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Research on the Impact of Digital Inclusive Finance on Corporate Financing Cost: Theoretical Mechanism and Empirical Test

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Abstract. Based on the data of A-share non-financial listed companies from 2011 to 2023, this paper matches the Peking University prefecture-level city digital inclusive finance index with corporate financial data, and empirically examines the impact of digital inclusive finance on corporate financing cost and its mechanism of action. Financing cost is measured by the financial expense ratio, and the industry and year fixed effects model is used for estimation. The study finds that the increase of the regional digital inclusive finance development level significantly reduces corporate financing cost; the mechanism analysis shows that digital inclusive finance plays its role by improving the external information environment of enterprises and raising analyst following and research report coverage. The heterogeneity analysis shows that this effect is more obvious in non-state-owned enterprises, the eastern region and larger-scale enterprises. The study provides an empirical basis for improving digital financial infrastructure, optimizing corporate credit information governance and differentiated credit pricing.

Keywords: Digital inclusive finance, Financing cost, External information environment, Information asymmetry, Heterogeneity analysis

1. Introduction

1.1. Research background

1.1.1. Corporate financing cost and the problem of information asymmetry

Corporate financing cost directly affects corporate cash flow, investment decisions and business expansion, and is also an important reflection of the risk pricing of financial institutions and the efficiency of financial resource allocation. For enterprises with smaller scale, insufficient credit accumulation or lack of stable financing channels, external financing has not only the quantity constraint of "whether it can be obtained", but also the cost constraint of "at what price it can be obtained". In addition to interest expenses, enterprises may also bear handling fees and other related financial expenses, and a higher comprehensive financing burden will compress the space of funds that enterprises can use for production and operation and long-term investment [1, 2].

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The difference of corporate financing cost is closely related to mortgage capacity, business risk and information quality. Compared with enterprises with larger asset scale and more complete credit records, smaller-scale enterprises often lack standardized mortgage assets and have greater business fluctuation; non-state-owned enterprises may also bear higher costs of information search and risk identification because of weaker credit endorsement. When financial institutions cannot fully observe the real operating condition, order stability and solvency of enterprises, they will make risk compensation by raising the risk premium, strengthening guarantee requirements or tightening credit conditions.

From the perspective of information economics, enterprises usually hold more private information about their own operating condition, use of funds and risk level, while external fund providers mainly rely on financial statements, credit records, collateral and external information intermediaries to make judgments. When enterprise quality and default probability are difficult to identify accurately, adverse selection and moral hazard will raise the screening, supervision and pricing costs of financial institutions, and finally transmit into higher corporate financing expenses. Therefore, improving the external information environment of enterprises and raising the efficiency of risk identification is an important path to reduce financing cost.

1.1.2. Development of Digital Inclusive Finance (DIF) and its potential impact

Digital inclusive finance (Digital Inclusive Finance, DIF) is a new financial service model formed by the combination of digital technology and inclusive finance. It mainly relies on big data, mobile internet, cloud computing and artificial intelligence and other technologies, and provides more convenient financing services for small and micro enterprises, rural areas and other groups whose coverage by traditional financial services is limited. From the supply side, digital inclusive finance has the characteristics of service differentiation, lower operating cost and sustainable business model, and can raise the efficiency of financial supply while lowering the service threshold.

The potential impact of digital inclusive finance on financing cost is mainly reflected in two aspects: the compression of operating cost and the optimization of risk pricing. First, digital channels can reduce the dependence of financial services on physical outlets, manual due diligence and the circulation of paper materials, and lower the operating cost of customer acquisition, review, lending and post-loan management and other links. Second, digital inclusive finance can integrate transaction flow, tax, supply chain, online operation and other multi-dimensional information, and form a more continuous picture of enterprise operation, so that financial institutions can more accurately identify enterprise operating quality and default risk, and implement differentiated pricing accordingly.

1.1.3. Literature review and research gaps

Around corporate financing and digital inclusive finance, the existing literature has accumulated relatively rich theoretical and empirical evidence. First, the information asymmetry theory provides a classic analysis framework for understanding corporate credit rationing and financing pricing, and many studies explain the formation of external financing cost from the angles of collateral, credit market structure and bank-enterprise information difference [3, 4]. Second, most of the existing studies discuss the financing relief effect of digital inclusive finance, and find that digital technology can ease financing constraints by lowering transaction cost, improving information acquisition and expanding financial coverage [5]. Third, the research on government information empowerment and supply chain finance further shows that verifiable enterprise operating information can improve the

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credit identification and resource allocation of financial institutions [5, 6]. These studies provide a theoretical basis for examining the relationship between digital finance and corporate financing cost.

The existing research still has room for further expansion. First, many studies take financing constraints, financing availability or credit scale as the core outcome variables, and the discussion on how digital inclusive finance affects the actual financing expense burden of enterprises is relatively limited. Second, the role of digital finance in improving information acquisition is often used to explain the financing effect, but whether the external information intermediaries of enterprises increase as regional digital finance develops can still be further tested with micro data. Third, there are differences in ownership, enterprise scale, and the credit basis, data availability and financial service conditions of different regions, and the marginal effect of digital inclusive finance may show obvious heterogeneity.

