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RESEARCH ARTICLE

Digital Inclusive Finance and Commercial Bank Credit Risk: Evidence from Listed Banks in China

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Abstracts

The rapid development of contemporary digital inclusive finance has a significant impact on the credit risk of commercial banks, and this paper investigates the potential relationship between digital inclusive finance and the line credit risk of commercial banks based on the panel data of 42 listed commercial banks in China from 2012 to 2024. The conclusions of the study are as follows: (1) The development of digital inclusive finance has enhanced the credit risk of commercial banks. (2) With the enhancement of digital inclusive finance, the marginal impact on the credit risk of commercial banks decreases. (3) Digital inclusive finance further intensifies the credit risks of commercial banks through the partial intermediary effect of cross-industry competition and inter-industry competition. (4) Economic situation and policy uncertainty play a positive moderating role in the relationship between digital inclusive finance and the credit risk of commercial banks. Finally, the paper puts forward relevant policy suggestions, making marginal contributions to China's financial system and regulation in the new era.

Keywords: digital inclusive finance; Credit risk of commercial banks; Threshold effect; Cross-industry competition

Introduction

The Central Economic Work Conference stressed that inclusive finance, as one of the "five major articles" of finance, is promoting the common development of all social strata and groups through a series of innovative policies and measures to achieve wide coverage and deep penetration of financial services. The connotation of inclusive finance in China is to provide appropriate and effective financial services at an affordable cost to all social strata and groups in need of financial services based on the requirements of equal opportunity and the

principle of sustainable business. At the same time, small and micro enterprises, farmers, urban low-income people, poor people, the disabled, the elderly and other special groups are the key service objects of China's inclusive finance. Successful inclusive finance should make obvious progress in at least six aspects: first, basic financial services should be more universal, each township has a banking institution, banking services cover the countryside; Second, financing has become more convenient for business entities, and the financing sustainability of small and micro enterprises, individual industrial and commercial households, farmers and new agricultural business entities has been significantly improved. Third, financial services for rural development have been stronger, the rural financial service system has been better, and financial support for rural industrial development and infrastructure construction has been continuously increased. Fourth, the financial consumer education and protection mechanism has been improved, and the popularization of financial knowledge has been significantly improved; Fifth, the prevention and control of financial risks has been more effective, and the risk prevention and control capabilities of key institutions and areas such as small and medium-sized financial institutions have been significantly improved. Sixth, the supporting mechanisms for inclusive finance have been improved, the quality and efficiency of credit information sharing have been further improved, and the supporting legal system has been further improved. Display quotations of over 40 words, or as needed.

As the largest capital provider of the real economy, the credit risk management of commercial banks is very important to prevent the systemic risk of modern financial system. Digital inclusive finance, as one of the main forces boosting the development of the global economy, the integration of digital technology represented by big data and traditional inclusive financial services makes the competition among commercial banks increasingly fierce, and brings impact to the credit risk management of commercial banks. Therefore, under the new wave of "digital + finance" innovation, strengthening the credit risk management of commercial banks plays a key role in maintaining financial stability. By studying the relationship between digital inclusive finance and the credit risk of commercial banks, this paper introduces the dual perspectives of cross-industry competition and inter-industry competition, which provides a certain marginal role for financial regulators and commercial banks to further manage credit risks and for digital inclusive finance to better promote contemporary economic development.

Literature Review and Hypotheses

Impact of Digital Inclusive Finance on the Credit Risk of Commercial Banks

The researches of digital inclusive finance are numerous. Saini and Saha (2024) examined digital finance inclusion in India and found that digital tools can help those who were previously excluded from the traditional banking systems. Babarinde (2023) examined the impact of digital finance in Nigeria and found that it can significantly improve the credit allocations for commercial banks. The development of digital inclusive finance has brought a huge impact on the assets and liabilities of commercial banks. Wei et al. (2019) proposed that digital inclusive finance reduced transaction costs and thus intensified the competition in the traditional financial market.

Gu et al. (2022) and Cai et al. (2024) proposed that this is a new crowding out effect, which further impacts the credit risk management of commercial banks.

