaffected counties after experiencing heat shocks in other locations

- One SD increase in firm-shock $\Longrightarrow$ 0.09 pp increase in the probability of entry
- Effect is stronger when the new county has low exposure to heat damage (SEAGLAS)

Other Results

- Reallocation investment is stronger in financially healthy firms ▸ Result
- Firm-driven spatial reallocation is stronger when heat shocks affect counties with:
  - high vulnerability and low resilience to climate (FEMA National Risk Index) ▸ Result
  - high unionization ▸ Result
- Spatial reallocation is weaker when destination counties have:
  - negative GDP growth and low bank presence ▸ Result
  - high labor market concentration (measured as HHI) ▸ Result
- Mitigation response has a U-shaped relationship with distance from the affected county ▸ Result

Related literature

1. Extreme heat and firm performance
   - Addoum et al. (2020), Jin et al. (2021), Addoum et al. (2023), Pankratz et al. (2023): Extreme heat adversely impacts establishment revenue and costs
   - Ponticelli et al. (2023): High temperatures increase local labor market concentration
2. Firm response to climate shocks
   - Lin et al. (2020), Pankratz and Schiller (2021), Bartram et al. (2022): Firms terminate supplier relationships and increase investments in flexible production technologies in response to climate shocks
   - Castro-Vincenzi (2023): Spatial restructuring due to flood risk among car manufacturers
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 labor productivity shocks by relocating operations

Heat anecdotes

Conclusion

- Evidence suggests that
  - Multi-establishment firms relocate activities to unaffected, less exposed, locations
  - In a manner consistent with firm-level costs and benefits of mitigation
  - Multi-location firms can be considered "heat insulators" for an economy's employment
- Open questions
  - Are mitigating firms more resilient to FUTURE stress?
  - How much does mitigation help in the aggregate to insulate economy against climate change?

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

Relationship between SHELDUS heat shocks and high temperatures

$$\#\text{ Hot Days}_{c,t} = \beta \times \#\text{ Days(T}\geq\text{99Pctile)}_{c,t} + \alpha_c + \alpha_t + \varepsilon_{c,t}$$

Definitions

- $\#$ Hot Days$_{c,t}$: Number of hot days in county c in year t according to SHELDUS
- $\#$ Days(T$\geq$99Pctile)$_{c,t}$: Number of days in year t when the average temperature in county c was above its 99th percentile value over the 1982-2020 period. Calculated using dry-bulb temperature data from PRISM
- High Social Vulnerability/Low Resilience: Counties have above median value of social vulnerability or below median value of resilience according to FEMA National Risk Index

	# Hot Days			
# Days(T≥99Pctile)	0.116***	0.117***	0.109***	0.066***
	(0.003)	(0.005)	(0.006)	(0.006)
# Days(T≥99Pctile) × High Social Vulnerability/Low Resilience				0.076***
				(0.009)
County FE		✓	✓	✓
Year FE			✓	✓
Observations	113,763	113,763	113,763	113,763
$\bar{y}$	0.728	0.728	0.728	0.728
Adj. R^2	0.014	0.022	0.082	0.083

Key Result: SHELDUS heat shocks are positively correlated with high temperatures. Relationship is stronger in socially vulnerable and low resilience counties

▸ Back

Summary Statistics (cont'd)

Summary Statistics (County-Year Panel):

	Mean	SD	1%tile	5%tile	25%tile	Median	75%tile	95%tile	99%tile
Employment	21,840	76,801	20	182	1,172	3,606	11,931	98,678	323,537
Δ Log(Employment) (%)	1.3	7.8	-21	-10	-1.6	0	3.6	15	29
Δ Log(Employment), Locals (%)	-.27	3	-6.8	-4.6	-1.7	-.25	1.1	3.9	7.7
Δ Log(Employment), Migrants (%)	.18	2.4	-3.4	-1.8	-.56	.039	.82	2.7	4.8
Own Shock	.03	.24	0	0	0	0	0	0	1.6
Peer Shock	6.2	1.5	2.9	3.9	5.3	6.2	7.1	8.7	10