1.2. Research questions

The development of digital inclusive finance has changed the way financial institutions obtain, process and use enterprise information, and has also changed the external financial environment in which enterprises are located. This paper centers on the relationship between digital inclusive finance and corporate financing cost, and focuses on answering the following three research questions.

First, is the increase of the regional digital inclusive finance development level significantly related to the decline of financing cost? This paper constructs the financing cost indicator on the basis of the financing expense ratio of corporate financial expenses relative to asset scale, and examines the potential relationship between the city-level digital inclusive finance index and corporate financing cost [6]. Second, will digital inclusive finance ease the external information environment of enterprises? This paper measures the degree of attention from information intermediaries received by enterprises with the number of analyst attention and the number of research reports produced by analysts, and examines whether the development of regional digital finance improves the degree of production, interpretation and dissemination of enterprise information. Third, does the relationship between digital inclusive finance and financing cost differ by enterprise ownership, enterprise scale and regional location? This paper will compare the estimation results of state-owned enterprises and non-state-owned enterprises, smaller-scale and larger-scale enterprises, and enterprises in the eastern region and the central, western and northeast regions.

1.3. Research ideas and research methods

This paper matches the Peking University prefecture-level city digital inclusive finance index with the annual financial data of A-share listed non-financial companies, uses the city-level digital inclusive finance aggregate index as the core explanatory variable, and takes the natural logarithm of the financing expense ratio as the explained variable. The baseline regression takes enterprise scale, asset-liability ratio, profitability, growth and enterprise age as control variables, and adds industry fixed effects and year fixed effects, with standard errors clustered at the enterprise level. The information channel test takes the logarithm of the number of analyst following and the logarithm of the number of research reports as the explained variables respectively; the heterogeneity analysis carries out grouped regression by ownership, enterprise scale and region.

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1.4. Research purpose and significance

At the theoretical level, this paper examines the economic effect of digital inclusive finance from the angle of financing expense burden, and brings the external information environment into the analysis framework. Compared with only paying attention to financing availability and credit scale, financing cost can more directly reflect the pricing result of financial institutions on enterprise risk, information quality and solvency. By analyzing the relationship between digital finance development and analyst following and research report coverage, this paper further depicts the connection between the digital financial environment and enterprise information production.

At the practical level, this paper can provide an empirical basis for the construction of digital financial infrastructure, corporate credit information governance and differentiated credit pricing. On the one hand, the development of city-level digital inclusive finance reflects the regional digital financial service capacity, and its relationship with corporate financing expenses can provide a reference for local financial resource allocation; on the other hand, the heterogeneity analysis of ownership, scale and region can identify the differences in the use of digital financial infrastructure by different enterprises, and provide a more targeted policy basis for non-state-owned enterprises, smaller-scale enterprises and different regions to improve their data basis and financial service capacity.

1.5. Structure of the paper

The full text is divided into five chapters. The first chapter is the introduction, which introduces the research background, literature basis, research questions, research ideas and methods, and research significance. The second chapter is theoretical analysis and research hypotheses. On the basis of defining digital inclusive finance and financing cost, it analyzes the external information environment channel, and discusses heterogeneity from the three dimensions of ownership, enterprise scale and region. The third chapter is research design, which explains data sources, sample construction, variable definition, econometric model and robustness test scheme. The fourth chapter is empirical results and analysis, which reports the baseline regression, information channel test, heterogeneity analysis and robustness test results in order. The fifth chapter is conclusions and policy implications.

2. Theoretical analysis and research hypotheses

2.1. Definition of core concepts

2.1.1. Digital inclusive finance (DIF)

Digital inclusive finance is a financial service model formed by the deep integration of traditional inclusive finance forms and internet technology. Its core lies in that, under the premise of defined cost and sustainable operation of enterprises, it uses big data, cloud computing, mobile internet and artificial intelligence and other tools to lower the threshold of financial services and information cost, and makes financial services reach more effectively the long-tail groups that are not sufficiently covered by the traditional financial system, including small and micro enterprises, individual businesses and other market subjects with low availability of financial services. Compared with the old inclusive finance that mainly relies on the expansion of physical outlets, digital inclusive finance puts more emphasis on the role of digital channels, automatic risk control

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and alternative data in the supply of financial services, so as to raise the efficiency of risk identification and resource allocation while expanding the coverage.

In addition, this paper takes the digital inclusive finance index published by Peking University as the core explanatory variable. This index analyzes the development degree of digital inclusive finance in various places as a whole from the three angles of coverage breadth, use depth and digitalization degree, and is an indicator widely used in the existing domestic literature [7]. This paper uses the digital inclusive finance aggregate index at the prefecture-level city level, and matches it with corporate financial data according to the prefecture-level city where the enterprise is registered and the year. The prefecture-level city digital inclusive finance index depicts the regional digital financial environment in which the enterprise is located. Enterprises in the same city and the same year share the same DIF index, while there are differences in the digital finance development level between different cities and different years. This paper uses this regional and time difference to examine the potential relationship between the development of digital inclusive finance and corporate financing cost.

2.1.2. Financing cost

Financing cost (Cost of Financing) is the financial expense burden borne by enterprises to obtain and maintain external financing. According to the actual construction way of the current regression data, this paper measures the intensity of financing expenses with the ratio of financial expenses relative to the asset scale of the enterprise. Financial expenses include the net interest expense, handling fees and related financial expenses confirmed by the enterprise in financing activities, and the change of their relative asset scale can reflect the annual financing expense burden of the enterprise.

