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The impact of rainfall on productivity: Implications for Chinese manufacturing

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Key Points

- Extreme rainfall (≥100mm daily) significantly reduces Chinese manufacturing firms' productivity.
- Labor-intensive, low-tech, foreign-owned firms and those in southern China are more vulnerable.
- Productivity losses stem from reduced labor supply, disrupted agricultural inputs, and transport issues.
- Firms use insurance/inventory adjustments; macro infrastructure (dams, roads) and sustainable SSP policies mitigate risks.

Policy Focus

Global climate change amplifies rainfall volatility, posing risks to China's manufacturing sector— a global powerhouse accounting for 22% of world manufacturing output. Addressing gaps in macro-centric research, this study offers micro-level empirical evidence to guide targeted policy: support vulnerable firms (labor-intensive, low-tech, foreign-owned, and those in rainy regions), strengthen anti-flood, transportation, and drainage infrastructure in high-risk areas, and align environmental policies with SSP scenarios. These measures aim to mitigate future productivity and output losses, safeguarding sustainable industrial growth.

Study Methodology

The study integrates ground station-level climate data (from China's National Meteorological Information Center) and micro-data of 568,888 manufacturing firms (1998–2007) from the ASIF database (covering over 90% of China's industrial output). It uses fixed-effects panel regression (controlling firm, industry, year fixed effects) and quadratic climate variable terms, with rainfall measured via annual/seasonal totals, bins (e.g., ≥250mm), anomalies, and lagged effects.

Robustness checks include adjusting econometric settings, controlling snowfall, and testing alternative rainfall bin references. Heterogeneity analysis covers sectors (labor/capital-intensive), ownership (state/foreign-owned), and regions (southern rainy/northwestern arid), with productivity validated via OP, LP, and labor productivity measures.

Findings and Analysis

Extreme Rainfall Induces Significant Productivity Losses

Extreme rainfall exerts a pronounced negative impact on the productivity of Chinese manufacturing firms, with losses escalating as rainfall intensity increases. Specifically, a single day of daily rainfall ≥250mm (extraordinary storm) leads to a 1.77% productivity loss, while 100–250mm (downpour) and 50–100mm (torrential rain) result in losses of 1.51% and 0.19% respectively. In contrast, rainfall ≤50mm (including moderate rain and drizzle) shows no significant negative effects on productivity. Seasonally, summer and autumn rainfall have notable adverse impacts on firm productivity, whereas spring and winter rainfall do not trigger significant productivity fluctuations.

Heterogeneous Vulnerability Across Firms, Sectors, and Regions

Clear heterogeneity exists in the impact of extreme rainfall across different dimensions. From a sectoral perspective, agricultural processing and outdoor production industries are the most vulnerable, suffering severe productivity declines under extreme rainfall. In terms of firm ownership, foreign-owned firms are highly susceptible—experiencing a 12.91% productivity loss from ≥250mm rainfall—while state-owned firms demonstrate strong resilience with no significant productivity response Regionally, firms in southern China (a rainy region with an annual average rainfall of 1730mm) face far greater losses from extreme rainfall, whereas firms in arid northwest China (with only 399mm annual average rainfall) are minimally affected due to the rarity of extreme rainfall events. Additionally, labor-intensive, low-tech, and less productive firms are more prone to rainfall-induced productivity losses compared to their capital-intensive, high-tech, and more developed counterparts.

Three Core Channels of Productivity Loss

The study identifies three primary mechanisms through which extreme rainfall reduces manufacturing productivity. First, labor supply is impaired: a single day of ≥250mm rainfall leads to a 2.95% reduction in labor supply for manufacturing firms, with labor-intensive firms experiencing an even steeper 4.31% decline. Second, agricultural spillover effects occur: manufacturing firms dependent on agricultural intermediate inputs suffer a 2.56% productivity loss from ≥250mm rainfall, as extreme rainfall disrupts agricultural production and the supply of raw materials. Third, transport disruptions emerge: transport-dependent firms face a 6.47% productivity loss from ≥250mm rainfall, far exceeding the baseline average of 1.77%, due to rainfall-induced damage to transport infrastructure and hindered material transportation.

Effective Adaptation Strategies Mitigate Losses

Firms and policymakers have adopted multiple adaptation measures to alleviate the negative impacts of extreme rainfall. At the firm level, manufacturing enterprises increase investments in non-productive inputs such as insurance and inventory to hedge against rainfall risks, which effectively mitigates extreme rainfall-induced productivity losses. Non-state-owned firms also adjust their market entry and exit strategies in response to extreme rainfall, enhancing overall resilience.

