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Urban Climate Adaptation and Corporate Patient Capital: Evidence from China's 2017 Pilot Program

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Abstract. This study estimates how China's 2017 climate-adaptive city pilot program affected corporate patient capital among nonfinancial A-share firms over 2009–2023. The baseline covers 30,748 firm-year observations in 248 cities. With firm and year fixed effects and the full set of controls, the difference-in-differences estimate is 0.1315 log points, equivalent to 10.7% of the index's sample standard deviation. The positive estimate persists under alternative measures, pre-policy matching and weighting, sample adjustments, and separate controls for concurrent city policies. The event-study estimates are positive and significant at the 10% level in event years 2–5 after implementation. Among the financing components, the first strategic equity measure shows the clearest response. The pilot estimates also indicate lower disaster losses and a smaller affected population, alongside greater supply-chain resilience. Annual reports show stronger green strategic orientation, wider environmental and sustainability disclosure, and more frequent long-term managerial language. Together, the financing and operating results identify patient capital as a corporate outcome associated with municipal climate adaptation.

Keywords: urban climate adaptation, patient capital, long-term financing, green strategy, sustainability disclosure

1. Introduction

Patient capital comprises financing relationships that can accommodate short-term earnings fluctuations while firms pursue investments with delayed returns [1]. Research on investor horizons has examined how those relationships shape corporate decisions [2]. The operating conditions behind those decisions extend to the city. A firm's ability to maintain production during a climate shock depends on its own facilities and on the transport, electricity, and supplier networks that serve them.

Municipal drainage, warning systems, and emergency coordination address risks shared by firms in the same location. These services affect the continuity of procurement and delivery and therefore enter assessments of future cash flows. Evidence on institutional investors and corporate capital structure establishes the relevance of climate exposure to financing [3, 4]. Urban adaptation provides a policy setting in which to examine the financing response to changes in the management of that exposure.

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China designated 28 localities for the first climate-adaptive city pilot program in 2017 [5]. The program incorporated climate adaptation into urban planning and management through monitoring, infrastructure improvements, ecological protection, and emergency preparedness. The timing and geographic coverage of the pilot allow the study to compare listed firms registered in pilot cities with firms in other cities before and after the program began.

The analysis uses nonfinancial A-share firms from 2009 to 2023. It estimates the change in the patient-capital index and examines the debt and equity measures separately. This comparison links the composite result to the financing forms represented in the index. The same policy setting also provides estimates for regional disaster outcomes, firm supply-chain resilience, and changes in annual reports. The operating and reporting measures provide evidence on the channels through which adaptation and financing are related.

The contribution concerns the connection between city-level risk management and corporate financing relationships. The registered-city comparison identifies a policy exposure common to firms in a locality, while the firm-level measures distinguish financing, strategy, and disclosure responses. Bringing these outcomes together places municipal infrastructure alongside corporate governance and investor horizons in the analysis of patient capital.

2. Theoretical framework and hypotheses

The effect on patient capital begins with the operating risks attached to long-term investment. Drainage and emergency preparedness can preserve access to facilities and limit interruptions to services on which firms depend. A more reliable operating environment supports expected cash flows over the period in which lenders and shareholders assess returns. Debt and equity providers evaluate those cash flows through different claims on the firm, which motivates examining each financing component alongside the index. H1. Urban climate adaptation increases corporate patient capital.

Operational continuity provides one route from adaptation to financing. Disruption at a supplier can reach a firm through a specialized input, even when the firm's own facilities remain operational [6]. Shared infrastructure and coordinated recovery can shorten disruptions to procurement and delivery. Disaster losses and the affected population describe the local exposure, while supply-chain resilience captures continuity at the firm level. The two sets of measures correspond to regional risk and the network through which it reaches firms. H2. Urban adaptation promotes patient capital by mitigating physical risk and improving operational continuity.