The baseline financing cost indicator is defined as the ratio of financial expenses to average total assets, and the natural logarithm of this ratio is taken:

$$\text{FinCost} = \text{Financial expenses} / \text{Average total assets} \tag{1}$$

$$\text{Average total assets} = (\text{Total assets at the beginning of the period} + \text{Total assets at the end of the period}) / 2 ; ln_\text{FinCost} = ln(\text{FinCost})$$

Average total assets can smooth the change of asset scale within the year, so that annual financial expenses match the average operating scale of the enterprise. In the robustness test, the ratio of financial expenses to average total liabilities is further used to construct an alternative financing cost indicator, and the natural logarithm is also taken to form ln_FinCost_liab, so as to test whether the conclusion depends on the baseline financing cost caliber.

2.2. The mechanism through which digital inclusive finance affects financing cost: the external information environment channel

2.2.1. How digital inclusive finance improves the external information environment

The pricing of external financing of enterprises highly depends on the quantity and quality of information available to financial institutions and market participants. When enterprise operating information is scattered and the level of information disclosure is limited, and the external market lacks sufficient information sources, creditors need to invest more cost to identify enterprise risk,

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and reflect risk compensation in financing pricing. Relying on payment flow, tax records, supply chain and other digital operating information, digital inclusive finance raises the traceability and verifiability of enterprise operating activities, and lowers the barrier for the external market to obtain the private information of enterprises. The digital information environment also lowers the collection and processing cost of information intermediaries. The richer the enterprise operating data and the higher the degree of digitalization, the easier it is for analysts and research institutions to form continuous following and special research. The number of analyst following reflects the breadth of attention from professional information intermediaries received by the enterprise, and the number of research reports reflects the intensity with which the relevant information of the enterprise is continuously produced, interpreted and disseminated. The development of regional digital inclusive finance can strengthen the external information coverage of enterprises by raising data availability and information processing efficiency.

This paper takes the number of analyst following and the number of research reports as the proxy variables of the external information environment. If the increase of the digital inclusive finance development level is accompanied by more analyst attention and research report coverage, it indicates that the development of digital finance is consistent with the enhancement of the external information production and dissemination of enterprises.

2.2.2. How the improvement of the external information environment reduces financing cost

The improvement of the external information environment can lower the information identification cost and the uncertainty of risk judgment in the financing market. Information intermediaries such as analysts expand the dissemination range of public information and raise the understanding of market participants about enterprise profitability, business risk and cash flow condition by collecting, sorting and interpreting enterprise operating information. After enterprises are more fully observed, financial institutions and other creditors can more accurately distinguish enterprises of different risk types, and thus reduce the extra risk premium formed because of insufficient information.

At the same time, relatively sufficient information production can form external supervision, and promote the information disclosure and governance behavior of enterprises to be more standardized. The improvement of information quality and the decline of information acquisition cost jointly raise the efficiency of credit screening and risk pricing, and make the financing price closer to the risk level of the enterprise itself. Digital inclusive finance can therefore reduce the financing expense burden brought by information friction by easing the external information environment of enterprises.

Based on the above logic, this paper tests the relationship between digital inclusive finance and the number of analyst following and the number of research reports respectively in the empirical part.

2.3. Heterogeneity theoretical analysis: ownership, enterprise scale and region

2.3.1. Ownership heterogeneity (state-owned enterprises and non-state-owned enterprises)

Enterprise ownership affects the credit basis, financing channels and the risk judgment of financial institutions. State-owned enterprises usually have relatively stable bank relations and a relatively strong credit basis, and some enterprises also have implicit credit support, so the marginal sensitivity of their financing conditions to new digital information may be low. Non-state-owned enterprises rely more on market-based risk identification and the operating information of the enterprise itself.

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After digital inclusive finance raises information availability and risk identification efficiency, their financing cost may show a more obvious improvement.

From the angle of information increment, the role of digital finance depends on whether it can supplement traditional credit information. For non-state-owned enterprises whose original financing channels are weak and whose mortgage resources and credit endorsement are relatively limited, transaction flow, online operation and other alternative data can form new credit signals and lower the uncertainty of financial institutions' judgment on enterprise risk. Therefore, the reduction effect of digital inclusive finance on the financing cost of non-state-owned enterprises is more significant.

2.3.2. Regional heterogeneity (eastern region and central, western and northeast regions)

There are differences in digital infrastructure, traditional financial supply and data governance capacity among different regions. In the eastern region, the financial market and digital infrastructure are relatively mature, the degree of digital operation of enterprises is relatively high, and financial institutions are also more able to turn data resources into credit identification and risk pricing; in such an environment, digital inclusive finance may raise the efficiency of financing services by forming complementarity with the existing financial system.

In the central, western and northeast regions, traditional financial resources are relatively limited, and digital channels can break through outlet and geographical restrictions, and expand the coverage of financial services through online data, so a relatively strong gap-filling effect may also be produced. This paper makes a group comparison between the eastern region and the central, western and northeast regions, and examines whether the linear relationship between digital inclusive finance and corporate financing cost changes with the regional financial ecology.