Wang et al. (2025) proposed that digital inclusive finance can effectively solve the problem of information asymmetry, which is conducive to the control of credit risks by commercial banks. This has led to financial frictions. Qiu et al. (2008) proposed that the integration of digital technology and financial services not only alleviates the problem of information asymmetry, but also further weakens the information monopoly advantage among commercial banks, thus improving the degree of competition in the banking market. Yang et al. (2018) and Tang et al. (2019) proposed that due to the rapid change of scientific and technological innovation and the short transformation cycle of financial products, financial risks will be more hidden, rapid and multi-channel transmission, and the development level of fintech will be different in different eras. This study believes that the development of digital inclusive finance has a phased impact on the credit risk of commercial banks. That is, there is a threshold effect.

Based on this, this paper proposes Hypothesis 1 and Hypothesis 2.

Hypothesis 1: The development of digital inclusive finance increases the credit risk of commercial banks.

Hypothesis 2: The development of digital inclusive finance has a threshold effect on the credit risk of commercial banks

Mediating effect of digital inclusive finance in cross-industry competition and inter-industry competition

Sun et al. (2015) pointed out that in the process of big data digitization, digital inclusive finance has accelerated the disintermediation of customers, funds and channels of commercial banks, leading to the transfer of a large number of deposits and loans of banks to the financial market, and the transactions are directly conducted between the supply and demand sides, making commercial banks gradually "exogenous" to the financial system.

From the perspective of industry competition, in the traditional financial system, large state-owned banks are more inclined to provide loans to state-owned enterprises, central enterprises and corresponding government agencies with strong repayment ability and stable growth of performance scale. However, commercial banks, city commercial banks and other small and medium-sized banks are more inclined to provide loan support to small and medium-sized enterprises, emerging enterprises and individuals with large development space. However, the emergence of digital inclusive finance has broken the original market pattern, and the form of digital + Internet has intensified the cross-industry competition of fintech enterprises. While dealing with external competition, traditional commercial banks also need to compete with other banks to seize the extremely limited market resources. This will lead banks to seize resources to provide more favourable interest rates, lower the credit threshold and provide differentiated products to establish their own competitive advantages. But it has exacerbated credit risks in financial markets.

Based on this, this paper puts forward hypothesis 3.

Hypothesis 3: Digital inclusive finance further intensifies the credit risk of commercial banks through the mediating effect of cross-industry competition and inter-industry competition

Moderating effect of economic form and policy uncertainty

The uncertainty of economic form and policy aggravates information asymmetry, market environment uncertainty, policy adjustment impact uncertainty and customer behaviours uncertainty. When the economic situation and policies are uncertain, the operation and income status of enterprises and individuals change frequently. Although digital inclusive finance relies on technologies such as big data to assess credit risks, economic policy uncertainty may make the update speed of relevant data unable to keep up with changes in the actual situation. At the same time, the uncertainty of economic policy is easy to cause industry fluctuations. Some industries that are greatly affected by the policy, such as real estate and new energy, may face huge market changes when the policy is adjusted. The proportion of loans involving these industries in digital inclusive finance business may be high. When the development of the industry is inhibited or uncertain, the repayment ability of enterprises decreases and the risk of loan default increases, thus increasing the credit risk of commercial banks. In an uncertain economic situation, the income stability of individuals and businesses is affected and the repayment ability may decrease. The uncertainty of economic policy will change the risk preference of customers. Some customers may choose to repay their loans early to reduce their debt burden due to concerns about the future economic situation; Others may be taking more risks with their loans, seeking higher returns on risky investments to cope with the stress of economic uncertainty. Both situations will have an impact on the credit risk of commercial banks. The former may lead to the bank's capital return too fast and affect the rational allocation of funds. The latter, in turn, directly increases the probability of loan default. Based on this, this paper puts forward hypothesis 4.

Hypothesis 4: Economic form and policy uncertainty increase the promoting effect of digital inclusive finance on the credit risk of commercial banks.

Methodology

Data sources

Based on the availability of data, this paper selects the panel data of 42 listed commercial banks from 2011 to 2024 based on the annual reports of CTAIC, Wind and the listed banks. Other macro data come from financial statistical yearbooks and the official website of the National Bureau of Statistics. At the same time, in order to avoid errors caused by outliers to the empirical results, this paper proposes some missing samples and uses the interpolation method to supplement them.

