Hot and Cold Choices: The Role of Extreme Temperatures in Shaping Industrial Geographical Distribution

Ding Ma[1], Min Wang[1], Shuo Li[2], Xiumei Yu[3]

1. National School of Development, Peking University
2. Faculty of Business and Economics, The University of Hong Kong
3. School of Public Finance and Taxation, Zhongnan University of Economics and Law

May 17th, 2025

Roadmap

Motivation

- A large literature documents the adverse effects of extreme temperatures on production.
- **Gap in existing literature:**
  - Prior studies focus on short-term productivity losses (e.g., Deschênes and Greenstone (2007), Zhang et al., 2018, Somanathan et al. (2021)).
  - Much less is known about long-term firm behavior—do extreme temperatures affect firm entry and location choices?
- **Why it matters**
  - Firm entry/exit drives industrial dynamics and economic growth (Foster et al., 2008).
  - Climate-vulnerable regions (e.g., Africa, South Asia) will be left behind.
- **This paper asks**
  - Do persistent hot/cold extremes deter firm entry?
  - What are the underlying mechanisms?
  - How will climate change reshape the geography of economic activity?

Preview of Main Results

- Exposure to extreme temperatures significantly reduces firm entry, with effects persisting up to 12 years.
  - Firm exit remains largely unaffected.
- Heterogeneity:
  - Large and private entrants are more responsive than small and state-owned entrants.
  - Cold (hot) days deter entry more in colder (warmer) regions.
- Mechanisms:
  - Extreme temperatures reduce firm entry in tradable sectors—agriculture and industry—by lowering the market competitiveness of firms in highly exposed regions.
  - This, in turn, depresses local demand and reduces entry in non-tradable sectors such as services.
  - Firms reallocate investment toward regions with more moderate temperature profiles.
- Future projections:
  - By the end of the century, climate change may reduce firm entry in over half of Chinese counties.
  - Southern regions will suffer larger losses than the north.

Contribution

- New evidence on firms' long-term climate adaptation:
  - Earlier studies emphasize air conditioning use (Somanathan et al., 2021) or labor reallocation (Acharya et al., 2023).
  - We highlight a novel adaptation margin: strategic location choice.
- Extending New Economic Geography (NEG):
  - Classic NEG model emphasizes how economic geography is shaped by economic fundamentals such as agglomeration economies, market access, and transport infrastructure (Krugman, 1991; Redding and Sturm, 2008; Donaldson and Hornbeck, 2016).
  - We show that climate shapes the spatial distribution of firms and thereby the economic geography.
- Policy implications:
  - Invest in infrastructure in climate-friendly regions likely to attract future industrial activity.
  - Design adaptive policies to retain economic vitality in climate-vulnerable regions.

A Simple Illustration

- Consider a long-run production function:

$$\pi = p\,F(\tilde{K}, \tilde{L}, T) - rK - wL$$

  where
  - $\tilde{K} = A_K(T)K$ and $\tilde{L} = A_L(T)L$.
  - K, L, T, and A denote capital input, labor input, temperature, and effective input productivity, respectively.
- Temperature affects effective input productivity
  - $A'_K(T) < 0$ and $A'_L(T) < 0$ when T is sufficiently high.
  - $A'_K(T) > 0$ and $A'_L(T) > 0$ when T is sufficiently low.
- Extensive margin decision: enter if $\pi > 0$, exit if $\pi < 0$.

A Simple Illustration

- Temperature can affect firms' output through three potential **supply side** channels:
  1. **Direct Effect on Output (esp. agriculture)**
     - $\frac{\partial F(\tilde{K}, \tilde{L}, T)}{\partial T} < 0$ and $\frac{\partial F(\tilde{K}, \tilde{L}, T)}{\partial T} > 0$ when T is sufficiently high and low.
     - E.g., crop failure beyond thermal thresholds.
  2. **Labor Productivity Decline (all sectors):**
     - Health risks (heat stroke, frostbite) $\Rightarrow -\frac{\partial F}{\partial \tilde{L}} A_L'(T) < 0$ and $\frac{\partial F}{\partial \tilde{L}} A_L'(T) > 0$ when T is sufficiently high and low.
  3. **Capital Productivity Decline (minor, all sectores):**
     - Machine overheating/freezing $\Rightarrow -\frac{\partial F}{\partial \tilde{K}} A_K'(T) < 0$ and $\frac{\partial F}{\partial \tilde{K}} A_K'(T) > 0$ when T is sufficiently high and low.
- **Empirical implication:** the negative impact of extreme temperatures on firm entry is stronger in sectors where TFP is more sensitive to extreme temperatures.