2.3.3. Enterprise scale heterogeneity (smaller-scale and larger-scale enterprises)

Enterprise scale affects both the degree of financing constraints and the efficiency with which digital information is used by financial institutions. Smaller-scale enterprises usually have less credit accumulation and weaker mortgage capacity, so they have stronger demand for the alternative information and online financing channels provided by digital finance. If digital inclusive finance can effectively supplement their traditional credit information, it may significantly improve financing conditions. On the other hand, larger-scale enterprises usually have more standardized financial disclosure, more stable operating records and richer digital data, and financial institutions can more easily bring this information into credit models and risk pricing. Only when digital financial infrastructure is combined with a verifiable data basis can it more fully form a pricing advantage. Therefore, the financing cost effect of digital inclusive finance may also show stronger in larger-scale enterprises. This paper divides smaller-scale and larger-scale enterprises according to the annual median of enterprise scale, and compares the estimation results of the two groups.

2.4. Research hypotheses

Based on the above theoretical analysis, this paper puts forward research hypotheses from three levels: the overall effect, the external information environment, and the heterogeneity of ownership, enterprise scale and region.

H1: The higher the development level of regional digital inclusive finance, the lower the corporate financing cost.

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H2: The development of digital inclusive finance can raise the attention of external information intermediaries and the information coverage of enterprises, and reduce corporate financing cost by improving the external information environment.

H3a: The impact of digital inclusive finance on corporate financing cost has ownership heterogeneity, and its effect of reducing financing cost is more significant in non-state-owned enterprises.

H3b: The impact of digital inclusive finance on corporate financing cost has regional difference.

H3c: The impact of digital inclusive finance on corporate financing cost has enterprise scale difference.

3. Research design

3.1. Data sources and sample construction

3.1.1. Data sources

This paper uses the digital inclusive finance index at the regional dimension and the listed company data at the enterprise aspect to construct enterprise-year panel data. The regional digital inclusive finance data come from the "Peking University Digital Inclusive Finance Index" published by the Peking University Digital Finance Research Center, and the original index covers 2011 to 2023. The enterprise-level data come from the CSMAR database, mainly including corporate financial statements, industry classification, property rights nature, listing year, and analyst following and research reports and other information.

3.1.2. Sample construction

This paper takes A-share non-financial listed companies as the initial enterprise sample, and matches the city-level digital inclusive finance index to the enterprise level according to the registration place and year of the enterprise. The baseline regression keeps non-financial industry enterprises, so as to avoid that the asset-liability structure and financial expense composition of financial enterprises have systematic differences from those of real enterprises. The baseline regression finally contains 25611 enterprise-year observations, involving 3810 non-financial A-share listed companies.

3.2. Variable definition and measurement

3.2.1. Explained variable: financing cost

This paper measures the baseline financing cost with the ratio of corporate financial expenses relative to average total assets. This indicator reflects the burden degree of the annual financial expenses of the enterprise relative to the asset scale of the enterprise, and the calculation way is:

$$FinCost_{it} = Financial\ expenses_{it} / [(Total\ assets_{i,t-1} + Total\ assets_{it}) / 2] \quad (2)$$

In the empirical regression, the logarithm of FinCost is taken to obtain ln_FinCost. The higher the financing cost, the heavier the financial expense burden corresponding to the unit asset scale of the enterprise. The robustness test uses the ratio of financial expenses to average total liabilities to construct an alternative indicator:

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$$FinCost_liab_{it} = Financial\ expenses_{it} / [(Total\ liabilities_{i,t-1} + Total\ liabilities_{it})/2] \quad (3)$$

The natural logarithm of this indicator is also taken to form ln_FinCost_liab, which is used to test the sensitivity of the baseline conclusion to the measurement caliber of financing cost.

3.2.2. Core explanatory variable: digital inclusive finance

The digital inclusive finance aggregate index of the prefecture-level city where the enterprise is registered is taken as the core explanatory variable. This paper divides the original city-level index by 100, and constructs the DIF_city_index_100 variable. This treatment only changes the measurement unit of the variable, which is convenient for the display of regression coefficients. A larger value means that the development level of digital inclusive finance in the city where the enterprise is located is higher.

3.2.3. Information channel variables

This paper uses the number of analyst attention and the number of research reports produced by analysts to depict the external information environment of enterprises. The analyst attention variable ln_Analyst is the logarithm taken after adding 1 to the number of analysts each year; the research report variable ln_Report is similar to the former. The higher the analyst attention and the wider the research report coverage, the greater the degree of attention from information intermediaries received by the enterprise and the more information media it contacts.

3.2.4. Control variables

The baseline regression takes enterprise scale (Size), asset-liability ratio (Lev), return on total assets (ROA), growth (Growth) and enterprise age (Age) as the baseline variables. Among them, Size takes the logarithm of total assets; Lev is the ratio of total liabilities to total assets; ROA measures the profitability of the enterprise; Growth is the growth rate of operating revenue; Age is the logarithm taken after adding 1 to the listing years of the enterprise. The above variables respectively control the differences of enterprise scale, capital structure, profit condition, business growth and life cycle.

