



Digital Inclusive Finance and Corporate Innovation: The Moderating Effect of Financing Constraints — Empirical Evidence from Chinese A-Share Listed Companies

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Abstract. This study uses panel data for Chinese A-share listed firms from 2012 to 2023 to examine how digital inclusive finance is related to corporate innovation. Patent-based measures are employed to distinguish overall innovation output from breakthrough innovation, and financing constraints are introduced to assess whether they condition this relationship. The empirical evidence shows that firms located in areas with a higher level of digital inclusive finance exhibit better innovation performance. This positive association is stronger when innovation is measured by invention-related outcomes, suggesting a closer link with higher-quality innovation. The results also indicate that the role of digital inclusive finance becomes more salient for firms facing tighter financing constraints. Further subgroup analysis reveals that the association is more pronounced in firms where the positions of chairman and general manager are held concurrently. By jointly considering financing conditions, governance differences, and heterogeneous innovation outcomes, this paper offers firm-level evidence on the role of digital inclusive finance in supporting innovation activities in China.

Keywords: Digital Inclusive Finance, Corporate Innovation, Financing constraints, Breakthrough Innovation, Chinese A-share listed companies.

1 Introduction

The 15th Five-Year Plan places clear emphasis on the development of inclusive finance and its digital transformation, which gives digital inclusive finance substantial policy relevance in supporting the real economy and innovation-driven growth. At the same time, corporate innovation is commonly accompanied by large upfront investment, long payback periods, high uncertainty, and considerable risk. Because of these features, innovation projects usually require sustained external funding. Relative to routine operating activities, they also tend to involve weaker collateral support and more serious information asymmetry. Under these conditions, conventional financial channels may fail to adequately satisfy firms' financing needs. In this setting, digital inclusive finance, supported by data technologies such as cloud computing and artificial intelligence, may reduce informational barriers, improve the efficiency of financial

matching, and expand firms' access to financial services, thereby creating more favorable conditions for innovation.

Prior studies may be grouped into three broad lines of inquiry. The first line examines the role of digital inclusive finance in firm development and generally finds that it contributes to high-quality development by easing financing frictions and improving the allocation of financial resources, although the magnitude of this role varies across firms^[1]. The second line focuses more directly on innovation outcomes. Existing evidence largely suggests that digital inclusive finance contributes to firm innovation through channels such as lower financing costs and improved financing availability, and related findings have also been reported for small and medium-sized enterprises in other countries^[2-3]. The third line investigates underlying channels and heterogeneity. Research in this stream indicates that digital inclusive finance may stimulate innovation through financing relief, industrial upgrading, governance improvement, and greater R&D input, while the strength and form of its influence may differ across firms and institutional settings and may even display nonlinear features^[4-7].

Although the existing literature has established a close connection between digital inclusive finance, firm development, and innovation, two issues still warrant further examination. One concerns whether the innovation-related role of digital inclusive finance differs according to firms' financing conditions. Much of the existing work pays more attention to transmission channels, whereas less emphasis has been placed on the possibility that financing constraints may shape the strength of the relationship itself. The other concerns differences across types of innovation output. By separating overall innovation from breakthrough innovation, this study seeks to provide more detailed evidence on the heterogeneous innovation outcomes associated with digital inclusive finance.

2 Theoretical Basis and Research Hypotheses

2.1 Digital Inclusive Finance and Corporate Innovation Performance

Successful innovation requires not only internal resource accumulation but also effective external financial support. In particular, external capital needs to be matched to innovation demand in a timely way. Compared with ordinary firms, innovative firms often face different conditions in capital markets, and innovation activities can change both the scale of financing demand and the difficulty of obtaining outside funds. In this respect, digital inclusive finance differs from traditional financial services. By relying on digital technologies, it can broaden financial coverage, improve information processing and raise the efficiency of capital matching, thereby offering more suitable support for innovation-related activities. Existing empirical studies have shown that digital inclusive finance is associated with stronger R&D engagement, greater innovation output and higher innovation efficiency among firms^[8-9]. Based on this reasoning, the following hypothesis is proposed:

Hypothesis 1: Digital inclusive finance has a significantly positive effect on firms' innovation level.