Sector–Specific Mechanisms

- Tradable sectors: agriculture & industry
  - Firms face competition in the national market.
  - Extreme $T \Rightarrow \downarrow$ local productivity $\Rightarrow \downarrow$ market competitiveness $\Rightarrow \downarrow$ entry.
- Non-tradable sector: services
  - Firms are dependent on local demand.
  - Extreme $T \Rightarrow \downarrow$ output of downstream tradable sectors $\Rightarrow \downarrow$ service demand (e.g., transportation, finance) $\Rightarrow \downarrow$ entry.
  - Also: extreme temperatures may suppress household demand (e.g., retail, entertainment).

Data

Data Overview

- Firm Registration Database (1990-2019)
- Annual Survey of Industrial Firms (1998-2007)
- History Daily Weather Data (1951-2019)
- Climate Projections from NASA NEX-GDDP (2080-2099)

Data

Firm Data

- **Firm Registration Database (1990-2019)**
  - A population dataset providing details of all Chinese firms' registration records.
  - For each firm, we observe registration dates and cancellation or revocation dates (if applicable).
  - We compute the number of firm entry, firm exit, and firm-to-firm equity investments at county-year level during 1990-2013.
    - **Begin in 1990** - China's economy became more market-oriented in the early 1990s, following economic liberalization policies that opened the country to foreign trade and investment and relaxed regulations on private enterprises.
    - **End in 2013** - China's 2014 Company Law reform significantly lowered entry barriers and led to concerns over inflated or inactive registrations.
  - In addition to tracking new firm creation, we construct firm-to-firm equity investment links using shareholder records.

Data

Summary Statistics

Table 1: Summary statistics of firm entry, firm exit, and firm-to-firm equity investments

	(1) Observation	(2) Mean	(3) S.D.	(4) min	(5) max
Panel A: Firm entry and exit					
Number of firm entry	67,632	420.0	1,105	0	42,922
Number of firm exit	67,632	190.4	599.1	0	25,770
Panel B: Intra-county firm-to-firm equity investments					
Number	67,632	12.91	45.34	0	3,060
Panel C: Outward inter-county firm-to-firm equity investments					
Number	67,632	9.700	43.85	0	2,109
Number (colder regions)	67,632	4.721	23.52	0	1,622
Number (warmer regions)	67,632	4.941	26.01	0	1,675
Panel D: Inward inter-county firm-to-firm equity investments					
Number	67,632	9.696	39.29	0	1,949
Panel E: City-pair equity investments					
Number	2,798,928	0.111	1.763	0	743

Data

- **Annual Survey of Industrial Firms (1998-2007)**
  - Firm-level information on firms' operations.
  - Includes all State-Owned Enterprises (SOEs) irrespective of size and non-SOEs with annual sales surpassing CNY 5 million (USD 0.7 million).
  - In our sample: 1,398,007 firm-year observations from 387,541 unique firms.

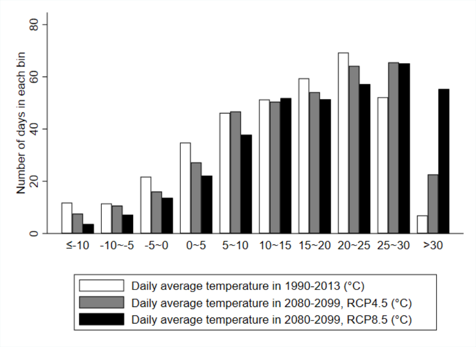
Data

Weather and Climate Projections

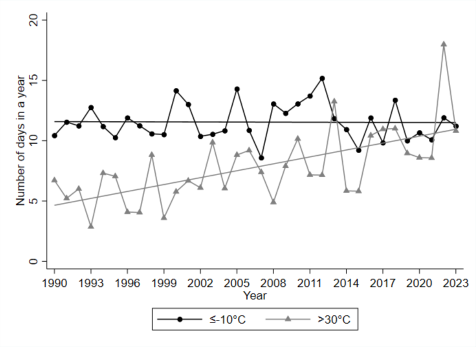
- **Historical weather data (1951-2013)**
  - From the China Meteorological Data Sharing Service (CMDSS) system.
  - Variables: daily average temperature, precipitation, average relative humidity, wind speed, and sunshine hours from more than 2000 weather stations.
  - Station level $\Rightarrow$ County level: IDW of all valid station observations within a 50-mile (80-kilometer) radius of each county centroid (greater weight to closer stations).
- **Climate projection data (2080-2099)**
  - From the NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP).
  - Variables: daily maximum and minimum temperatures at $0.25^{\circ} \times 0.25^{\circ}$ and 21 models.
  - Two Representative Concentration Pathways (RCPs): RCP4.5 (stabilization scenario), and RCP8.5 (A high-emissions "business-as-usual" scenario).
  - How we use: aggregate to county level $\Rightarrow$ average to get the daily average temperature $\Rightarrow$ use the median projected temperature across the 21 models.