3.2.5. Heterogeneity grouping variables

The ownership grouping variable SOE is constructed according to the nature of the actual controller of the enterprise, with 1 for state-owned enterprises and 0 for non-state-owned enterprises. The enterprise scale grouping variable small_firm is constructed according to the annual median of enterprise Size, with 1 for enterprises below the median of that year and 0 for the other enterprises. The region grouping variable east is constructed according to the province where the enterprise is registered, with 1 for Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan, and 0 for the other regions.

3.3. Econometric model specification

3.3.1. Baseline regression model

To explore the relationship between the development of regional digital inclusive finance and corporate financing cost, this paper builds an industry fixed effect and year fixed effect model:

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$$ln_FinCost_{it} = \alpha + \beta DIF_city, ct + \gamma' X_{it} + \eta_j + \lambda_t + \varepsilon_{it} \quad (4)$$

Among them, i denotes the enterprise, t denotes the year, c denotes the prefecture-level city where the enterprise is registered, and j denotes the industry to which the enterprise belongs. ln_FinCost is the natural logarithm of corporate financing cost, DIF_city is defined as above, and X is the enterprise-level control variable. η_j denotes the industry fixed effect, which is used to control the relatively stable financing characteristics among industries; λ_t denotes the year fixed effect, which is used to absorb the annual common shocks of macro economy, financial policy and market environment.

3.3.2. External information environment channel test

The external information environment takes ln_Analyst and ln_Report as the explained variables respectively, and the following model is built with the control variables, industry fixed effects and year fixed effects that are consistent with the baseline regression:

$$Info_{it} = \alpha + \delta DIF_city, ct + \gamma' X_{it} + \eta_j + \lambda_t + \varepsilon_{it} \quad (5)$$

Among them, Info denotes the logarithm of the number of analyst following and the logarithm of the number of research reports respectively. If δ is positive, it means that in regions with a higher development level of digital inclusive finance, enterprises obtain more analyst attention and research report coverage, and the external information production and dissemination are more sufficient.

3.3.3. Heterogeneity analysis

This paper carries out grouped regression from the three dimensions of ownership, enterprise scale and region. The ownership dimension estimates the baseline model in the samples of state-owned enterprises and non-state-owned enterprises respectively; the enterprise scale dimension estimates in the samples of small enterprises and large enterprises respectively; the region dimension estimates in the samples of the eastern region and the central, western and northeast regions respectively. Each group uses the control variables, industry fixed effects, year fixed effects and enterprise-level clustered standard errors that are consistent with the baseline model. The ownership grouping is used to examine the difference in the role of digital finance in enterprises with different credit basis and financing channels; the scale grouping is used to examine the influence of the enterprise data basis and the degree of financing constraints on the effect of digital finance; the region grouping is used to compare the complementary or gap-filling relationship between digital finance and the traditional financial basis.

3.4. Robustness test design

This paper carries out robustness tests from the angles of variable caliber, fixed effects and special years according to the current regression setting.

First, replace the explained variable. The baseline explained variable ln_FinCost is replaced by ln_FinCost_liab, that is, financing cost is measured by the ratio of financial expenses relative to average total liabilities, and the other model settings are kept unchanged.

Second, add province fixed effects. On the above basis, province fixed effects are further added to control the long-standing differences of financial resource endowment, institutional environment and regional characteristics among different provinces.

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Third, drop the samples of 2020 to 2021. Considering that the operation and financing environment of enterprises from 2020 to 2021 was hit by the epidemic. After dropping the above data, regression analysis will be carried out again to examine whether the core relationship is affected by abnormal macro shocks.

Fourth, drop the samples of 2018. Because in 2018 the policies of the new asset management regulation, financial deleveraging and helping private enterprises with financing relief were introduced in a concentrated way, it is planned to drop this year and then carry out regression again.

Fifth, drop the samples of 2019. In 2019, the reform of the loan market quotation rate pushed the adjustment of the loan interest rate pricing mechanism. Regression again will be helpful to test the sensitivity of the baseline relationship to the change of the interest rate pricing system.

4. Empirical results and analysis

4.1. Descriptive statistics

The regression sample of this paper contains 25611 enterprise-year observations, covering 3810 A-share listed companies, and the sample period is consistent with the available years of the Peking University prefecture-level city digital inclusive finance index. The descriptive statistics of the variables involved are shown in Table 1.

Table 1. Descriptive statistics

	count	mean	sd	min	max
ln_FinCost	25611	-4.934077	1.140096	-8.891104	-3.010167
DIF_city_index	25611	2.578215	.6955955	.5395	3.732214
Size	25611	22.47746	1.329888	19.72937	26.46627
Lev	25611	.4992607	.1870327	.1143773	.9966778
ROA	25611	.018594	.0736651	-.4269833	.1699805
Growth	25611	.164091	.4766953	-.6570027	3.194438
Age	25611	2.316219	.7545536	0	3.401197
N	25611				

The mean of the explained variable financing cost (ln_FinCost) is −4.9341, the standard deviation is 1.1401, and the minimum and maximum values are −8.8911 and −3.0102 respectively, which indicates that there are relatively obvious differences in the financing expense ratio of the sample enterprises. The mean of the core explanatory variable city-level digital inclusive finance index (DIF_city_index_100) is 2.5782, and the standard deviation is 0.6956, which indicates that there are significant differences in the development degree of digital inclusive finance among different cities.

4.2. Baseline regression results

Table 2 reports the baseline regression results. The model considers industry fixed effects and year fixed effects, and clusters standard errors at the enterprise level.