Explained variable

Commercial bank credit risk (RISK) refers to the possibility of loss caused by the uncertainty in credit activities, to be precise, all risks caused by customer default. For example, the deterioration of asset quality caused by the borrower's inability to repay debts in the asset business; In the liability business, depositors withdraw cash in large quantities to form a run and so on. Aroghene et al.（2024）noticed internal variables of the banks should be evaluated in order to expose what actually endear loan non-performance in financial service sector. At present, the main research mainly refers to Xie et al. (2020) to select Z value, loan provision ratio and non-performing loan ratio to measure the credit risk of commercial banks, where z value focuses on measuring bankruptcy risk, loan provision ratio focuses on measuring the provision for potential loan losses, and non-performing loan ratio focuses on loan default risk. In this study, the non-performing loan ratio is selected as the variable to measure the credit risk degree of commercial banks, and the larger the value is, the higher the credit risk of commercial banks is.

Explanatory variables

The development degree of digital inclusive finance (DF), this study refers to the research methods of Zhang et al. (2024), Lv et al. (2023), Zhang et al. (2023) and others, and selects the digital inclusive finance index jointly released by the Institute of Digital Finance of Peking University and Ant Group as the measurement index to measure the development level of regional digital inclusive finance. To further solve the dimensional problem, this study obtains the explanatory variable to measure the development degree of digital inclusive finance after the total index at the provincial level /100 of the index.

Mediating variables

This study uses the financial disintermediation index to measure the degree of cross-industry competition, and refers to the practice of Gu et al. (2022) to measure the degree of financial disintermediation by the proportion of regional direct financing in the total financing scale of the region.

At present, there are a variety of indicators to measure the competition of commercial banks, such as CRn Index (Concentration Ratio), Herfindahl-Hirschman index (HHI Index), Gini Coefficient (Gini Coefficient), The CRn Index focuses on measuring the monopoly degree of leading institutions, the HHI index focuses on the balance of the scale of institutions in the whole market, and the Gini coefficient focuses on measuring the inequality degree of market share. This index focuses on quantifying the price distortion degree of monopoly power based on the results of enterprise behaviours, and the calculation method is shown in module (1).

$$Lerner = \frac{P_{i,t} - MC_{i,t}}{P_{i,t}} \quad (1)$$

Where $P_{i,t}$represents the total income of commercial banks, and $MC_{i,t}$ represents the marginal cost of the ith bank at time t. The calculation method of marginal cost refers to the calculation method of Xue et al. (2025), and the total cost $TC_{i,t}$ is expressed by the fees of commercial banks. Total bank output $Q_{i,t}$ is measured by the size of the bank's total assets, the price of funds is measured by the interest cost, and the price of labour and capital is measured by the share of non-interest expenses to fixed assets, which together constitute a vector of input factor prices, which are calculated as shown in model (2)-(3).

$$\ln TC_{i,t} = \alpha_0 + \alpha_1 \ln Q_{i,t} + \frac{1}{2}\alpha_2 (\ln Q_{i,t})^2 + \sum_{l=1}^{2} \beta_l \ln W_{l,i,t} + \sum_{l=1}^{2}\sum_{m=1}^{2} \beta_{lm} \ln W_{l,i,t} \ln W_{m,i,t} + \sum_{l=1}^{2} \sigma_{ql} \ln Q_{i,t} W_{l,i,t} + \varepsilon \quad (2)$$

$$MC = \frac{TC_{i,t}}{Q_{i,t}} (\alpha_1 + \alpha_2 \ln Q_{i,t} + \sum_{l=1}^{2} \sigma_{ql} \ln W_{l,i,t}) \quad (3)$$

Moderating variables

The academic circle mainly uses the following methods to measure the economic situation and policy uncertainty. (1) Mainstream media texts are adopted, such as the Wall Street Journal and The New York Times for the EPU index in the United States, while People's Daily, Guangming Daily and major financial media (such as China Securities Journal) are used for the EPU index in China. (2) The subjective perception method based on enterprise surveys, such as the Enterprise Survey of the World Bank and the Economic Outlook Survey of the Federal Reserve, asks enterprises about the expected uncertainty of policy changes. (3) "Implied volatility method" based on financial market (4) "Semantic Network Analysis method" based on policy text This study adopts the mainstream method China EPU index, China EPU index includes the total index, And fiscal policy uncertainty index, monetary policy uncertainty index, trade policy uncertainty index, exchange rate uncertainty index and other sub-indexes, which can reflect the situation of economic policy uncertainty from different dimensions. This indicator was originally developed by Steven J. Davis, Dingqian Liu, and Xuguang S. S. Sheng, using People's Daily and Guangming Daily as data sources to quantify concepts related to uncertainty from October 1949. First, monthly counts of articles containing at least one term in the three term sets were obtained. Second, the raw monthly EPU counts are scaled by the total number of articles in the same newspaper and in the same month. Then, the sample is divided into three periods, namely, the central planning period (1949-1978), the reform and opening period (1979-1999) and the globalization era (after 2000). Unit standardization is achieved using data from 2000 to 2018 in the era of globalization. Next, a simple average of the standardized series of newspapers was calculated monthly. Finally, the index values for each period are normalized to a mean of 100.