2.2 The Moderating Effect of Financing Constraints

The extent to which innovation responds to improvements in financial conditions is unlikely to be the same for all firms. Firms subject to stronger financing constraints are generally more vulnerable to capital shortages and therefore rely more heavily on external financing support to continue innovation activities. Prior research suggests that the benefits of digital inclusive finance may be more visible among firms with tighter financing conditions, especially small and medium-sized enterprises and private firms^[1]. This implies that the relationship between digital inclusive finance and innovation may vary with the degree of financing constraints. When financing constraints are more severe, any improvement in external financial access may generate a larger marginal response in innovation. On this basis, the following hypothesis is proposed:

Hypothesis 2: Financing constraints positively moderate the effect of digital inclusive finance on firms' innovation level.

3 Research Design

3.1 Model Specification

Drawing on the preceding analysis and related literature, this paper examines the relationship between digital inclusive finance and firm innovation by taking corporate innovation as the explained variable and the level of digital inclusive finance as the main explanatory variable. The baseline specifications are given in Equations (1) and (2):

$$\text{Innovation}_{i,t} = \beta_0 + \beta_1 \text{dif}_{i,t} + \beta_2 \text{Control}_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (1)$$

$$\text{Inv}_{i,t} = \theta_0 + \theta_1 \text{dif}_{i,t} + \theta_2 \text{Control}_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (2)$$

In these models, i denotes firm and t denotes year. Innovation and Inv represent the two measures of corporate innovation. The variable dif captures the level of digital inclusive finance in the city where firm i is located in year t . The coefficient β_1 is the main coefficient of interest. A positive and statistically significant estimate for β_1 indicates that digital inclusive finance is associated with stronger corporate innovation. $\text{Control}_{i,t}$ denotes the set of control variables. μ_i and λ_t represent industry and year fixed effects respectively, while $\varepsilon_{i,t}$ is the disturbance term.

To test whether financing constraints change the strength of the relationship between digital inclusive finance and corporate innovation, this paper further introduces the interaction between the financing-constraint indicator and digital inclusive finance, leading to Equations (3) and (4):

$$\text{Innovation}_{i,t} = \beta_0 + \beta_1 \text{dif}_{i,t} + \beta_2 \text{SA}_{i,t} + \beta_3 \text{dif}_{i,t} \times \text{SA}_{i,t} + \beta_4 \text{Control}_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (3)$$

$$\text{Inv}_{i,t} = \theta_0 + \theta_1 \text{dif}_{i,t} + \theta_2 \text{SA}_{i,t} + \theta_3 \text{dif}_{i,t} \times \text{SA}_{i,t} + \theta_4 \text{Control}_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (4)$$

In these models, $SA_{i,t}$ measures the financing constraints faced by firm i in year t , and $dif_{i,t} \times SA_{i,t}$ is the interaction term between digital inclusive finance and financing constraints. The coefficient β_3 is the parameter of central interest in the moderating-effect analysis. A significantly positive β_3 indicates that tighter financing constraints amplify the positive relationship between digital inclusive finance and corporate innovation.

3.2 Variable Selection

Dependent variables: In order to distinguish innovation quantity from innovation quality, this paper uses two indicators of corporate innovation. The first is overall innovation performance (Innovation), measured as the natural logarithm of one plus the total number of invention, utility model, and design patents jointly applied for by a firm in a given year. The second is breakthrough innovation performance (Inv), measured as the natural logarithm of one plus the number of invention patents jointly applied for by a firm in that year. This distinction makes it possible to observe whether digital inclusive finance has different associations with broad innovation activity and higher-quality innovation outcomes.

Explanatory variable: Digital inclusive finance (dif) is measured by the city-level digital inclusive finance index divided by 100.

Moderating variable: Financing constraints (SA) are measured following Hadlock and Pierce^[10]. The SA index is constructed from firm size and firm age: $SA = -0.737 \times \text{firm size} + 0.043 \times \text{firm size}^2 - 0.04 \times \text{firm age}$.

Control variables: The control variables include leverage ratio (Lev), firm size (Size), Tobin's Q (TobinQ), the shareholding ratio of the largest shareholder (Top1), ownership nature (SOE), return on assets (ROA), firm growth (Growth), cash flow (Cashflow), board size (Board), and CEO-chair duality (Dual). Descriptive statistics are reported in Table 1.