Green investment provides a second route. Changes in equipment, production methods, and environmental management require current expenditure, while their returns accrue over time. A long-term orientation makes those projects relevant to corporate value beyond current earnings [7]. Adaptation can improve the operating conditions for such investments. Firms' green objectives and environmental management arrangements describe how they plan and implement the corresponding adjustments. H3. Urban adaptation promotes patient capital through stronger green strategic orientation and environmental management.

The information channel concerns the evidence available to capital providers. Sustainability disclosure conveys details about risk management and the prospects for investment [8]. Institutional investors also seek information about firm-specific climate risks [9]. As firms respond to urban adaptation, annual reports can document environmental responsibilities, management practices, and the horizon over which management evaluates projects. These disclosures provide a basis for assessing the firm's strategy and operating exposure over time. H4. Urban adaptation promotes patient capital through sustainability disclosure and communication of long-term prospects.

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3. Research design and data

The baseline panel contains 30,748 firm-year observations for nonfinancial A-share firms in 248 cities over 2009–2023. Registered location links each firm to the first-cohort pilot list [5]. The panel combines financial accounts, governance indicators, financing relationships, and annual-report disclosures. Continuous variables are winsorized. The baseline closes in 2023, before the 2024 expansion of the pilot program [10]. The specifications extending through 2024 are examined separately.

Assignment and measurement operate at two levels. Pilot status and the disaster outcomes are defined at the city level. Financing relationships, supply-chain resilience, strategic orientation, and disclosures are recorded for firms. The location match connects a firm's annual observations to its registered city. For a disaster spanning several cities, the economic loss is divided equally across affected cities before aggregation by city and year. The mechanism regressions use the observations available for each outcome. The city assignment supplies the link between the disaster series and the firms in the panel.

Equation (1) defines patient capital from relational debt (RD) and strategic equity measure 1 ($SE^{(1)}$). Both components enter the logarithm of their sum plus one. The same index construction applies to firms in pilot and comparison cities.

$$PatientCapital_{it} = \ln(1 + RD_{it} + SE_{it}^{(1)}) \tag{1}$$

The index has a sample mean of 2.725 and a standard deviation of 1.224. The reported policy coefficient measures a change on the log scale [11]. Dividing the estimate by 1.224 expresses its magnitude in sample standard deviations. Component regressions report the changes in the individual debt and equity measures alongside the composite estimate.

The DID indicator has a mean of 0.058 and a standard deviation of 0.234. The average leverage ratio is 0.427, return on assets averages 0.031, and cash holdings average 0.173 of assets. The mean Tobin's Q is 2.091. For the governance variables, the mean share of independent directors is 0.377 and the largest shareholder's mean ownership share is 0.337.

Equation (2) estimates the difference in patient-capital changes associated with the pilot program.

$$PatientCapital_{ict} = \alpha + \beta DID_{ct} + \gamma' X_{it} + \mu_i + \lambda_t + \varepsilon_{ict} \tag{2}$$

The subscripts i, c, and t denote firm, city, and year. DID is the interaction of an indicator for registration in a pilot city with an indicator for 2017 onward. The firm effects account for persistent differences in financing across firms. The year effects absorb annual shocks common to the panel. The DID coefficient compares post-2017 changes at firms in pilot and comparison cities conditional on these effects and the included controls. The regressions cluster standard errors by city, the level at which the pilot is assigned [12].

The first control block contains log total assets, debt relative to assets, and return on assets. The second adds Tobin's Q, cash relative to assets, and operating revenue growth. The final block covers board size, the share of independent directors, the largest shareholder's ownership share, state ownership, and an indicator for a CEO who also chairs the board. All baseline columns use the same panel, with the control blocks added in this order.

The policy interpretation assumes parallel trends in patient capital for pilot and comparison firms in the absence of the program. Equation (3) traces their differences by event year. It indexes event time to 2017 and uses 2016, the year immediately preceding the pilot, as the reference.