Table 1 Summary of data sets

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Summary of data sets.

	Observation	Mean	Standard devi.	Minimum	Maximum
Panel of Plants data					
TFP (log) (OP estimate)	1,559,844	2.61	1.02	−3.65	8.17
TFP (log) (LP estimate)	1,559,844	5.09	1.03	0.04	10.20
Labour Productivity (log) (Value added/Labour)	1,559,844	3.77	1.10	−2.85	10.02
Value added (log) (thousand CNY)	1,559,844	8.57	1.28	4.16	13.01
Capital (log) (thousand CNY)	1,559,844	8.54	1.50	3.94	12.80
Labour (log) (Person)	1,559,844	4.80	1.04	2.30	8.38
Investment (log) (thousand CNY)	1,559,844	6.91	1.70	−4.60	12.36
Intermediate inputs (log) (thousand CNY)	1,559,844	9.57	1.24	4.88	13.88
Inventory (log) (thousand CNY)	1,419,964	7.55	1.73	0.00	14.60
Insurance (log) (thousand CNY)	1,559,459	1.30	1.83	0.00	11.05
Age (log) ($Year^{current}$-$Year^{founding}$)	1,559,844	2.00	0.79	0.00	3.40
Weather Data					
Rainfall (mm)	1,559,844	1087.68	479.04	25.44	2681.16
Rainfall-Spring (mm)	1,559,844	274.38	193.26	1.02	993.33
Rainfall-Summer (mm)	1,559,844	510.3	225.39	9.63	1635.39
Rainfall-Autumn (mm)	1,559,844	187.95	106.68	0.00	1200.78
Rainfall-Winter (mm)	1,559,844	115.02	94.11	0.00	497.7
Rain day -above 250 mm (days)	1,559,844	0.004	0.07	0.00	2.00
Rain day -100–250 mm (days)	1,559,844	0.32	0.71	0.00	9.00
Rain day -50–100 mm (days)	1,559,844	2.30	2.29	0.00	15.00
Rain day -25–50 mm (days)	1,559,844	7.86	4.87	0.00	31.00
Rain day -10–25 mm (days)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