Table 1. Descriptive Statistics

VarName	Obs	Mean	SD	Min	Median	Max
Innovation	35877	1.928	1.699	0.000	1.946	6.236
Inv	35877	1.387	1.446	0.000	1.099	5.642
dif	35877	2.661	0.693	0.991	2.813	3.632
SA	35452	-3.864	0.264	-4.550	-3.864	-3.199
Size	35877	22.232	1.319	19.862	22.028	26.298
Lev	35877	0.413	0.208	0.052	0.403	0.904
ROA	35877	0.039	0.067	-0.232	0.039	0.221
Cashflow	35877	0.047	0.068	-0.156	0.046	0.241
Growth	35877	0.143	0.370	-0.567	0.089	2.126
Top1	35877	0.337	0.148	0.083	0.313	0.740
TobinQ	35877	2.021	1.291	0.834	1.605	8.436
SOE	35877	0.349	0.477	0.000	0.000	1.000
Dual	35877	0.303	0.460	0.000	0.000	1.000
Board	35877	2.108	0.199	1.609	2.197	2.639

3.3 Sample Selection and Data Sources

The sample consists of Shanghai and Shenzhen A-share listed firms over the period 2012–2023. To improve sample quality, financial firms, firms with negative net assets, ST, *ST, and PT firms, and observations with insufficient data are excluded. All continuous variables are winsorized at the 1% level in both tails. Patent data are obtained from CNRDS. The Digital Inclusive Finance Index is taken from the Institute of Digital Finance at Peking University, and firm-level financial data are drawn from the Wind and CSMAR databases. The final sample contains 4,729 listed firms and 35,877 firm-year observations. Differences in sample size across specifications mainly arise from missing values in variables introduced in particular regressions, including the financing-constraint measure, some control variables, and alternative dependent-variable definitions.

4 Empirical Results Analysis

4.1 Baseline Regression Analysis of Digital Inclusive Finance and Corporate Innovation

The baseline estimation results are shown in Table 2. Industry and year fixed effects are included in Columns (1) and (2), and Columns (3) and (4) additionally control for firm-level characteristics. In all specifications, digital inclusive finance enters with a positive coefficient that is statistically significant at the 1% level, suggesting a higher level of digital inclusive finance is consistently associated with stronger corporate innovation performance.

Table 2. Baseline Regressions

	(1)	(2)	(3)	(4)
	Innovation	Inv	Innovation	Inv
dif	0.479*** (0.098)	0.521*** (0.086)	0.363*** (0.091)	0.433*** (0.080)
Size			0.328*** (0.023)	0.705 (0.041)
Lev			-0.240** (0.103)	-0.260*** (0.088)
ROA			2.480*** (0.216)	1.852*** (0.186)
Cashflow			0.324* (0.176)	-0.061 (0.151)
Growth			-0.096*** (0.022)	-0.068*** (0.019)
Dual			0.060* (0.034)	0.063** (0.030)

	(1)	(2)	(3)	(4)
Top1			0.289**	0.065
			(0.133)	(0.115)
TobinQ			-0.003	0.036***
			(0.012)	(0.011)
SOE			-0.071	0.022
			(0.048)	(0.043)
Board			0.347***	0.285***
			(0.115)	(0.102)
_cons	0.653**	0.000	-7.360***	-8.413***
	(0.261)	(0.230)	(0.608)	(0.552)
Industry Effect	YES	YES	YES	YES
Year Effect	YES	YES	YES	YES
N	35935	35935	35877	35877
R ²	0.295	0.236	0.358	0.318

Notes: Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

4.2 Moderating Effect of Financing Constraints

The estimation results for Equations (3) and (4) are presented in Table 3. In both models, the coefficient on the interaction term $dif \times SA$ is positive and statistically significant, at the 5% level in the Innovation regression and at the 1% level in the Inv regression. This pattern implies that tighter financing constraints amplify the positive relationship between digital inclusive finance and firm innovation, which supports Hypothesis 2.