Data

Summary Statistics



Temperature distribution



Average number of days

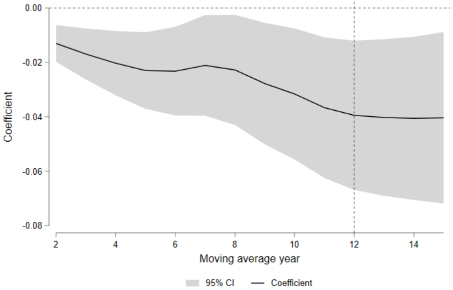
Baseline Specification

- Firm entry and exit are count variables with many zero observations $\Rightarrow$ Employ Poisson Pseudo Maximum Likelihood (PPML) estimator by estimating the following equation:

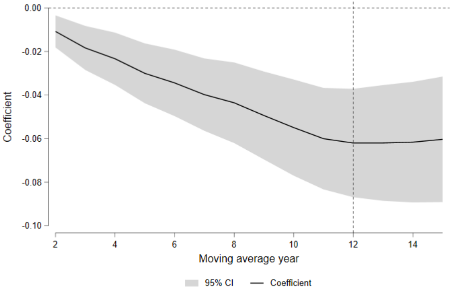
$$Y_{c,t} = \exp\left(\alpha + \sum_j \beta^j \times \left[\frac{1}{k}\sum_{i=0}^{k-1} TEMP^j_{c,t-i}\right] + \delta \times \left[\frac{1}{k}\sum_{i=0}^{k-1} X_{c,t-i}\right] + \lambda_c + \gamma_{p,t}\right) \times \epsilon_{c,t} \quad (1)$$

  - $Y_{c,t}$: the number of new firm entries (or exits) in county c and year t.
  - $TEMP^j_{c,t-i}$: number of days in which the daily average temperature in county c and year $t-i$ falls into the jth 5°C bin.
    - Use 12-year moving average to capture long-term exposure, i.e., $k = 12$.
  - $X_{c,t-i}$: other weather control variables, including humidity, sunshine hours, wind speed, and precipitation.
  - λ_c - county fixed effects; $\gamma_{p,t}$ - province by year fixed effects.
  - $\epsilon_{c,t}$ - error term, clustered at county level.

Identification Window

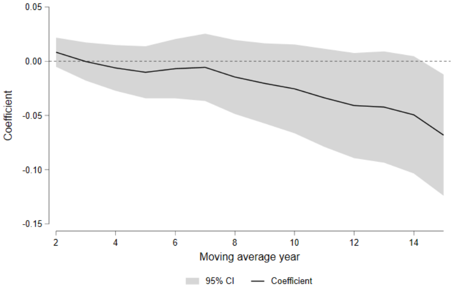


Firm entry, temperature $\leq$-10°C

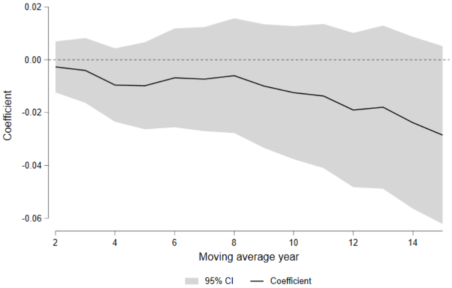


Firm entry, temperature $>$30°C

Identification Window



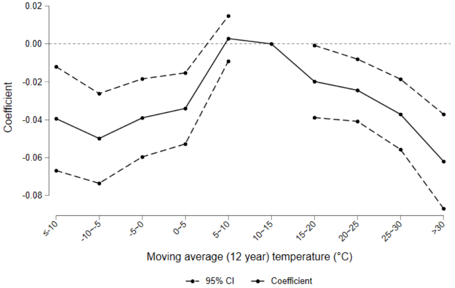
Firm exit, temperature $\leq$-10°C



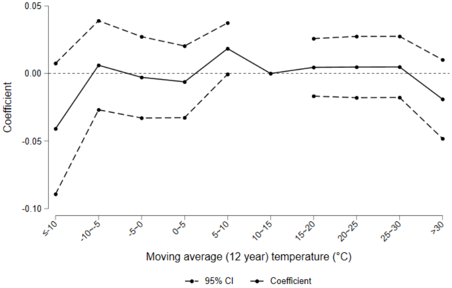
Firm exit, temperature $>$30°C

Baseline Results

- +1 hot day (>30°C) ⇒ ↓ entry number **6.20%**; +1 cold day (≤-10°C) ⇒ ↓ entry number **3.94%**.
- Exit largely unaffected ⇒ entry decisions dominates.