Control variables

This study refers to the research method of Wang et al. (2025), and from the perspective of banks themselves, We control the capital adequacy ratio (CAP), non-interest income ratio (NINO), cost-to-income ratio (CIR), return on equity (ROE), net interest margin (NIM), asset-liability ratio (ALR), loan-to-deposit ratio (LDR) and other variables that may affect the credit risk of commercial banks; From the perspective of regional economic development, we control other variables that may affect the credit risk of commercial banks, such as the cumulative year-on-year growth rate of GDP (GDP) and the cumulative year-on-year growth rate of CPI (CPI).

Table 1. Definition of variables and their measurement criteria

Variable type	variable name	variable symbol	benchmark
explanatory variable	Commercial bank credit risk	RISK	Non-performing loans/total loan balance
explanatory variable	Digital Inclusive Finance Index	DF	Peking University Provincial Digital Inclusive Finance Overall Index/ 100
intermediary variable	Financial disintermediation index	FD	Regional scale of direct financing / Regional scale of total social financing
	Industry competition index	Lerner	Lerner index (math.)
moderator variable	Economic and policy uncertainty	EPU	China EPU Index
control variable	capital adequacy ratio	CAP	Total capital/risk assets
	Percentage of non-interest income	NINO	Non-interest income/operating income
	Cost-to-income ratio	CIR	Operating expenses/income
	return on net assets	ROE	Net profit/average net assets
	net interest margin	NIM	(Total bank interest income - Total bank interest expense) / Total interest-earning assets
	gearing	ALR	(Total liabilities/total assets) x 100%
	loan-to-deposit ratio	LDR	Total loans/total deposits
	Cumulative year-on-year GDP growth rate	GDP	Cumulative total GDP for the current period - cumulative total GDP for the base period / cumulative total GDP for the base period x 100%

	Cumulative year-on-year CPI CPI growth rate	Cumulative total CPI for the current period - cumulative total CPI for the base period / cumulative total CPI for the base period x 100%

Model construction

Benchmark regression model

In this paper, the benchmark regression model (4) is constructed through panel data to verify Hypothesis 1.

$$RISK_{it} = \alpha_0 + \alpha_1 DF_{it} + \sum \alpha_2 Control_{it} + \gamma_i + \varepsilon_{it} \quad (4)$$

Where $RISK_{it}$it represents the credit risk of commercial banks, DF_{it}it is the digital inclusive financial index, $Control_{it}$it is the control variable, α_0 is the constant term, γ_i is the individual fixed effect, and ε_{it} is the random disturbance term.

Threshold regression model

At present, commercial banks take the initiative to carry out digital transformation in order to stabilize customer groups. By constructing the threshold regression model (5), this paper further explores the phased characteristics of the impact of the development of digital inclusive finance on the credit risk of commercial banks and further tests Hypothesis 2.

$$RISK_{it} = \beta_0 + \beta_1 DF_{it} \cdot I(Threshold_{it} \leqslant \delta) + \beta_2 DF_{it} \cdot I(Threshold_{it} > \delta) + \sum \beta_k Control_{it}^{k} + \gamma_i + \varepsilon_{it} \quad (5)$$

Where $Threshold_{it}$ is the threshold variable, I is the representation function, $\delta$is the threshold value, $\beta_0$is the constant term, and the rest of the variables are the same as above.