Table 3. Moderating Effect of Financing Constraints

	(1)	(2)
	Innovation	Inv
dif	0.966***	1.326***
	(0.283)	(0.250)
SA	0.132	-0.182
	(0.222)	(0.192)
dif \times SA	0.163**	0.238***
	(0.070)	(0.062)
Controls	YES	YES
Industry FE	YES	YES
Year FE	YES	YES
N	35452	35452
R ²	0.366	0.326

Notes: Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

4.3 Robustness Tests

To assess whether the baseline findings are sensitive to alternative specifications, this paper conducts several robustness tests, including lagged controls, alternative dependent variables, and the exclusion of a special year. The corresponding results are shown in Table 4.

Table 4. Robustness Test

	(1)	(2)	(3)	(4)	(5)	(6)
	Innovation	Inv	Innovation2	Inv2	Innovation	Inv
dif	0.356*** (0.097)	0.430*** (0.084)	0.312*** (0.081)	0.365*** (0.06)	0.355*** (0.092)	0.422*** (0.08)
Controls	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
N	30409	30409	40426	40426	32455	32455
R ²	0.361	0.322	0.364	0.29	0.36	0.32

Notes: Robust standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Columns (1) and (2) report the regressions in which all control variables are lagged by one period to alleviate potential concerns related to omitted variables. The coefficient on digital inclusive finance remains positive and significant at the 1% level, and its magnitude remains close to that in the baseline regressions. This indicates that the main result does not depend on the contemporaneous specification of the control variables.

In Columns (3) and (4), the baseline innovation measures are replaced with two alternative patent-based indicators, namely the current-year total number of jointly applied patents (Innovation2) and the current-year number of jointly applied invention patents (Inv2). The coefficient on digital inclusive finance remains positive and significant after this substitution, which suggests that the main result does not hinge on a specific measure of innovation.

In Columns (5) and (6), observations from 2020 are excluded to reduce the influence of the COVID-19 shock. The coefficient on digital inclusive finance continues to be significantly positive, showing that the baseline conclusion is not driven by that special year.

4.4 Heterogeneity Analysis

To assess governance-related heterogeneity, this paper splits the sample by whether the same individual serves as both chairman and general manager. Table 5 shows that the coefficient on digital inclusive finance is larger for firms with this leadership structure

than for other firms. This pattern suggests that digital inclusive finance is more closely associated with innovation in duality firms. A possible reason is that concentrated leadership may streamline innovation decisions and help firms turn improved financing conditions into innovation output more efficiently.

Table 5. Heterogeneity Analysis: Corporate Governance Structure

	(1)	(2)	(3)	(4)
	Innovation (Duality firms)	Innovation (Non-duality firms)	Inv (Duality firms)	Inv (Non-duality firms)
dif	0.556*** (0.133)	0.292*** (0.107)	0.563*** (0.117)	0.384*** (0.093)
Controls	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	10886	24990	10886	24990
R ²	0.335	0.372	0.293	0.337

Notes: Robust standard errors are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

5 Conclusion and Policy Implications

Using Chinese A-share listed firms from 2012 to 2023 as the research sample, this paper examines the relationship between digital inclusive finance and corporate innovation, with particular attention to the moderating role of financing constraints. The empirical results show that digital inclusive finance is positively related to corporate innovation. Moreover, the estimated coefficient is larger for breakthrough innovation than for overall innovation, suggesting that digital inclusive finance is more closely associated with higher-quality innovation outcomes. The moderating-effect analysis further indicates that tighter financing constraints strengthen this positive relationship. In addition, the heterogeneity analysis shows that the estimated relationship is stronger in firms where the chairman and general manager positions are combined, reflecting differences across governance structures.

Based on these findings, three policy implications can be drawn. First, digital inclusive finance infrastructure should be further improved, with particular emphasis on digital credit information, data sharing, AI-based risk assessment and online financial service platforms. These measures can help financial institutions better identify firms' innovation capacity and growth potential, thereby alleviating financing barriers caused by information asymmetry. Second, financial support should be differentiated according to the type of innovation. General innovation requires broader and more accessible digital financial services to support continuous R&D activities, while breakthrough innovation requires financing arrangements with greater risk tolerance and more suitable credit conditions. Third, more targeted support should be provided to firms facing tighter financing constraints. Since the innovation effect of digital inclusive finance appears more pronounced for such firms, digital credit tools and differen-

tiated lending mechanisms should be optimized to improve financial support for firms with strong innovation potential but limited access to external finance.

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