Firm entry, 12-yr ma temperature



Firm exit, 12-yr ma temperature

Robustness Checks

1. Apply the inverse hyperbolic sine (IHS) transformation to the outcome variable and re-estimate the model using OLS.
2. Exclude all weather controls.
3. Include county-specific linear yearly trends.
4. Adjust the cluster level to county and province by year.
5. Extend our sample period to 2019.
6. Redefine temperature exposure using daily maximum temperatures.

Robustness Checks

Table 3: Robustness checks on firm entry number

	(1)	(2)	(3)	(4)	(5)		(6)
	IHS	No weather controls	Add county-specific trend	Change cluster	Add 2014-2019		Maximum temperature
≤-10°C	-0.0180*	-0.0335**	-0.0412***	-0.0394**	-0.0204*	≤-5°C	-0.0569***
	(0.0093)	(0.0133)	(0.0139)	(0.0171)	(0.0120)		(0.0138)
-10~-5°C	-0.0378***	-0.0457***	-0.0513***	-0.0499***	-0.0336***	-5~0°C	-0.0672***
	(0.0087)	(0.0120)	(0.0121)	(0.0135)	(0.0115)		(0.0125)
-5~0°C	-0.0238***	-0.0357***	-0.0404***	-0.0390***	-0.0318***	0~5°C	-0.0581***
	(0.0077)	(0.0106)	(0.0105)	(0.0112)	(0.0097)		(0.0110)
0~5°C	-0.0172***	-0.0346***	-0.0348***	-0.0340***	-0.0343***	5~10°C	-0.0374***
	(0.0062)	(0.0098)	(0.0096)	(0.0102)	(0.0084)		(0.0089)
5~10°C	0.0076	0.0056	0.0024	0.0028	-0.0008	10~15°C	0.0026
	(0.0048)	(0.0067)	(0.0061)	(0.0070)	(0.0056)		(0.0071)
15~20°C	-0.0013	-0.0141	-0.0195**	-0.0199*	-0.0091	20~25°C	-0.0380***
	(0.0051)	(0.0103)	(0.0097)	(0.0106)	(0.0087)		(0.0098)
20~25°C	-0.0069	-0.0128	-0.0247***	-0.0245***	-0.0154**	25~30°C	-0.0328***
	(0.0058)	(0.0085)	(0.0084)	(0.0090)	(0.0077)		(0.0076)
25~30°C	-0.0124**	-0.0221**	-0.0377***	-0.0372***	-0.0258***	30~35°C	-0.0516***
	(0.0062)	(0.0092)	(0.0095)	(0.0100)	(0.0083)		(0.0090)
>30°C	-0.0183**	-0.0453***	-0.0627***	-0.0620***	-0.0506***	>35°C	-0.0534***
	(0.0080)	(0.0116)	(0.0128)	(0.0137)	(0.0114)		(0.0105)
Observations	67,632	67,632	67,632	67,632	84,540		67,632
Pseudo R-squared	-	0.928	0.929	0.929	0.946		0.929
Adjusted R-squared	0.899	-	-	-	-		-

Robustness Checks

- **Long-difference approach (OLS):**

$$\Delta Y_{c,d} = \alpha + \sum_j \beta^j \times \Delta\left[TEMP^j_{c,d}\right] + \delta \times \Delta\left[X_{c,d}\right] + \lambda_c + \gamma_{p,d} + \mu_{c,d} \tag{2}$$

  - $\Delta Y_{c,d} = Y_{c,d} - Y_{c,d-1}$: the difference in the four-year average of the outcome variables between two adjacent periods, d and $d-1$, in county c, with $d \in \{2,3\}$.
    - Three periods: 1990–1993, 2000–2003, 2010–2013.
  - $\Delta\left[TEMPc, d^j\right]$ and $\Delta\left[X_{c,d}\right]$: the changes in the corresponding four-year period averages of temperature bins and other weather controls.
  - λ_c - county fixed effects; $\gamma_{p,d}$ - province by period fixed effects.
- **Long-term average approach (PPML):**

$$\bar{Y}_{c,d} = \exp\left(\alpha + \sum_j \beta^j \times \overline{TEMP}^j_{c,d} + \delta \times \bar{X}_{c,d} + \lambda_c + \gamma_{p,d}\right) \times \epsilon_{c,d} \tag{3}$$

  - $\bar{Y}_{c,d}$, $\overline{TEMP}^j_{c,d}$, and $\bar{X}_{c,d}$: the period average of firm entry number, temperature bins, and other weather variables in county c and period d.