Back

Employment reallocation in heat-affected counties: Role of firm size

$$\Delta \text{Log(Employment)}_{f,c,t-1\rightarrow t+k} = \alpha_f + \alpha_c + \alpha_t + \gamma_1^k \times \text{Own Shock}_{c,t} + \gamma_2^k \times \text{Own Shock}_{c,t} \times \text{Single-Location/Small}_f$$
$$+ \gamma_3^k \times \text{Own Shock}_{c,t} \times \text{Single-Location/Large}_f + \gamma_4^k \times \text{Own Shock}_{c,t} \times \text{Multi-Location/Small}_f + \varepsilon_{f,c,t}$$

Definitions: – Small firm: Average employment $\leq$ 250 (sample median)
– Single-Location firm: Present in single county throughout the sample period of 2009 to 2020

	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Own Shock	0.153*	0.169	0.381**	0.613***	0.931***	0.975***
	(0.081)	(0.138)	(0.177)	(0.182)	(0.218)	(0.196)
Single-Location/Small × Own Shock	-0.238	-0.983	-2.375***	-4.632***	-5.390***	-4.285***
	(0.336)	(0.683)	(0.909)	(1.077)	(0.946)	(0.764)
Single-Location/Large × Own Shock	0.364	-0.090	-1.100*	-1.531**	-2.385***	-1.500**
	(0.444)	(0.560)	(0.636)	(0.668)	(0.676)	(0.654)
Multi-Location/Small × Own Shock	-0.739***	-1.308***	-1.706***	-2.410***	-2.758***	-2.746***
	(0.170)	(0.280)	(0.351)	(0.399)	(0.414)	(0.430)
Firm FE	✓	✓	✓	✓	✓	✓
County FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	5,664,113	4,826,630	4,106,215	3,460,396	2,868,812	2,330,678
$\bar{y}$	0.802	1.898	2.618	3.488	4.190	5.072
Adj. R^2	0.012	0.033	0.052	0.073	0.096	0.122

Key Result: Negative impact of own shock is stronger in smaller firms (both single- and multi-location)

Back

Employment reallocation across firms in heat-affected counties (Matched Sample)

Data: Matched sample between Dun & Bradstreet and Lightcast databases

	ΔLog(Employment)$_{t-1,t+k}$ $\times$ 100					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Own Shock	-0.088	-0.169	-0.110	-0.151	0.143	0.066
	(0.073)	(0.106)	(0.109)	(0.128)	(0.161)	(0.149)
Single Location $\times$ Own Shock	0.361	-0.121	-1.220*	-2.345***	-2.512***	-0.775
	(0.503)	(0.608)	(0.659)	(0.747)	(0.753)	(0.799)
Firm FE	✓	✓	✓	✓	✓	✓
County FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	1,391,478	1,215,641	1,056,100	906,274	763,981	628,700
$\bar{y}$	0.685	1.569	2.321	3.231	3.847	4.600

Back

Reallocation to unaffected peer counties: Role of firm size

Panel (A): Employment growth

	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Peer Shock	0.633***	0.734***	1.024***	1.362***	1.653***	1.809***
	(0.019)	(0.028)	(0.038)	(0.050)	(0.061)	(0.070)
Small Firm × Peer Shock	-0.581***	-0.170***	-0.215***	-0.322***	-0.404***	-0.222***
	(0.031)	(0.043)	(0.053)	(0.060)	(0.066)	(0.070)
Firm FE	✓	✓	✓	✓	✓	✓
County × Year FE	✓	✓	✓	✓	✓	✓
Observations	5,555,947	4,726,836	4,015,440	3,378,682	2,797,336	2,267,285
$\bar{y}$	0.770	1.785	2.424	3.214	3.899	4.748