Mediating effect model

In order to test the financial disintermediation caused by digital inclusive finance on commercial banks, and explore the influence of inter-bank competition among commercial banks on the transmission mechanism of digital inclusive finance on the credit risk control of commercial banks, this paper constructs the mediating effect model (6) - (8).

$$FD_{it} = \sigma_0 + \sigma_1 DF_{it} + \sum \sigma_2 Control_{it} + \gamma_i + \varepsilon_{it} \quad (6)$$

$$Lerner_{it} = \sigma_0 + \sigma_1 DF_{it} + \sum \sigma_2 Control_{it} + \gamma_i + \varepsilon_{it} \quad (7)$$

$$RISK_{it} = \varphi_0 + \varphi_1 DF_{it} + \varphi_2 \ (\mathrm{FD} + \mathrm{Lerner})_{it} + \sum \varphi_3 Control_{it} + \gamma_i + \varepsilon_{it} \quad (8)$$

Where FD_{it} is the financial disintermediation index, $Lerner_{it}$ is the Lerner index, σ_0 is the constant term, σ_1 represents the influence factor of digital inclusive finance on the intermediary variable, and the remaining variables are the same as above.

Moderating effect model

To further explore the moderating role of economic form and policy uncertainty in the credit risk caused by digital inclusive finance on commercial banks, this study constructs the moderating effect model (9).

$$RISK_{it} = \omega_0 + \omega_1 DF_{it} + \omega_2 EPU_{it} + \omega_3 DF_{it} \times EPU_{it} + \sum \omega_4 Control_{it} + \gamma_i + \varepsilon_{it} \quad (9)$$

Where EPU_{it} is the economic form and policy uncertainty index, $DF_{it} \times EPU_{it}$ is the interaction product term, and the remaining variables are the same as above.

Empirical analysis

Descriptive statistics

The panel data of 42 listed commercial banks from 2011 to 2024 are selected for this study. It can be seen from the results that the standard deviation of credit risk of 42 listed commercial banks is 0.476, and the maximum and minimum values are 8.542 and 0.220 respectively, which are quite different. However, the standard deviation of digital inclusive finance is 1.064, and the maximum and minimum values are 4.957 and 0.683 respectively.

Benchmark regression results

In this study, with reference to Ting et al. (2025) research methodology, an individual fixed-effects model is used to empirically test the impact of digital financial inclusion on commercial banks' credit risk in order to test Hypothesis 1. The results of the benchmark regression are shown in Table 3.

Table 2. Descriptive statistical results

Variable	sample size	average value	standard deviation	minimum value	maximum values
RISK	588	1.324	0.476	0.220	8.542
DF	588	2.845	1.064	0.683	4.957
FD	588	0.258	0.146	0.157	0.621
Lerner	588	0.431	0.182	0.001	0.823
EPU	588	4.972	0.118	4.852	5.071
CAP	588	13.514	1.272	8.962	25.384
NINO	588	18.846	10.253	-13.296	53.628
CIR	588	31.628	6.396	18.876	67.215
ROE	588	14.298	4.696	4.512	32.681
NIM	588	2.462	0.479	1.240	4.721
ALR	588	93.677	1.328	83.946	98.147
LDR	588	73.691	14.591	27.641	117.587
GDP	588	7.289	2.806	-0.018	16.824
CPI	588	2.396	1.684	0.832	5.241

Table 3. Benchmark regression results of digital inclusive finance on commercial banks' credit risk

Variable	(1)	(2)
	RISK	RISK
DF	0.183***	0.359***
	(3.276)	(3.714)
CAP		0.056**
		(0.267)
NINO		0.003
		(0.004)
CIR		-0.021
		(0.007)
ROE		-0.106***
		(0.018)
NIM		-0.048
		(0.092)

Table 3. Continue. . . . .

ALR		0.035
		（0.054）
LDR		0.004**
		（0.003）
GDP		0.060
		（0.013）
CPI		-0.050
		（0.030）
_cons	1.012***	1.547
	（10.381）	（1.642）
N	588	588
individual fixed effect	Control	Control
R2	0.069	0.406

Note: ***, ***, and ** denote P < 0.01, P < 0.05, and P < 0.1, respectively.

In Table 3, column (1) without control variables and column (2) with all control variables, the results show that whether control variables are added or not, the p-values of digital financial inclusion (DF) and commercial bank credit risk (RISK) are significant at 1% level and the coefficients are positive, which further verifies Hypothesis 1 that the development of digital financial inclusion is positively correlated with commercial bank credit risk.

Threshold effect test

In order to further test hypothesis 2, that is, the development of digital inclusive finance has different impacts on commercial bank credit risk at different stages and there is a threshold effect, this study takes digital inclusive finance as a threshold variable to construct a threshold effect model, and the results of the model are shown in Table 4.