Robustness Checks

Table 4: Long-difference regression and average regression

	(1) Long-difference (4 years)	(2) Long-difference (6 years)	(3) Long-term average (4 years)	(4) Long-term average (6 years)
≤-10°C	-14.0908***	-9.3055**	-0.0322***	-0.0303***
	(4.8941)	(3.7926)	(0.0103)	(0.0108)
-10~-5°C	-14.2440***	-11.4004***	-0.0511***	-0.0435***
	(4.3199)	(3.5441)	(0.0095)	(0.0096)
-5~0°C	-11.6716***	-10.5711***	-0.0388***	-0.0329***
	(4.2676)	(3.7293)	(0.0077)	(0.0074)
0~5°C	-10.3461***	-11.6321***	-0.0379***	-0.0313***
	(3.2577)	(2.8879)	(0.0066)	(0.0063)
5~10°C	-4.8917*	-8.6998***	-0.0095**	-0.0051
	(2.5683)	(2.6609)	(0.0040)	(0.0046)
15~20°C	-1.0899	0.5920	0.0001	0.0096
	(1.6853)	(2.0577)	(0.0046)	(0.0061)
20~25°C	-3.4006	-5.8883**	-0.0110**	-0.0028
	(2.1421)	(2.3439)	(0.0053)	(0.0059)
25~30°C	-9.3346***	-7.4555***	-0.0106**	-0.0047
	(2.9313)	(2.6136)	(0.0047)	(0.0054)
>30°C	-10.0925	-14.0328*	-0.0354***	-0.0273***
	(8.6907)	(7.4237)	(0.0090)	(0.0085)
Observations	5,636	5,636	8,454	8,454
Pseudo R-squared	-	-	0.948	0.953
Adjusted R-squared	0.515	0.531	-	-

Heterogeneity

- Firms with different characteristics may respond differently to extreme temperatures.
  - Firms differ in market competitiveness and profit orientation, which may shape their responsiveness to climate-related shocks. $\Rightarrow$ heterogeneity analysis by **firm size** and **ownership**.
  - Firms located in different climate zones may have distinct adaptation capacities. $\Rightarrow$ heterogeneity analysis by **regional climate conditions**.

Heterogeneity

Table 5: Heterogeneous effects of temperatures on firm entry

	(1) Large	(2) Small	(3) SOE	(4) POE	(5) Cold regions	(6) Warm regions
≤-10°C	-0.0507***	-0.0241*	-0.0404**	-0.0398***	-0.0470***	-0.3364
	(0.0154)	(0.0145)	(0.0174)	(0.0144)	(0.0143)	(0.4793)
-10~-5°C	-0.0602***	-0.0373***	-0.0101	-0.0589***	-0.0541***	-0.0677
	(0.0142)	(0.0123)	(0.0163)	(0.0127)	(0.0129)	(0.0945)
-5~0°C	-0.0431***	-0.0319***	-0.0089	-0.0472***	-0.0527***	-0.0216
	(0.0114)	(0.0113)	(0.0134)	(0.0109)	(0.0117)	(0.0221)
0~5°C	-0.0368***	-0.0282***	-0.0071	-0.0381***	-0.0416***	-0.0247*
	(0.0101)	(0.0100)	(0.0111)	(0.0100)	(0.0112)	(0.0133)
5~10°C	-0.0092	0.0147**	0.0025	0.0032	-0.0391***	0.0139*
	(0.0064)	(0.0065)	(0.0076)	(0.0064)	(0.0088)	(0.0074)
15~20°C	-0.0193*	-0.0190*	0.0024	-0.0193*	-0.0272***	-0.0215
	(0.0108)	(0.0098)	(0.0085)	(0.0102)	(0.0104)	(0.0141)
20~25°C	-0.0267***	-0.0206**	-0.0196**	-0.0266***	-0.0411***	-0.0199*
	(0.0098)	(0.0083)	(0.0090)	(0.0090)	(0.0109)	(0.0111)
25~30°C	-0.0419***	-0.0305***	-0.0390***	-0.0402***	-0.0371***	-0.0359***
	(0.0108)	(0.0095)	(0.0104)	(0.0100)	(0.0112)	(0.0125)
>30°C	-0.0617***	-0.0603***	-0.0081	-0.0681***	-0.0445**	-0.0602***
	(0.0147)	(0.0127)	(0.0141)	(0.0130)	(0.0204)	(0.0153)
Observations	67,632	67,632	67,632	67,632	33,624	33,912
Pseudo R-squared	0.932	0.903	0.766	0.935	0.940	0.920

Mechanisms

Industry-specific impacts

- We begin by analyzing how extreme temperatures influence firm entry across three main sectors, i.e., agriculture, industry, and services.
- Both extremely high and low temperatures significantly reduce firm entry in all three sectors.