Panel (B): Job postings

	Total Postings/L.Employment$_{t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Peer Shock	0.828***	0.671***	0.577***	0.569***	0.478***	0.417***
	(0.037)	(0.033)	(0.034)	(0.032)	(0.032)	(0.029)
Small Firm × Peer Shock	-0.231***	-0.083	0.146**	0.099	0.031	-0.025
	(0.049)	(0.053)	(0.058)	(0.064)	(0.059)	(0.057)
Firm FE	✓	✓	✓	✓	✓	✓
County × Year FE	✓	✓	✓	✓	✓	✓
Observations	1,352,263	1,243,747	1,076,981	924,851	781,349	644,505
$\bar{y}$	7.048	7.342	7.632	8.032	8.312	8.610

Key Result: Multi-location firms (irrespective of size) increase employment and job postings in peer locations
– Small firms respond positively despite losing employment in affected location (rules out labor cost channel)

Back

Reallocation to unaffected counties in multi-location firms (Matched Sample)

Data: Matched sample between Dun & Bradstreet and Lightcast databases

	ΔLog(Employment)$_{t-1,t+k}$ $\times$ 100					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Peer Shock	0.375***	0.380***	0.579***	0.804***	0.990***	1.023***
	(0.020)	(0.031)	(0.040)	(0.050)	(0.058)	(0.067)
Firm FE	✓	✓	✓	✓	✓	✓
County $\times$ Year FE	✓	✓	✓	✓	✓	✓
Observations	1,352,263	1,180,595	1,024,939	878,691	740,013	607,770
$\bar{y}$	0.640	1.432	2.076	2.885	3.480	4.210
Adj. R^2	0.001	0.022	0.045	0.070	0.092	0.117

▸ Back

Job postings in heat-affected counties: Role of firm size

Definition: Total Postings/L.Employment (Job Posting rate): Total job postings scaled by lagged employment

	Total Postings/L.Employment$_{t+k}$ $\times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Own Shock	0.033	0.137	0.191*	0.076	-0.198	-0.203
	(0.126)	(0.147)	(0.113)	(0.110)	(0.149)	(0.133)
Single-Location/Small $\times$ Own Shock	0.173	0.605**	0.750**	0.522*	0.547**	-0.011
	(0.280)	(0.294)	(0.307)	(0.288)	(0.235)	(0.310)
Single-Location/Large $\times$ Own Shock	0.537**	0.554	0.745**	0.893***	1.131***	0.958***
	(0.258)	(0.353)	(0.336)	(0.319)	(0.298)	(0.308)
Multi-Location/Small $\times$ Own Shock	-0.041	0.054	-0.040	-0.077	-0.229	-0.296*
	(0.133)	(0.142)	(0.151)	(0.167)	(0.180)	(0.173)
Firm FE	✓	✓	✓	✓	✓	✓
County FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	1,391,478	1,277,856	1,106,821	950,763	803,600	663,195
$\bar{y}$	7.027	7.334	7.623	8.016	8.292	8.587
Adj. R^2	0.324	0.334	0.354	0.377	0.386	0.391

Key Result: Larger single-location firms increase job postings more than smaller ones

Back

Robustness: Alternative measures of Peer Shock

Definitions:

- 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
- 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)
- Peer Shock, $(\text{Eq-Wt})_{f,c,t}$ is the equal-weighted average of hot days in peer counties
- Peer Shock, $(\text{Top Tercile})_{f,c,t}$ indicates that the peer shock lies in the top tercile of the distribution
- Peer Shock, $(\text{T}\geq\text{99Pctile})_{f,c,t}$ indicates that the peer shock is created with hot days having temperature above 99%ile for the affected county

	$\Delta\text{Log(Employment)}_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Peer Shock, Alt	0.701***	0.449***	0.322***	0.731***	1.123***	1.092***
	(0.058)	(0.073)	(0.090)	(0.110)	(0.136)	(0.150)
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)
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)
Peer Shock (Top Tercile)	1.718***	1.895***	2.747***	3.823***	4.642***	5.317***
	(0.087)	(0.136)	(0.187)	(0.245)	(0.307)	(0.359)
Peer Shock (T≥99Pctile)	0.452***	0.779***	1.115***	1.448***	1.825***	2.053***
	(0.014)	(0.022)	(0.031)	(0.042)	(0.051)	(0.057)
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: Alternative fixed effects and clustering