Table 4. Test results of single threshold effect

Threshold variables	Threshold type	estimated value	Upper limit	Lower limit	F value	P value	Number of BS
DF	single threshold	2.741	2.968	2.475	47.620	0.000	500

From Table 4, the estimated value of the single-threshold model is 2.741, the upper threshold is 2.968, and the lower threshold is 2.475, which means that the model is divided into three stages by the threshold: (1) <2.475 (2) 2.475-2.968 (3) >2.968, and from the threshold estimation in Table 5, it can be seen that the coefficient of the bank's credit risk is positive when the Digital Financial Inclusion Index is less than or equal to the value of the single-threshold0.425 and is significant at the 1% level, and when the digital inclusion index is greater than the single threshold, the coefficient of bank credit risk is still positive, but the coefficient decreases by 0.188 to 0.237 and is significant at the 1% level. It further indicates that the development of digital financial inclusion has a threshold effect on bank credit risk, and the marginal effect on bank credit risk gradually decreases with the continuous development of digital financial inclusion.

Table 5. Threshold model estimation results

Variable	RISK
DF(threshold value $\leqslant \delta$)	0.425***
	(4.689)
DF(threshold value $> \delta$)	0.237***
	(3.624)
control variable	Control
R2	0.527
individual fixed effect	Control

Note: ***, ***, and ** denote P < 0.01, P < 0.05, and P < 0.1, respectively.

Mediating effect test

To test whether financial disintermediation and inter-bank competition are the transmission channels of digital inclusive finance on the credit risk of commercial banks, this study constructs a mediating effect model, and the model results are shown in Table 6.

Table 6 column (1) shows the baseline regression of digital financial inclusion on credit risk of commercial banks, column (2) expresses the regression results of digital financial inclusion on financial disintermediation index, the coefficient of digital financial inclusion is 0.287, which is significant at 1% level, indicating a positive correlation between digital financial inclusion and financial disintermediation.

Column (3) represents the regression results constructed with the financial disintermediation index as the mediating variable, and the regression coefficient is 0.084. Further referring to the research of Wen et al.(2014), the indirect effect is found to not contain 0 in the 95% confidence interval after testing with the Bootstrap method, indicating that the mediating effect of financial disintermediation is established. The coefficient of digital financial inclusion on credit risk of commercial banks is 0.307, which is significant at 1% level, showing partial mediation effect.

Table 6. Results of mediating effect model

Variable	(1)	(2)	(3)	(4)	(5)
	RISK	FD	RISK	Lerner	RISK
DF	0.359***	0.287***	0.307***	-0.064**	0.335***
	(3.714)	(10.689)	(6.738)	(-2.674)	(3.617)
FD			0.084		
			(0.866)		
Lerner					-2.535***
					(-4.747)
CAP	0.056**	0.087	0.142	-0.098***	-0.003***
	(0.267)	(0.204)	(1.298)	(-2.928)	(-0.876)
NINO	0.003	0.024*	0.004*	-0.049**	0.035**
	(0.004)	(0.010)	(0.007)	(-1.814)	(0.945)
CIR	-0.021	-0.084**	-0.241**	0.043**	0.354*
	(0.007)	(0.006)	(0.025)	(0.014)	(0.219)
ROE	-0.106***	-0.214**	-0.198**	0.484**	0.588**
	(0.018)	(0.047)	(0.053)	(0.623)	(0.873)
NIM	-0.048	-0.081**	-0.097**	0.542	0.374
	(0.092)	(0.124)	(0.294)	(0.264)	(0.287)
ALR	0.035	0.012	0.086	-0.578*	0.747
	(0.054)	(0.044)	(0.073)	(0.870)	(0.087)
LDR	0.004**	0.002*	0.003*	0.110*8	0.071*8
	(0.003)	(0.007)	(0.001)	(0.431)	(0.243)
GDP	0.060	0.024**	0.031**	-0.554*	0.361**
	(0.013)	(0.067)	(0.054)	(0.057)	(0.103)
CPI	-0.050	-0.024*	-0.091*	-0.584*	0.561*
	(0.03)	(0.024)	(0.036)	(0.052)	(0.848)
_cons	1.547	-0.582**	-0.843**	0.884***	0.896***
	(1.642)	(-2.936)	(0.946)	(4.517)	(2.965)
N	588	588	588	588	588
individual fixed effect	Control	Control	Control	Control	Control
R2	0.406	0.247	0.550	0.644	0.502

Note: ***, ***, and ** denote P < 0.01, P < 0.05, and P < 0.1, respectively.