Table 6: Firm entry in different industries

	(1) Agriculture	(2) Industry	(3) Services
≤-10°C	0.0034	-0.0628***	-0.0228
	(0.0338)	(0.0162)	(0.0152)
-10~-5°C	-0.0727***	-0.0690***	-0.0230*
	(0.0229)	(0.0139)	(0.0139)
-5~0°C	-0.0569***	-0.0350***	-0.0275**
	(0.0185)	(0.0127)	(0.0121)
0~5°C	-0.0349**	-0.0467***	-0.0226**
	(0.0138)	(0.0104)	(0.0111)
5~10°C	-0.0013	0.0130*	0.0012
	(0.0108)	(0.0076)	(0.0070)
15~20°C	0.0514***	-0.0134	-0.0308***
	(0.0128)	(0.0101)	(0.0111)
20~25°C	0.0227*	-0.0132	-0.0315***
	(0.0133)	(0.0089)	(0.0097)
25~30°C	0.0092	-0.0400***	-0.0387***
	(0.0138)	(0.0101)	(0.0112)
>30°C	-0.0716***	-0.0510***	-0.0645***
	(0.0195)	(0.0143)	(0.0153)
Observations	67,368	67,608	67,632
Pseudo R-squared	0.807	0.894	0.931

Mechanisms

Industry-specific impacts

- **Agriculture sector**
  - This effect may operate through two channels: crop production enterprises are directly sensitive to climatic conditions, while agricultural product processing firms may be indirectly affected through disruptions in the supply of raw agricultural inputs.
- **Industry sector**
  - Extreme temperatures may affect firm entry in industry sector by reducing firm productivity through declines in both labor and capital efficiency.
  - Using ASIF dataset, we estimate the effect of extreme temperatures on TFP across all 44 two-digit Chinese code industry subsectors, and obtain the subsector-specific effects of extreme temperatures on TFP, ρ_k^j.
  - Using the estimators of the coldest ($\leq$-10°C, ρ_k^1) and hottest ($>$30°C, $\rho_k^1 0$) temperature bin, we classify the 44 two-digit industry subsectors into four groups.

Mechanisms

Industry-specific impacts

Table 7: Mechanism of firm entry in the industry sector

	(1) High cold impact group	(2) Low cold impact group	(3) High heat impact group	(4) Low heat impact group
≤-10°C	-0.0727***	-0.0563***	-0.0733***	-0.0545***
	(0.0195)	(0.0153)	(0.0188)	(0.0157)
-10~-5°C	-0.0753***	-0.0641***	-0.0714***	-0.0657***
	(0.0174)	(0.0131)	(0.0161)	(0.0138)
-5~0°C	-0.0213	-0.0444***	-0.0216	-0.0452***
	(0.0166)	(0.0115)	(0.0152)	(0.0121)
0~5°C	-0.0457***	-0.0464***	-0.0493***	-0.0439***
	(0.0127)	(0.0098)	(0.0126)	(0.0095)
5~10°C	0.0328***	-0.0018	0.0232**	0.0038
	(0.0092)	(0.0075)	(0.0098)	(0.0069)
15~20°C	-0.0126	-0.0134	-0.0181	-0.0098
	(0.0132)	(0.0090)	(0.0131)	(0.0087)
20~25°C	-0.0084	-0.0176**	-0.0107	-0.0164**
	(0.0113)	(0.0083)	(0.0111)	(0.0082)
25~30°C	-0.0438***	-0.0380***	-0.0498***	-0.0333***
	(0.0125)	(0.0093)	(0.0127)	(0.0090)
>30°C	-0.0572***	-0.0458***	-0.0529***	-0.0524***
	(0.0168)	(0.0132)	(0.0160)	(0.0139)
Observations	67,560	67,560	67,536	67,584
Pseudo R-squared	0.876	0.869	0.890	0.851

Mechanisms

Industry-specific impacts

- **Services sector**
  - **Industry consumer:**
    - Many service subsectors serve as upstream suppliers to the industry sector, such as wholesale trade, transportation, warehousing, finance, and professional, scientific, and technical services.
    - A reduction in industrial activity due to temperature shocks may therefore transmit through the supply chain, adversely affecting the services sector.
    - We construct a downstream temperature exposure index for each of the 13 one-digit Chinese code service subsectors, and divide the 13 subsectors into two groups depending on the median.
    - E.g., the downstream extremely low temperature exposure index for subsector s is defined as:

$$\text{Exposure}_s = \sum_{k=1}^{44} w_{s,k} \rho_k^1$$

  - **Household consumer:**
    - Many services rely on household consumption, such as retail, entertainment, and residential services.
    - If extreme temperatures reduce individuals' outdoor activities, they may also depress the household demand for these service goods.
    - We use the IO table to compute the share of household consumption in each service subsector's output, and divide the 13 subsectors into two groups depending on the median.