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Table 2. Baseline regression

	(1) ln_FinCost
DIF_city_index_100	-0.1757***
	(0.0505)
Size	-0.0304***
	(0.0116)
Lev	3.1071***
	(0.0648)
ROA	-0.9069***
	(0.1193)
Growth	0.0033
	(0.0148)
Age	0.0155
	(0.0150)
Observations	25611
Adjusted R-squared	0.3242

Standard errors in parentheses* p < 0.10, ** p < 0.05, *** p < 0.01

The regression results show that the coefficient of the core explanatory variable DIF_city_index_100 is −0.1757, which is significantly negative at the level of 1%, indicating that there is a significant negative correlation between the development level of city digital inclusive finance and corporate financing cost. In terms of the meaning of the coefficient, for every 100% increase of the city-level digital inclusive finance index (that is, DIF_city_index_100 increases by 1 unit), ln_FinCost decreases by about 0.176 on average.

According to the hypotheses in Chapter 2, digital inclusive finance may affect financing cost by improving the external information environment of enterprises. Table 3 reports the regression results with the logarithm of the number of analyst attention (ln_Analyst) and the logarithm of the number of research reports (ln_Report) as the explained variables.

Table 3. Mechanism tests

	(1) ln_Analyst	(2) ln_Report
DIF_city_index_100	0.1645***	0.2220***
	(0.0534)	(0.0665)
Size	0.3839***	0.4783***

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Table 3. (continued)

	(0.0114)	(0.0143)
Lev	-0.5094***	-0.5817***
	(0.0674)	(0.0843)
ROA	3.6029***	4.8280***
	(0.1878)	(0.2434)
Growth	0.0410***	0.0844***
	(0.0146)	(0.0192)
Age	-0.1840***	-0.2213***
	(0.0155)	(0.0195)
Observations	16493	16514
Adjusted R-squared	0.2999	0.3004

Standard errors in parentheses* p < 0.10, ** p < 0.05, *** p < 0.01

The regression results show that the regression coefficient of DIF_city_index_100 on the logarithm of the number of analyst following is 0.1645, which is significantly positive at the level of 1%; the regression coefficient on the logarithm of the number of research reports is 0.2220, which is also significantly positive at the level of 1%. That is to say, in cities with a higher development level of digital inclusive finance, the sample enterprises obtain more analyst attention and research report coverage.

Analysts and research institutions are important information intermediaries in the capital market, and their following and coverage can increase the production, sorting and dissemination of enterprise information. The digital information of transaction, payment, tax, supply chain and online operation on which digital inclusive finance relies raises the recordability and verifiability of enterprise operating activities, and may lower the cost for external subjects to obtain and process enterprise information. More sufficient information circulation helps financial institutions understand the operating condition, profitability and default risk of enterprises in a more complete way, and thus reduces the role of information asymmetry in financing pricing.

4.3. Heterogeneity analysis: ownership, region and enterprise scale

The correlation between digital inclusive finance and corporate financing cost may differ with the ownership, region and scale of the enterprise. Table 4 reports the corresponding grouped regression results.

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Table 4. Heterogeneity tests

	(1) ln_FinCost	(2) ln_FinCost	(3) ln_FinCost	(4) ln_FinCost	(5) ln_FinCost	(6) ln_FinCost
DIF_city_index	-0.1180	-0.2031***	-0.1202*	-0.2066***	-0.2945***	-0.2023**
	(0.0886)	(0.0608)	(0.0686)	(0.0660)	(0.0771)	(0.0939)
Size	-0.0537***	0.0054	0.1411***	-0.1077***	-0.0618***	0.0214
	(0.0183)	(0.0152)	(0.0251)	(0.0179)	(0.0145)	(0.0191)
Lev	3.0704***	3.1822***	3.3429***	2.7833***	3.2331***	2.9859***
	(0.1205)	(0.0773)	(0.0791)	(0.1010)	(0.0864)	(0.0990)
ROA	-1.3680***	-0.7204***	-0.5793***	-2.0415***	-0.8141***	-0.9874***
	(0.2834)	(0.1311)	(0.1354)	(0.2261)	(0.1470)	(0.2077)
Growth	0.0696***	-0.0433**	-0.0597***	0.0710***	-0.0066	0.0209
	(0.0214)	(0.0191)	(0.0210)	(0.0199)	(0.0202)	(0.0216)
Age	0.0332	0.0552***	0.0131	0.0082	0.0461**	-0.0211
	(0.0307)	(0.0186)	(0.0184)	(0.0225)	(0.0186)	(0.0260)
Observations	9270	16340	12674	12935	16978	8632
Adjusted R-squared	0.3680	0.3142	0.3179	0.3399	0.3063	0.3615

Standard errors in parentheses* p < 0.10, ** p < 0.05, *** p < 0.01

4.3.1. Ownership heterogeneity (state-owned enterprises vs. non-state-owned enterprises)

Column (1) and column (2) respectively analyze the different results of state-owned enterprises and non-state-owned enterprises. In the sample of state-owned enterprises, the coefficient of DIF_city_index_100 is −0.1180, which does not reach the conventional significance level; in the sample of non-state-owned enterprises, this coefficient is −0.2031, and is significantly negative at the level of 1%. From the point estimate and significance, the negative correlation between digital inclusive finance and financing cost is more significant in non-state-owned enterprises. This difference can be understood from the information basis of enterprise financing. State-owned enterprises usually have more stable bank cooperation relations and a stronger credit basis, and the marginal sensitivity of their financing conditions to new digital information is relatively low. Non-state-owned enterprises rely more on market-based risk identification and their own operating information, and alternative data such as transaction flow and online operation can supplement

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traditional credit information, so the marginal effect of digital inclusive finance in the financing pricing of non-state-owned enterprises may be more obvious.