	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Firm×Year and County×Year FE						
Peer Shock	1.171***	2.093***	2.893***	3.598***	4.172***	4.785***
	(0.030)	(0.051)	(0.072)	(0.092)	(0.112)	(0.129)
Firm and County×Industry×Year FE						
Peer Shock	0.807***	1.069***	1.494***	1.995***	2.360***	2.640***
	(0.025)	(0.039)	(0.055)	(0.070)	(0.089)	(0.105)
County×Year FE						
Peer Shock	0.277***	0.394***	0.486***	0.602***	0.741***	0.890***
	(0.010)	(0.016)	(0.021)	(0.027)	(0.033)	(0.040)
Double clustering at County and Firm level						
Peer Shock	0.612***	0.728***	1.017***	1.352***	1.640***	1.803***
	(0.038)	(0.049)	(0.066)	(0.083)	(0.098)	(0.104)
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

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Robustness: Alternative outcome

Definition: Log(# Establishments): Number of establishments a firm has in a given county in a given year

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

	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 × 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

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Robustness: County-level results using QCEW data

Data: – Employment growth: Census Quarterly Census of Employment and Wages (QCEW) data

	Employment growth					
	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Own Shock	0.089	0.141	0.166	0.159	0.390	0.495**
	(0.104)	(0.177)	(0.213)	(0.244)	(0.258)	(0.224)
Peer Shock	0.615***	0.982**	1.541**	1.855**	1.787*	1.161*
	(0.201)	(0.471)	(0.714)	(0.936)	(0.918)	(0.630)
County FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	28,732	25,846	22,970	20,093	17,221	14,343
$\bar{y}$	0.391	1.288	2.117	2.855	3.503	4.209
Adj. R^2	0.146	0.202	0.308	0.446	0.607	0.728

Key Result: Employment growth increases in unaffected counties linked to affected ones through firms' establishment network

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Effect of heat shocks on county-level employment: Locals vs. Migrants

Data: – Calculated using IRS Statement of Income (SOI) data, which has county-to-county migration flows using tax return data

Panel (A): Employment growth (Locals)

	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Own Shock	-0.112*	-0.168**	-0.258***	-0.225**	-0.181*	-0.110
	(0.063)	(0.075)	(0.081)	(0.090)	(0.098)	(0.092)
Peer Shock	0.082	0.110	0.070	0.288**	0.427***	0.397**
	(0.057)	(0.079)	(0.102)	(0.140)	(0.159)	(0.187)
County FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	28,482	25,581	22,725	19,883	17,057	14,216
$\bar{y}$	-0.241	-0.369	-0.675	-1.056	-1.885	-2.264
Adj. R^2	0.513	0.518	0.631	0.675	0.720	0.780

Panel (B): Employment growth (Migrants)

	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Own Shock	0.016	0.042	0.093	0.089	0.123	0.158**
	(0.029)	(0.047)	(0.061)	(0.081)	(0.086)	(0.067)
Peer Shock	0.079*	0.054	-0.013	0.003	0.084	0.062
	(0.043)	(0.078)	(0.108)	(0.130)	(0.131)	(0.120)
County FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	28,572	25,726	22,884	20,032	17,172	14,325
$\bar{y}$	0.231	0.432	0.599	0.807	1.059	1.288
Adj. R^2	0.485	0.635	0.731	0.807	0.878	0.927

Key Result: Result on county-level employment growth are driven by locals and not by migration across counties

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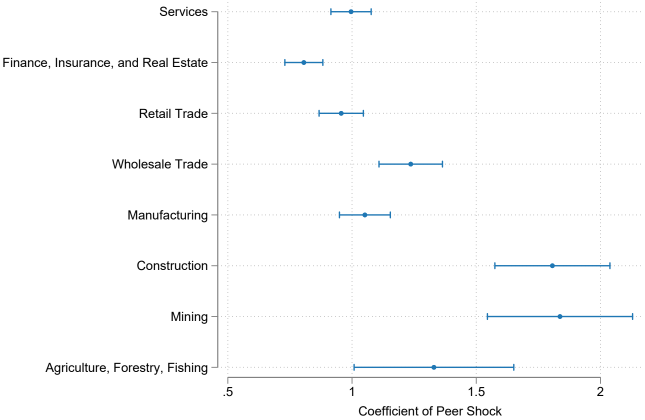
Mechanism: Mitigation across industries