Mechanisms

Industry-specific impacts

Table 8: Mechanism of firm entry in the service sector

	(1) High downstream cold-exposure	(2) Low downstream cold-exposure	(3) High downstream heat-exposure	(4) Low downstream cold-exposure	(5) High-ratio (Household consumption)	(6) Low-ratio (Household consumption)
≤-10°C	-0.0430***	-0.0143	-0.0194	-0.0416***	-0.0434***	-0.0188
	(0.0143)	(0.0164)	(0.0161)	(0.0134)	(0.0165)	(0.0157)
-10~-5°C	-0.0416***	-0.0157	-0.0213	-0.0329***	-0.0386***	-0.0202
	(0.0125)	(0.0153)	(0.0150)	(0.0109)	(0.0139)	(0.0147)
-5~0°C	-0.0436***	-0.0205	-0.0256**	-0.0395***	-0.0452***	-0.0243*
	(0.0110)	(0.0132)	(0.0130)	(0.0102)	(0.0128)	(0.0127)
0~5°C	-0.0302***	-0.0191	-0.0238**	-0.0136	-0.0260**	-0.0213*
	(0.0098)	(0.0123)	(0.0120)	(0.0090)	(0.0109)	(0.0118)
5~10°C	-0.0093	0.0069	0.0020	-0.0022	-0.0125*	0.0038
	(0.0066)	(0.0077)	(0.0076)	(0.0060)	(0.0073)	(0.0074)
15~20°C	-0.0224***	-0.0338***	-0.0344***	-0.0102	-0.0234**	-0.0321***
	(0.0086)	(0.0124)	(0.0121)	(0.0070)	(0.0094)	(0.0119)
20~25°C	-0.0222***	-0.0343***	-0.0343***	-0.0150**	-0.0259***	-0.0322***
	(0.0081)	(0.0107)	(0.0106)	(0.0072)	(0.0089)	(0.0104)
25~30°C	-0.0266***	-0.0430***	-0.0421***	-0.0172**	-0.0291***	-0.0400***
	(0.0088)	(0.0124)	(0.0123)	(0.0071)	(0.0096)	(0.0121)
>30°C	-0.0596***	-0.0664***	-0.0660***	-0.0552***	-0.0797***	-0.0617***
	(0.0122)	(0.0172)	(0.0166)	(0.0119)	(0.0152)	(0.0164)
Observations	67,632	67,632	67,632	67,584	67,632	67,632
Pseudo R-squared	0.931	0.915	0.929	0.864	0.894	0.926

Mechanisms

Cross-regional Equity Investments

- **Inter-county equity investments:**
  1. Intra-county investments: number of equity investments **from firms in county** c into newly established firms within **the same county** in year t;
  2. Outward inter-county investments: number of equity investments **from firms in county** c into newly established firms **outside of county** c in year t;
  3. Inward inter-county investments: number of equity investments **from firms outside of county** c into newly established firms **in county** c in year t.
- **City-pair regression:**
  - We construct a city-pair panel dataset by matching firm-to-firm equity investment flows between every pair of prefecture-level cities.
  - With 342 prefecture-level cities in China, this yields 116,622 (342×341) city pairs.

Mechanisms

Cross-regional Equity Investments

- The city-pair regression model is as follows:

$$Y_{o,d,t} = \exp\left(\alpha + \sum_j \beta^j \times diffTEMP^j_{o,d,t} + \delta \times diffX_{o,d,t} + \tau_{o,d} + \varphi_{p_o,t} + \varphi_{p_d,t}\right) \times \epsilon_{o,d,t} \tag{4}$$

  - $Y_{o,d,t}$: the total number of firm-to-firm equity investments from city o to city d in year t.
  - $diffTEMP^j_{o,d,t}$: the difference in the number of days falling into the jth temperature bin (based on 5°C intervals) between the two cities over the past 12 years.
  - $diffX_{o,d,t}$: the difference of other weather control variables between city o and city d.
  - $\tau_{o,d}$ - city-pair fixed effects; $\varphi_{p_o,t}$ - origin province by year fixed effects; $\varphi_{p_d,t}$ - destination province by year fixed effects.
  - $\epsilon_{o,d,t}$ - error term, clustered at city-pair level.