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$$PatientCapital_{ict} = \alpha + \sum_{k \neq -1} \beta_k (Treat_c \times Event_t^k) + \gamma' X_{it} + \mu_i + \lambda_t + \varepsilon_{ict} \quad (3)$$

The event study covers years −6 through 6 and reports 90% confidence intervals. Estimates before the pilot describe differences in the lead-up to implementation [13]. Additional comparisons adjust for observed characteristics using propensity scores based on size, leverage, profitability, cash holdings, and revenue growth during 2013–2016 [14]. Inverse-probability weights target the average treatment effect, and the matching specification uses a 1:3 nearest-neighbor rule.

Mechanism regressions apply the policy indicator to disaster outcomes, resilience, strategy, and disclosure measures. Their coefficients describe the response of each intermediate outcome to pilot exposure [15]. The disaster regressions use the city-level outcomes linked to firms' registered locations. The long-term language specification uses observations from 2013–2023. It uses firm and year effects as its controls. Table 2 records this specification alongside the regressions for the other outcomes.

The supplementary instrumental-variable specification uses historical extreme cold. Its instrument interacts the post-2017 indicator with membership in the top quartile of cities by the average number of extreme-cold days over 2005–2016. Both stages use firm and year fixed effects as their controls. Identification in this specification rests on historical exposure affecting subsequent patient capital through pilot participation, conditional on the fixed effects.

4. Results and identification checks

Table 1 gives four estimates of the policy coefficient in the same 30,748-observation panel. With firm and year effects, the estimate is 0.1059. It rises as the size, leverage, and profitability block enters and reaches 0.1315 after all controls are included. The full specification has a city-clustered standard error of 0.0491, with significance at the 1% level. On the sample scale, 0.1315 divided by 1.224 equals 0.107 standard deviations. The positive estimate across the four specifications supports H1.

Table 1. Baseline difference-in-differences estimates

Specification	(1)	(2)	(3)	(4)
DID	0.1059**	0.1175**	0.1278**	0.1315***
Standard error	(0.0504)	(0.0530)	(0.0500)	(0.0491)
R^2	0.672	0.691	0.699	0.726

Notes: Each specification uses 30,748 firm-year observations in 248 cities and includes firm and year fixed effects. Columns (2), (3), and (4) successively add the control blocks defined in Section 3. Standard errors are clustered by city. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels.

The comparison by event year locates the strongest response after the pilot had been in place for two years. In Figure 1, the intervals for the pre-policy coefficients include zero. The post-policy estimates for event years 2–5 are positive and significant at the 10% level. These correspond to 2019–2022. The positive sequence after implementation gives the timing of the change underlying the average coefficient in Table 1.

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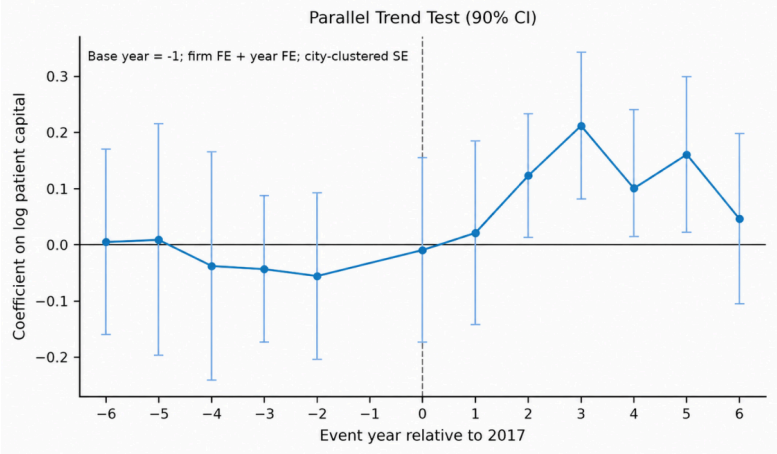

Figure 1. Event-study estimates relative to 2016

Notes: Event time is relative to 2017, with 2016 as the reference year. The bars show 90% confidence intervals based on city-clustered standard errors.