4.3.2. Regional heterogeneity (eastern region vs. central, western and northeast regions)

Column (5) and column (6) respectively analyze the regression results of the samples of the eastern region and the central, western and northeast regions. In the eastern region, the coefficient of DIF_city_index_100 is −0.2945, which is significantly negative at the level of 1%; the coefficient in the central, western and northeast regions is −0.2023, which is significantly negative at the level of 5%. Both results are negative, and from the point estimate, the negative relationship in the eastern region is more obvious. The above results are consistent with the mutual-help logic between digital technology and the existing financial infrastructure. In the eastern region, the financial market and digital technology are relatively mature, the degree of digital operation of enterprises is relatively high, and financial institutions can more easily use data resources for credit identification and risk pricing. Although the central, western and northeast regions also show a significant negative relationship, it is obvious that the degree of connection between the two is far lower than that in the eastern region.

4.3.3. Enterprise scale heterogeneity (smaller-scale enterprises vs. larger-scale enterprises)

Column (3) and column (4) are grouped according to the median of enterprise scale. In the sample of smaller-scale enterprises, the coefficient of DIF_city_index_100 is −0.1202, which is significantly negative at the level of 10%; in the sample of larger-scale enterprises, the coefficient is −0.2066, which is significantly negative at the level of 1%. From the point estimate and significance, the negative correlation in larger-scale enterprises is more significant. The reason is that larger-scale enterprises usually have more standardized financial disclosure, more continuous operating records and richer digital data, and financial institutions can more fully bring this information into credit assessment and risk pricing. Although smaller-scale enterprises have stronger demand for alternative information, their data accumulation and digital operation basis may be weaker.

4.4. Robustness tests

This paper further examines the sensitivity of the baseline estimation to different variable calibers and model settings from the three aspects of replacing the measurement of financing cost, adding province fixed effects and dropping special years, and the results are reported in Table 5.

Table 5. Robustness tests

	(1) ln_FinCost_liab	(2) ln_FinCost	(3) ln_FinCost	(4) ln_FinCost	(5) ln_FinCost
DIF_city_index	-0.1787***	-0.2523***	-0.1955***	-0.1815***	-0.1687***
	(0.0492)	(0.0669)	(0.0546)	(0.0502)	(0.0506)
Size	-0.0328***	-0.0293**	-0.0264**	-0.0336***	-0.0316***
	(0.0114)	(0.0120)	(0.0123)	(0.0116)	(0.0117)
Lev	0.9620***	3.1102***	3.1302***	3.0721***	3.0669***

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Table 5. (continued)

	(0.0626)	(0.0655)	(0.0687)	(0.0645)	(0.0657)
ROA	-1.4329***	-0.8946***	-0.9495***	-0.9668***	-0.9316***
	(0.1147)	(0.1187)	(0.1355)	(0.1286)	(0.1279)
Growth	0.0218	0.0031	-0.0027	0.0053	0.0078
	(0.0143)	(0.0148)	(0.0163)	(0.0154)	(0.0156)
Age	-0.0103	0.0171	0.0247	0.0145	0.0143
	(0.0147)	(0.0151)	(0.0160)	(0.0151)	(0.0150)
Observations	25611	25611	20136	23370	23221
Adjusted R-squared	0.1469	0.3266	0.3328	0.3215	0.3220

Standard errors in parentheses
* p < 0.10, ** p < 0.05, *** p < 0.01

Column (1) replaces the explained variable from the ratio of financial expenses to average total assets (ln_FinCost) with the ratio of financial expenses to average total liabilities (ln_FinCost_liab). The coefficient of DIF_city_index_100 is −0.1787, which is significantly negative at the level of 1%, and is close to the initial regression coefficient of the model (−0.1757). This shows that after using different measurements of financing cost, the direction of the core coefficient basically remains stable.

Column (2) further adds province fixed effects on the basis of industry fixed effects and year fixed effects, so as to absorb the long-term stable financial resource endowment, institutional environment and regional characteristics at the province level. The coefficient of DIF_city_index_100 is −0.2523, which is significantly negative at the level of 1%. This shows that after adding province fixed effects, the significance of the core conclusion remains unchanged.

Considering that the epidemic shock, financial regulation adjustment and interest rate marketization reform may change the financing environment of enterprises, this paper drops the relevant years respectively and re-estimates the baseline model. Column (3) drops the samples of 2020 to 2021, and 20,136 observations remain. The coefficient of DIF_city_index_100 is −0.1955, which is significantly negative at the level of 1%, and the direction is consistent with the baseline result.

Column (4) drops the samples of 2018. In this year, the financing environment changed greatly because of the introduction of policies. After dropping, the coefficient of DIF_city_index_100 is −0.1815, which is significantly negative at the level of 1%, and is consistent with the direction of the baseline estimation.