Mechanisms

Cross-regional Equity Investments

Table 9: Results on firm-to-firm equity investments in new firms

	(1) Intra-county	(2) Inter-county: outward	(3) Inter-county: inward	(4) Outward to colder counties	(5) Outward to warmer counties	(6) City pair
≤-10°C	-0.0339	-0.0247	-0.0493**	-0.0590***	-0.0112	-0.0372***
	(0.0214)	(0.0186)	(0.0198)	(0.0195)	(0.0281)	(0.0112)
-10~-5°C	-0.0287	-0.0026	-0.0461**	-0.0387**	0.0196	-0.0579***
	(0.0194)	(0.0160)	(0.0186)	(0.0167)	(0.0236)	(0.0106)
-5~0°C	-0.0197	-0.0079	-0.0438***	-0.0191	-0.0146	-0.0503***
	(0.0173)	(0.0147)	(0.0165)	(0.0163)	(0.0209)	(0.0096)
0~5°C	0.0059	0.0111	-0.0151	0.0041	0.0124	-0.0249***
	(0.0151)	(0.0131)	(0.0151)	(0.0147)	(0.0174)	(0.0079)
5~10°C	0.0294***	0.0266***	0.0263***	0.0187*	0.0395***	-0.0056
	(0.0105)	(0.0081)	(0.0095)	(0.0096)	(0.0102)	(0.0049)
15~20°C	0.0079	0.0049	0.0180	0.0125	0.0110	0.0237***
	(0.0131)	(0.0131)	(0.0137)	(0.0147)	(0.0174)	(0.0069)
20~25°C	-0.0078	-0.0162	0.0025	-0.0043	-0.0256	0.0056
	(0.0134)	(0.0132)	(0.0127)	(0.0130)	(0.0198)	(0.0072)
25~30°C	-0.0274**	-0.0214*	-0.0177	-0.0107	-0.0376**	-0.0005
	(0.0137)	(0.0128)	(0.0110)	(0.0128)	(0.0184)	(0.0078)
>30°C	-0.0262	-0.0279	-0.0224	-0.0017	-0.0574**	-0.0039
	(0.0167)	(0.0190)	(0.0184)	(0.0199)	(0.0238)	(0.0084)
Observations	66,140	65,568	66,588	63,425	59,354	589,991
Pseudo R-squared	0.831	0.906	0.862	0.863	0.885	0.714

Climate Projections

Projection Method

- Climate projections from the NEX-GDDP dataset suggests that China will experience more extremely hot days and fewer extremely cold days by the end of this century.
- To assess how climate change may reshape the geography of firm entry, we predict the changes in firm entry by the end of the century:

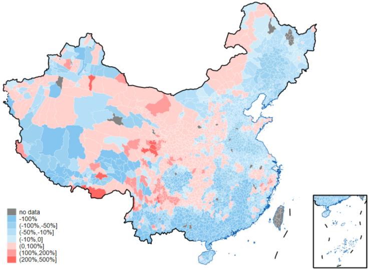
$$\Delta Y_c(\%) = \left(\sum_j \hat{\beta}^j \times \Delta TEMP_c^j \right) \times 100\% \tag{5}$$

  - $\Delta Y_c(\%)$: the projected percentage change in firm entry in county c.
  - $\hat{\beta}^j$: estimator for temperature bin j in equation (1).
  - $\triangle TEMP_c^j$: the difference of the number of days in the jth temperature bin between 2080-2099 and 1990-2013.
  - ΔY_c: the isolated effect of changes in temperature patterns on firm entry, holding other weather variables constant.

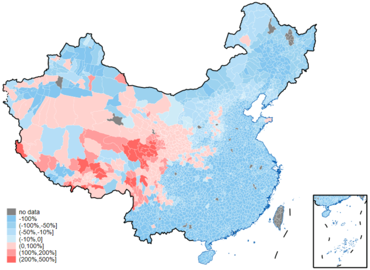
Climate Projections

Projected Firm Entry Change 2080-2099

- Under RCP4.5 (8.5), climate change will reduce the number of firm entry by approximately 358 (953) per county per year.
- These declines are substantial, given that the average number of firm entry per county was around 1,028 in 2013 and 2,701 in 2019.



Projection in RCP4.5



Projection in RCP8.5

Conclusion

- **Temperature-firm entry and exit relationship:**
  - Inverted U-shaped curve in entry: extreme heat and cold reduce firm entry.
  - Firm exit is unaffected.
- **Mechanisms:**
  - Industry perspective:
    - Agriculture/Industry: production shocks ($\downarrow$ productivity).
    - Services: demand-side effects ($\downarrow$ local demand).
  - Firms' cross regional investment:
    - $\downarrow$ Intra-county & inward inter-county investments.
    - $\uparrow$ Outward investments to milder-climate regions.
    - City-pair analysis: firms prefer investing in cities with better climates than home cities.
- **End-of-century projection:**
  - Firm entry is projected to decline in over half of China's counties.
  - Southern regions will experience greater firm losses than the north due to rising temperatures.

Thank you!

Questions & comments welcome.