Definition: – Use major divisions (based on their primary economic activities) according to the SIC industry classification system



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

Back

Mechanism: Mitigation across industries (contd)

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

Definitions: – Non-Tradable: geographical concentration-based classification of Mian and Sufi (2014). According to this measure, more geographically dispersed industries are classified as non-tradable.

	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Panel (b): Non-Tradability						
Peer Shock	0.624***	0.710***	1.004***	1.333***	1.620***	1.779***
	(0.018)	(0.028)	(0.039)	(0.051)	(0.061)	(0.069)
Non-Tradable × Peer Shock	-0.077***	0.122***	0.088**	0.130***	0.148***	0.174***
	(0.020)	(0.029)	(0.038)	(0.047)	(0.055)	(0.059)

Key Result: Firm response is stronger in non-tradable industries

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Reallocation with Heat-Related Injuries/Fatalities

$$\Delta \text{Log(Employment)}_{f,c,t-1\to t+k} = \delta^k \times \text{Peer Shock (Without Injuries)}_{f,c,t} + \gamma^k \times \text{Peer Shock (With Injuries)}_{f,c,t} + \alpha_f + \alpha_{c,t} + \varepsilon_{f,c,t}$$

Definition: Peer Shock (With/Without Injuries)$_{f,c,t}$ corresponds to hot days with and without an incidence of workplace injuries/fatalities in the county

	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Peer Shock (Without Injuries)	0.560***	0.685***	0.918***	1.140***	1.389***	1.580***
	(0.017)	(0.027)	(0.037)	(0.046)	(0.057)	(0.068)
Peer Shock (With Injuries)	0.210***	0.199***	0.314***	0.508***	0.606***	0.578***
	(0.016)	(0.023)	(0.031)	(0.042)	(0.055)	(0.070)
Firm FE	✓	✓	✓	✓	✓	✓
County × Year FE	✓	✓	✓	✓	✓	✓
Observations	5,555,947	4,726,836	4,015,440	3,378,682	2,797,336	2,267,285
$\bar{y}$	0.770	1.785	2.424	3.214	3.899	4.748
Adj. R^2	0.012	0.027	0.042	0.058	0.075	0.093

Key Result:

– Response to heat shocks with injuries is similar (although smaller) to those without injuries

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Reallocation investment is stronger in financially healthy firms

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

	ΔLog(Employment)$_{t-1,t+k} \times 100$		
	k=+2	k=+2	k=+2
Peer Shock	2.018***	1.973***	2.004***
	(0.083)	(0.087)	(0.095)
Low Leverage	-0.275		
	(0.565)		
Low Leverage × Peer Shock	0.533***		
	(0.091)		
High Z-Score		0.526	
		(0.506)	
High Z-Score × Peer Shock		0.305***	
		(0.070)	
High Profitability			6.653***
			(0.563)
High Profitability × Peer Shock			0.176**
			(0.080)
Firm FE	✓	✓	✓
County × Year FE	✓	✓	✓
Sample	Compustat	Compustat	Compustat
Observations	463,068	463,068	463,068
$\bar{y}$	4.207	4.207	4.207
Adj. R^2	0.035	0.035	0.036

Key Result: Employment reallocation is higher for firms with low leverage, high Z-score, and high profitability

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Impact of county characteristics (affected county)

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

Definitions: – Peer Shock (High Vulnerability/Low Resilience): Peer shock calculated using heat shocks that affect counties having above median value of social vulnerability or below median value of resilience according to FEMA National Risk Index

– Peer Shock (High Union Membership): Peer shock calculated using heat shocks that affect counties having above median value of union membership (calculated using Hirsch et al., 2024)