Column (4) Lerner is a negative term indicator, the regression result of digital financial inclusion on bank interbank competition has a coefficient of -0.064, which is significant at the 5% level, indicating that digital financial inclusion is positively related to the degree of bank interbank competition. Column (5) takes bank interbank competition as a mediating variable to further explore the transmission mechanism of digital inclusive finance on commercial banks' credit risk, and the results show that the coefficient of bank interbank competition on commercial banks' credit risk is -2.535 and is significant at the 1% level, presenting a partial mediation effect. Hypothesis 3 was further tested that cross-bank competition and interbank competition play a mediating effect in the process of digital financial inclusion on commercial bank credit risk.

Moderating effect test

In order to further study the moderating role of economic situation and policy uncertainty in the impact of digital inclusive finance on the credit risk of commercial banks, this study uses it as a moderating variable to construct regression, and the regression results are shown in Table 7.

Table 7. Results of the moderating effect model

Variable	(1)	(2)
	RISK	RISK
DF	0.424***	0.288***
	(5.024)	(4.814)
EPU	0.960***	0.971***
	(4.762)	(4.943)
$DF \times EPU$		0.472***
		(4.443)
CAP	0.045**	0.084**
	(0.183)	(0.298)
NINO	0.007	0.005
	(0.002)	(0.001)
CIR	-0.037*	-0.028*
	(0.012)	(0.025)
ROE	-0.285***	-0.368***
	(0.039)	(0.043)
NIM	-0.031	-0.049
	(0.108)	(0.108)
ALR	0.084**	0.064**
	(0.096)	(0.084)

Table 7. Continue. . . . .

LDR	0.019**	0.022**
	(0.008)	(0.013)
GDP	0.027***	0.038***
	(0.037)	(0.044)
CPI	-0.140	-0.290
	(0.043)	(0.051)
_cons	1.961	1.843
	(1.852)	(1.677)
N	588	588
individual fixed effect	Control	Control
R2	0.439	0.494

Note: ***, ***, and ** denote P < 0.01, P < 0.05, and P < 0.1, respectively.

From Table 7, the coefficient of DF × EPU is 0.472 and significant at 1% level, which indicates that the increase in the level of uncertainty about the economic situation and policies increases the degree of impact of digital financial inclusion on the credit risk of commercial banks, further verifying Hypothesis 4.

Robustness test

In order to enhance the credibility of the above results, this paper refers to the research methodology of Wang et al. (2025), which employs lagging of explanatory variables with replacement of the core explanatory variables for robustness testing.

(1) Explanatory variables lagged

In this paper, the data of digital financial inclusion indicators lagged by one period and two periods are used as explanatory variables, and the results of the lag effect test are shown in Table 8.

Table 8 shows that after incorporating the instrumental variables lagged by one period versus two periods of the Digital Inclusion Index into the baseline regression model. The coefficients of digital financial inclusion on commercial bank credit risk remain positive and both are significant at the 1 per cent level. It shows that digital financial inclusion is positively related to the credit risk of commercial banks, which is consistent with the results of the benchmark regression, thus validating the robustness of the research model and results.

Table 8. Results of one/two period lag test

Variable	(1) RISK	(2) lnRISK DF lag one phase	(3) lnRISK DF lag two periods
DF	0.183*** (3.276)		
lnDF		0.157*** (2.399)	
ln2DF			0.104*** (1.682)
control variable	Control	Control	Control
individual fixed effect	Control	Control	Control

Note: ***, ***, and ** denote P < 0.01, P < 0.05, and P < 0.1, respectively.

(2) Replacement of core explanatory variables

In this paper, three sub-variables of digital financial inclusion - breadth of coverage, depth of use and degree of digitization - are used as new explanatory variables to replace the core explanatory variable, digital financial inclusion index, and the test results are shown in Table 9.

Table 9. Replacement of core explanatory variables test results

Variable	(1) RISK	(2) RISK	(3) RISK	(4) RISK
DF	0.183*** (3.276)			
breadth of coverage		0.202*** (3.334)		
depth of use			0.096*** (2.874)	
degree of digitization				0.224*** (3.614)
control variable	Control	Control	Control	Control
individual fixed effect	Control	Control	Control	Control

Note: ***, ***, and ** denote P < 0.01, P < 0.05, and P < 0.1, respectively.