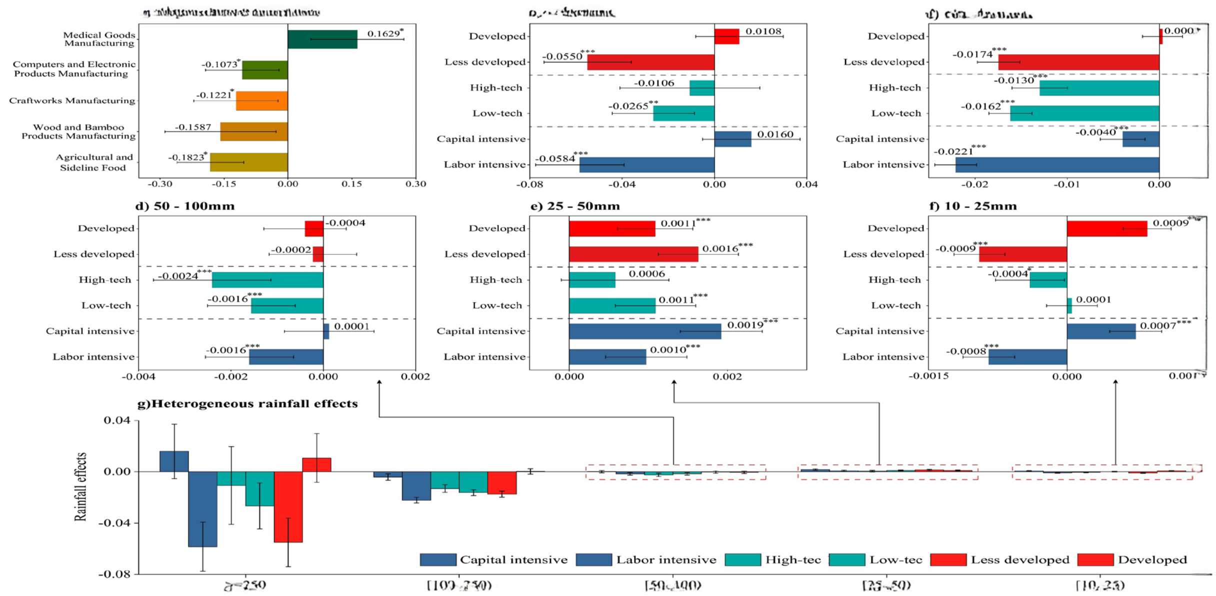

Figure 2 Heterogeneous rainfall effects on productivity by industry

At the macro level, infrastructure construction plays a critical role: anti-flood dams protect downstream firms, with downstream enterprises gaining a 5–50% productivity premium compared to upstream firms after dam construction (the premium increases as the distance to the dam decreases). Additionally, improved highway infrastructure and drainage systems significantly reduce productivity losses by mitigating transport disruptions and waterlogging issues caused by extreme rainfall.

Recommendations

Targeted Support for Vulnerable Firms

Prioritize assistance for high-risk entities—labor-intensive, low-tech, and foreign-owned firms, as well as those in agricultural processing and outdoor production sectors—by subsidizing non-productive investments such as insurance and inventory reserves, which effectively hedge against extreme rainfall risks. Offer tailored technical training to enhance operational resilience, with a focus on firms located in rainfall-prone regions like southern China, where extreme rainfall impacts are most severe. For non-state-owned firms, introduce supportive policies (e.g., streamlined administrative procedures, temporary financial relief) to ease market entry and exit pressures during climate shocks, as they are more responsive to such adjustments than state-owned counterparts.

Strengthen Infrastructure in High-Risk Areas

Accelerate the construction and upgrading of climate-resilient infrastructure in rainfall-prone regions. Prioritize anti-flood dam expansion in key river basins, leveraging evidence that downstream firms gain a 5–50% productivity premium post-construction (with greater benefits for firms closer to dams). Enhance highway networks and drainage systems to mitigate transport disruptions and waterlogging—critical issues for transport-dependent firms, which suffer 6.47% productivity loss from ≥250mm rainfall. Align infrastructure planning with regional rainfall patterns, focusing on southern China (with 1730mm annual average rainfall) and other wet regions where firms face the heaviest losses.

Align Policies with Sustainable SSP Scenarios

Integrate climate resilience into long-term environmental policies by adopting pathways consistent with SSP1–2.6 (low-emission, sustainable development). Implement carbon emission controls and clean energy transitions to reduce extreme rainfall impacts—projections show this can cut the effects of ≥250mm rainfall by over 50% by 2100. Avoid high-emission pathways like SSP5–8.5, which could double extreme rainfall's adverse effects by 2100, leading to up to 14.9 billion CNY in output losses. Embed rainfall impact assessments into industrial planning to ensure policies address sector-specific vulnerabilities, such as the high losses in agricultural processing and outdoor production.

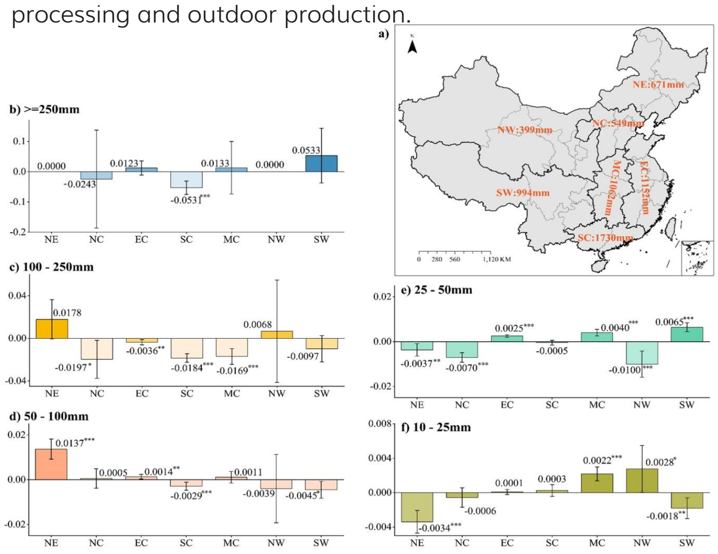

Figure 3 Heterogeneous rainfall effects on productivity by region

Main Reference

Chen, X., Lin, Y., & Zhu, P. (2025). "The impact of rainfall on productivity: Implications for Chinese manufacturing." Journal of Comparative Economics, 53(2), 389–411.https://doi.org/10.1016/j.jce.2025.03.005

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