The alternative patient-capital index produces a coefficient of 0.1187 with a standard error of 0.0690, significant at the 10% level. In the component regressions, strategic equity measure 1 has a coefficient of 0.1233 with a standard error of 0.0573, significant at the 5% level. The estimates for strategic equity measure 2 and relational debt are 0.0858 and 0.0011, with standard errors of 0.0813 and 0.0089. Both estimates have confidence intervals spanning zero at conventional levels.

Adjusting the comparison for the pre-policy covariates gives coefficients of 0.1347 under inverse-probability weighting and 0.1574 under matching. Their standard errors are 0.0438 and 0.0512, respectively. Both coefficients attain the 1% significance level. The 2009–2024 and 2005–2024 windows produce coefficients of 0.1219 and 0.1125, with standard errors of 0.0478 and 0.0455. Both estimates attain the 5% level. Excluding Beijing, Shanghai, Tianjin, and Chongqing gives 0.0978 with a standard error of 0.0538. These results describe the sensitivity of the estimate to the comparison group and the time window, including specifications that extend into the year of the pilot expansion.

Separate adjustments for concurrent city programs yield coefficients between 0.1243 and 0.1339. The controls cover zero-waste cities, industry and finance, intellectual property, big data, trade in services, and artificial intelligence. Each program enters the baseline regression through its own policy indicator in a separate specification. The range is close to the fully controlled coefficient of 0.1315, with the lower endpoint in the services-trade specification and the upper endpoint in the big-data specification. Their standard errors are 0.0486 and 0.0474. The other four specifications give estimates between 0.1297 and 0.1314.

Figure 2 combines the two placebo checks. The left panel applies hypothetical implementation dates from 2012 to 2016 to the 2009–2016 sample. The intervals span zero at the 10% significance level across those dates. The right panel gives the distribution under randomized treatment assignment, with estimates concentrated around zero. The observed baseline coefficient of 0.1315 lies in the positive tail of that distribution.

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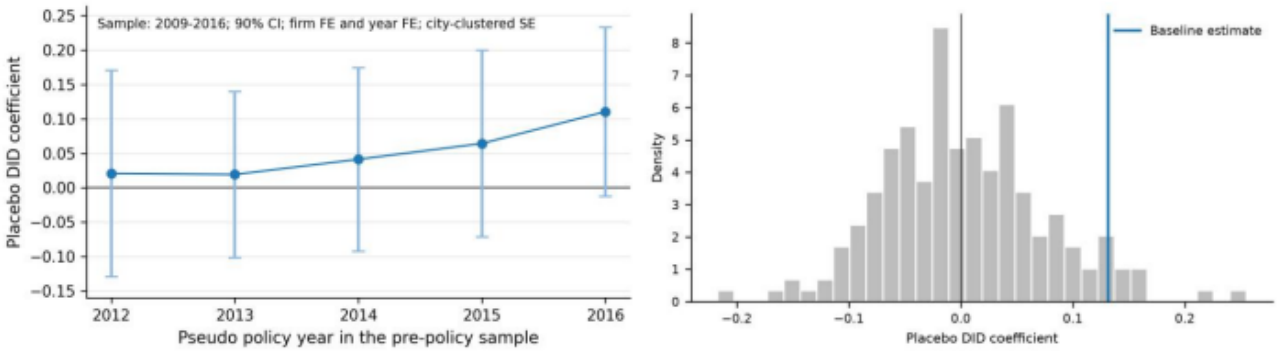

Figure 2. Timing (left) and randomized (right) placebos

Notes: The timing panel uses observations from 2009–2016. Error bars show 90% confidence intervals. The vertical line in the reassignment panel marks the baseline estimate of 0.1315.