Table 9 shows that after replacing the core explanatory variables, the regression coefficient of digital financial inclusion is still significantly positive, indicating that digital financial inclusion is positively correlated with the credit risk of commercial banks, which is consistent with the results of the benchmark regression, and further verifies that the original model and results are robust.

Conclusions and policy recommendations

This paper examines the potential relationship between digital financial inclusion and commercial banks' row credit risk using panel data of 42 listed commercial banks in China from 2012 to 2024, with the following conclusions:(1) The development of digital financial inclusion enhances the credit risk of commercial banks.(2) The marginal impact on the credit risk of commercial banks decreases as the unpaired Ness of digital financial inclusion enhances.(3) Digital inclusive finance further exacerbates the credit risk of commercial banks through the partial mediation effect of cross-industry competition and peer competition.(4) Economic situation and policy uncertainty play a positive moderating role in the relationship between digital financial inclusion and commercial bank credit risk.

In response to the above conclusions, this paper puts forward the following policy recommendations:

First, to strengthen the risk monitoring and assessment system, the regulator should urge commercial banks to establish a credit risk monitoring system specifically for digital inclusive finance business, use big data, artificial intelligence and other technologies to collect and analyses in real time customers' transaction data, credit records and other information in digital financial scenarios, to identify potential risks in a timely manner. For example, risk early warning models have been established to take early measures for high-risk customers, such as adjusting credit limits and strengthening post-loan management. To improve the credit risk management mechanism, commercial banks themselves should optimize their internal credit risk management processes and clarify the risk responsibilities of each link in the digital inclusive finance business. In the credit approval process, they should strictly review customer qualifications and reasonably determine credit limits; in the post-credit management process, they should strengthen the tracking of the flow of loan funds to prevent the misappropriation of funds and other risks. At the same time, risk mitigation mechanisms are established, such as the introduction of guarantees, insurance and other means to reduce credit risk losses.

Secondly, regulating the order of competition in the financial market: regulators should strengthen their supervision of the financial market, regulate the competitive behaviour of digital inclusive financial institutions and commercial banks, and prevent unfair competition. They should formulate clear market access and exit rules, strengthen compliance review of financial innovation businesses, maintain a fair and orderly market competition environment, and reduce the rise in credit risk caused by excessive competition. Guiding commercial banks to differentiated development, encouraging commercial banks to follow the path of differentiated development based on their own positioning and advantages. For large commercial banks, they can give full play to their financial strength and brand advantages, and moderately participate in digital inclusive financial services while

serving large enterprises and high-end customers; small and medium-sized commercial banks can focus on the local market and distinctive customer groups, and provide personalized and differentiated financial services, avoiding homogeneous competition and reducing credit risks arising from competition.

Thirdly, financial innovation and cooperation should be promoted, and commercial banks and digital inclusive financial institutions should be encouraged to carry out in-depth cooperation and jointly innovate financial products and service models. For example, cooperation in the development of microfinance products based on digital technology, using the technological advantages and customer data advantages of digital inclusive financial institutions, and the capital and risk control advantages of commercial banks, to achieve complementary advantages, to better meet customer needs and improve the efficiency of financial services while reducing risks. Strengthen the cultivation of fintech talents, commercial banks should increase the introduction and training of fintech talents, and improve their employees' understanding of digital inclusive financial services and risk control capabilities. Through internal training and external recruitment, a professional team that understands both financial business and is familiar with digital technology should be created to adapt to the business changes and risk challenges brought about by the development of digital inclusive finance.

Finally, a policy communication and coordination mechanism should be established, and government departments should strengthen communication and coordination in policy formulation to enhance the transparency and stability of policies. When introducing policies involving digital inclusive finance and commercial banks, they should fully consult all parties and conduct policy pre-assessment to reduce the impact of policy uncertainty on the financial market. For example, when monetary policy is adjusted, signals are sent to the market in advance to guide commercial banks to reasonably adjust their credit strategies. To enhance the risk response capacity of commercial banks, commercial banks should strengthen their research and analysis of the macroeconomic situation and policy changes, and establish an early warning mechanism for macroeconomic risks. According to changes in the economic situation and policies, they should adjust their asset-liability structure and credit investment strategies in a timely manner, improve their ability to respond to macroeconomic fluctuations and policy uncertainties, and reduce the impact of changes in the external environment on credit risk.

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