Column (5) drops the samples of 2019. In this year, the reform of LPR pushed the adjustment of the loan interest rate pricing mechanism and affected the pricing of financing cost. After dropping, the coefficient of DIF_city_index_100 is −0.1687, which is significantly negative at the level of 1%, and the significance of the core conclusion remains stable.

In the above tests, the estimated coefficients of DIF_city_index_100 are all significantly negative, indicating that the baseline result has good stability with respect to the caliber of financing cost, province fixed effects and the treatment of special years, and the conclusion is general.

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5. Conclusions and policy implications

5.1. Main conclusions

This paper takes the financial data of A-share non-financial listed companies from 2011 to 2023 as the sample, matches the prefecture-level city digital inclusive finance index with the financial data of companies, explores the correlation between digital inclusive finance and corporate financing cost, and further analyzes the influence brought by the external information environment and the differences of company ownership, region and enterprise scale. The main conclusions are as follows:

First, the development degree of regional digital inclusive finance is significantly negatively correlated with corporate financing cost. In the baseline regression, the coefficient of DIF_city_index_100 is −0.1757, which is significantly negative at the level of 1%; for every 100% increase of the city-level digital inclusive finance index, ln_FinCost decreases by about 0.176 on average.

Second, the mechanism regression provides support for the information environment channel. The higher the development level of digital inclusive finance, the more analyst attention and research report coverage the enterprise obtains. The increasingly convenient information acquisition opens up the information gap between financial institutions and enterprises, and greatly reduces unnecessary cost expenditure.

Third, the grouped regression shows differences in ownership, region and enterprise scale. In the sample of non-state-owned enterprises, the coefficient of DIF_city_index_100 is −0.2031 and is significantly negative, while the coefficient in the sample of state-owned enterprises does not reach the conventional significance level; the point estimate of the eastern region (−0.2945) is larger than that of the central, western and northeast regions (−0.2023); the point estimate of larger-scale enterprises (−0.2066) is also larger than that of smaller-scale enterprises (−0.1202). These results show that the negative correlation between digital inclusive finance and financing cost is more significant in non-state-owned enterprises, the eastern region and larger-scale enterprises.

5.2. Policy implications

First, improve the sharing of enterprise operating data and the digital credit reporting system. The regression results show that the promotion of digital inclusive finance is related to higher analyst following and research report coverage, which indicates that the availability and verifiability of enterprise digital information are an important basis of financial pricing. It is possible to further promote the data coordination among tax, industry and commerce, customs, supply chain and payment platforms, improve the credit information files of enterprises, and provide a more complete information basis for financial institutions to use alternative data to carry out risk identification and pricing.

Second, raise the digital financial infrastructure and the application capacity of data platforms in the central, western and northeast regions. The grouped results show that the negative relationship in the sample of the eastern region is more obvious, which indicates that the role of digital finance may form complementarity with the existing financial infrastructure, the degree of enterprise digitalization and the platform use capacity. The policy focus can be placed on making up for digital infrastructure, raising the standardization degree of enterprise operating data, and strengthening the ability of financial institutions to identify and apply digital information.

Third, optimize digital credit products and risk assessment methods for non-state-owned enterprises and smaller-scale enterprises. The negative relationship in the sample of non-state-owned

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enterprises is more obvious, while the point estimate of smaller-scale enterprises is relatively weak. Financial institutions can, according to the operating characteristics of such enterprises, bring alternative data such as online transaction flow, tax declaration and supply chain transactions into credit assessment, and improve risk identification and financing pricing under the condition of insufficient traditional mortgage information.

Fourth, improve the information disclosure and information intermediary coverage mechanism. Analyst following and research report coverage show a significant positive correlation with the development degree of digital inclusive finance, indicating that external information intermediaries are an important channel for enterprise information to enter the capital market and the financing pricing system. It is possible to expand the research coverage of small and medium market value and non-state-owned enterprises by raising the standardization and machine-readable degree of information disclosure and lowering the cost of information acquisition and processing.

5.3. Further research

Based on the above empirical analysis, follow-up research may perhaps be carried out on the following questions.

First, refine the measurement standard of financing cost. This paper measures financing cost with the ratio of financial expenses to asset scale or liability scale, and this indicator is also affected by accounting treatment factors such as the financing structure of the enterprise, interest capitalization and exchange gains and losses. Follow-up research can introduce loan interest rate, bond issuance spread or other more direct debt financing price indicators, so as to depict corporate financing cost more precisely. Second, add new measurement indicators of the information environment. This paper depicts external information production with the number of analyst following and the number of research report coverage, and these two indicators mainly reflect the attention breadth of capital market information intermediaries and the intensity of information production. Follow-up research can combine credit spread, stock liquidity, information disclosure quality or other indicators that directly reflect bank-enterprise information friction, and construct richer evidence of the information environment. Third, continue to study the logic chain of transmission in depth. The existing fixed effects framework mainly verifies the conditional correlation after controlling enterprise characteristics, industry and year factors. Follow-up research can use quasi-natural experiments such as digital finance pilots and changes in platform access, or construct instrumental variables with clear economic meaning, to further identify the transmission path through which digital inclusive finance affects corporate financing cost.

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