	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Panel (A): Community Risk						
Peer Shock	0.111***	0.299***	0.416***	0.728***	0.771***	0.782***
	(0.025)	(0.038)	(0.045)	(0.060)	(0.070)	(0.078)
Peer Shock (High Vulnerability/Low Resilience)	0.592***	0.509***	0.706***	0.723***	1.011***	1.184***
	(0.026)	(0.036)	(0.048)	(0.055)	(0.069)	(0.087)
Panel (B): Unionization						
Peer Shock	0.306***	0.477***	0.679***	1.093***	1.301***	1.620***
	(0.019)	(0.031)	(0.047)	(0.062)	(0.076)	(0.092)
Peer Shock (High Union Membership)	0.383***	0.315***	0.419***	0.312***	0.411***	0.216**
	(0.023)	(0.034)	(0.049)	(0.058)	(0.072)	(0.086)
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	0.012	0.027	0.042	0.057	0.075	0.093

Back

Mitigation across varying distance from the shock

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

	ΔLog(Employment)$_{t-1,t+k} \times 100$					
	k=+0	k=+1	k=+2	k=+3	k=+4	k=+5
Peer Shock≤100	0.482***	0.680***	0.907***	1.072***	1.183***	1.330***
	(0.038)	(0.053)	(0.069)	(0.085)	(0.094)	(0.108)
Peer Shock∈(100,250]	0.360***	0.449***	0.585***	0.735***	0.828***	0.837***
	(0.027)	(0.037)	(0.047)	(0.060)	(0.074)	(0.086)
Peer Shock∈(250,500]	0.251***	0.259***	0.363***	0.475***	0.531***	0.535***
	(0.018)	(0.026)	(0.035)	(0.045)	(0.055)	(0.065)
Peer Shock∈(500,750]	0.384***	0.429***	0.591***	0.781***	0.901***	0.967***
	(0.018)	(0.027)	(0.037)	(0.051)	(0.061)	(0.071)
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	0.012	0.027	0.042	0.057	0.075	0.092

Key Result: Mitigation response has a U-shaped relationship with distance from the affected county

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Role of economic factors in the destination county

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

Definition:

- Low bank presence: Counties having below-median value of per-capita loan originations according to the Fed Board's CRA data

Figure: Negative GDP growth

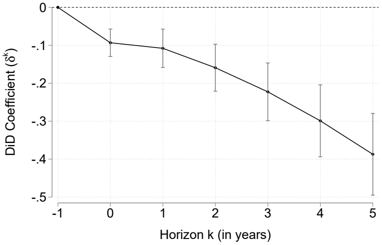
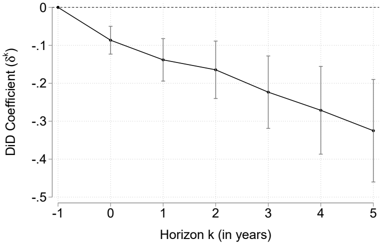


Figure: Low bank presence



Key Result: Employment growth in response to peer shock is weaker for destination counties experiencing economic distress

Back

Role of labor market factors in the destination county

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

Definitions:

- High employment HHI: Counties with above-median value of employment HHI calculated using D&B data
- High non-compete enforceability: Counties with above-median value of non-compete enforceability calculated using Starr (2019) data

Figure: High employment HHI

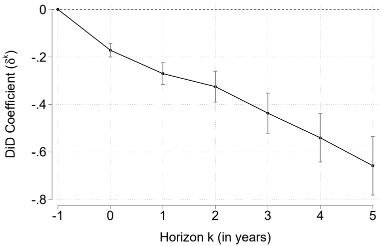
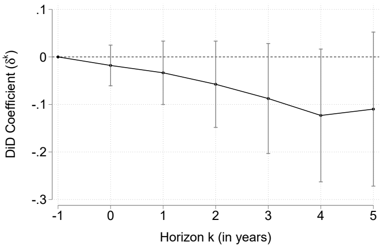


Figure: High non-compete enforceability



Key Result: Employment growth in response to peer shock is weaker for destination counties with more concentrated labor markets

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