The historical-cold instrument yields a first-stage coefficient of 0.4367 with a standard error of 0.1316 and an F statistic of 11.01. The second-stage coefficient is 0.2032 with a standard error of 0.1034. The specification includes the firm and year effects and uses the historical assignment variation described in Section 3. Its positive second-stage estimate provides supplementary evidence on the direction of the financing response.

5. Mechanism evidence

Table 2 reports the intermediate outcomes for H2–H4. The first group covers disaster losses, the affected population, and supply-chain resilience. The second group tracks green strategic orientation and environmental management disclosure. The third covers sustainability-related reporting and the language of management discussion. The groups pair changes in the local risk environment with changes in firms' operations and annual reports.

Table 2. Policy effects on intermediate outcomes

Outcome	DID estimate	Standard error
Direct economic losses	−0.1225**	(0.0625)
Affected population	−0.2863***	(0.0991)
Supply-chain resilience	0.0039***	(0.0009)
Green strategic orientation 1	0.0666***	(0.0257)
Green strategic orientation 2	0.0824**	(0.0340)
Environmental management disclosure	0.0751**	(0.0318)
Environmental and safety disclosure	0.0810***	(0.0253)
Environmental and sustainability disclosure	0.0440**	(0.0208)
Long-term managerial language	1.3582*	(0.8214)

Notes: All models include firm and year effects. The long-term language model uses these effects as its controls and covers 2013–2023. The other models also include time-varying controls. Losses from multi-city disasters are allocated equally across affected cities. Green orientation and environmental management disclosure are log-transformed. Standard errors are clustered by city. Significance notation follows Table 1.

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Direct economic losses and the affected population have negative coefficients of −0.1225 and −0.2863. The coefficient for supply-chain resilience is 0.0039, significant at the 1% level. The regional measures reflect the hazards experienced and the population and assets exposed in each city. The firm measure adds evidence on continuity in supply networks. Their directions agree with the risk and operational channel proposed in H2.

Both measures of green strategic orientation increase after pilot implementation. The environmental management disclosure coefficient is 0.0751, with a standard error of 0.0318. The disclosure score covers environmental targets, management systems, training, environmental initiatives, emergency preparedness, and awards. The estimates combine a change in strategic emphasis with a change in the reported arrangements for carrying it out. Those two responses supply the evidence for H3.

Environmental and safety responsibility disclosure and environmental and sustainability disclosure also increase. The estimated change in long-term language is 1.3582, with a standard error of 0.8214 and significance at the 10% level. The language measure comes from management discussion and analysis. The two disclosure measures record the scope of reported environmental responsibilities, while the language measure captures the emphasis on longer horizons. These findings are consistent with the reporting and communication channel in H4 [8, 9].

The results span lower local disaster impacts, stronger continuity in supply networks, and changes in the reported environmental practices and priorities of firms. These measures describe the operating, strategic, and information responses that accompany the increase in patient capital in the pilot setting.

6. Conclusion

The 2017 climate-adaptive city pilot is associated with higher corporate patient capital among nonfinancial A-share firms. The full baseline estimate equals 0.107 sample standard deviations of the financing index. The first strategic equity measure provides the clearest component response. The estimate for the index stays positive across the alternative samples, adjustments for observable characteristics, and separate controls for other city programs.

The corporate financing result accompanies lower disaster losses, a smaller affected population, and greater supply-chain resilience. Annual reports show stronger green strategic orientation and more environmental and sustainability disclosure. Long-term managerial language increases in the specification that uses the 2013–2023 observations. These outcomes place the operating and reporting responses in the same empirical setting as the change in stable financing.

The findings extend research on patient capital to the municipal systems that support firms' cash flows. In this setting, the financing response is measured through relational debt and strategic equity at firms linked to pilot cities by registered location. The policy estimates give corporate finance a place alongside disaster risk and operating continuity in evaluations of urban adaptation.

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