Research on Digital Finance, Financial Regulation and Commercial Bank Risk-taking

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Abstract:
This paper selects the data of 160 commercial banks in China from 2015 to 2023, and empirically analyzes the impacts and mechanisms of digital finance and financial regulation on commercial banks' risk-taking by using a systematic GMM model. It is found that digital finance increases the level of commercial bank risk-taking, and the effect is more significant for smaller banks. In addition, increasing the intensity of financial regulation inhibits the effect of digital finance on the level of commercial bank risk-taking. The findings of this paper have certain reference value for commercial banks in the context of the rapid development of digital finance how to more effective risk management and financial regulators how to better prevent and control systemic risk, commercial banks should continue to enhance their own competitiveness, and financial regulators should maintain the sound operation of the banking industry to prevent the occurrence of systemic risk.

Keywords:
Digital finance; Financial regulation; Risk-taking

1.Introduction

With the continuous innovation and wide application of digital technologies such as big data, artificial intelligence and cloud computing, China's digital finance has developed rapidly, enhancing the convenience, accessibility and universality of financial services. At present, digital financial services such as third-party payment, mobile payment and Internet wealth management have basically covered the credit, loans and other important financial services of China's commercial banks, and changed the original competitive pattern of commercial banks. On the one hand, digital finance has a complementary relationship with the traditional financial system, and on the other hand, it also has a substitution effect on the traditional financial system, bringing opportunities and challenges for the transformation and development of commercial banks.

Commercial banks occupy a dominant position in China's financial system, and changes in the level of risk-taking in the banking sector in the context of the development of digital finance also have a great impact on the stability of the financial system. At the same time, the adjustment of the level of financial regulation will also play a role in the level of bank risk-taking under the new competition pattern. Therefore, in the

context of the rapid development of digital finance, it is of great significance to study the impact of digital finance and financial regulation on the risk-taking of commercial banks to maintain the smooth development of the financial system. This paper selects the data of 160 commercial banks in China from 2015 to 2023 and empirically investigates the impact of digital finance and financial regulation on commercial bank risk-taking by using the systematic GMM estimation method, and empirically examines the mechanism of action.

2.Theoretical analysis and research hypothesis

2.1 Digital Finance and Commercial Bank Risk Taking

Scholars have analyzed the impact of digital finance on commercial banks' risk taking from different aspects. On the one hand, it has been found that the development of digital finance will reduce the level of commercial bank risk-taking, and the traditional risk control model currently used by commercial banks and the credit data of the central bank have already controlled the risk more effectively, and on this basis, with the advantage of big data of digital finance, the big data information on consumer behavior accumulated by customers on the Internet is used to replace the original information on collateral assets, financial data, and credit information, so that the risk level of customers can be identified more accurately and reduce the information asymmetry between borrowers and lenders, thus improving the bank's risk identification ability. accurately identify the customer's risk level and reduce the information asymmetry between the borrowing and lending parties, thus improving the bank's risk identification ability (Berg, et al., 2019; Pérez-Martín, et al., 2018), and effectively realizing the ex ante risk prevention management (Sheng Tianxiang and Fan Lian, 2020). In addition, the development of digital finance has changed the traditional business model, banks use big data analysis technology for risk monitoring and early warning, and arrive at specific solutions for different risk categories, which improves the level of risk management of commercial banks, realizes the closed loop of risk management in the midst of the incident and after the incident (Li, et al., 2022), and innovates and improves the risk compliance management system of commercial banks. The long-tail effect of new technology makes it easier to meet the personalized needs of customers and obtain feedback, increases customer stickiness and word-of-mouth effect, reduces the cost of information search for small and micro-customers, and the cost of preparation and maintenance of offline outlets, which improves the operational efficiency of commercial banks and their risk-bearing capacity, and effectively reduces the risk of bankruptcy of commercial banks (Delis and Kouretas, 2011).

On the other hand, many scholars believe that the development of digital finance will, on the contrary, increase the level of risk-taking by commercial banks. Theoretically, digital finance greatly satisfies the investment needs of long-tail customers and some bank deposits and wealth management customers with convenient operation methods and higher capital returns, raising the cost of liabilities for banks and thus increasing the level of risk-taking to compensate for the narrowing of spreads. Small and medium-sized banks are in a weaker position, and their liability costs are elevated even higher, resulting in aggressive behavior in high-risk projects. On the asset side of commercial banks, digital finance utilizes big data, cloud computing and other technologies to form more efficient and accurate credit risk control standards, which have obvious advantages over traditional manual approval by banks, and commercial banks have responded to the impact by expanding their product audience, relaxing their approval conditions, and enhancing their risk-taking. Small

and medium-sized banks' core business on the asset side has been hit more drastically, thus increasing their risk tolerance higher. Established studies have also empirically verified the impact in this regard, arguing that digital finance is mainly an innovation in technology, channels and transaction methods, which does not change the essence of finance, but instead brings risks at the technical level due to information security issues (Fang Yi et al., 2020; Gabor and Brooks, 2017). Yu Weifeng and Zhou Dai (2018) found that Internet finance has intensified market competition in the banking sector by using its channel and information advantages, thus boosting banks' risk-taking behavior and increasing their risk-taking. Qiu Han et al. (2018) found that fintech promoted interest rate marketization, making banks more dependent on interbank liabilities, and in order to compensate for the rise in the cost of the liability side, banks have elevated preferences for risky assets, increasing their risk-taking. In addition, digital finance increases banks' risk-taking by raising their administrative costs and increasing competition from small and medium-sized banks.

This leads to the hypothesis formulated in this paper:

H1: The development of digital finance has increased the level of risk-taking in commercial banks.

2.2 Heterogeneity of digital finance on commercial bank risk-taking

In addition to this, the risk-taking behavior of different types of commercial banks reacts differently in the face of digital financial shocks. Compared with local commercial banks, large state-owned banks and national joint-stock commercial banks have large asset sizes, stronger risk management capabilities, and lower customer default risks. Local commercial banks, on the other hand, have an imperfect financial service infrastructure and a lower degree of financial business diversification, and the introduction of digital technology can optimize the service process and improve operational efficiency for small commercial banks, thus enhancing risk management capabilities. The study of Yu Jingwen and Wu Binyang (2021) points out that the impact of digital financial development on state-owned commercial banks is relatively small, and that banks are able to expand new business channels, optimize the revenue structure, and improve the level of bank performance through the use of digital technology. But on the other hand, small commercial banks

This leads to the following hypotheses in this paper:

H2: Heterogeneity in the impact of digital financial development on the level of risk-taking in commercial banks.

2.3 Analysis of the moderating role of financial regulation

On the one hand, digital finance affects the risk-taking level of commercial banks through their operational efficiency, risk management, management costs, and income structure; on the other hand, digital finance promotes the interest rate marketization reform, which makes the banking industry more competitive and profit margins are compressed, forcing commercial banks to take the initiative to broaden their profit channels and engage in diversified businesses, in which commercial banks, through the diversification of their assets, are able to reduce the level of risk-taking. and reduce the level of risk-taking.

Against the backdrop of digital transformation, competition in the banking sector has intensified, and commercial banks are generally engaged in financial innovation business; the development of digital finance has

shortened the development cycle of financial products, which will increase the level of risk-taking by banks. While providing convenience, digital finance also poses a severe test for regulators. Larger commercial banks have an important impact on the stability of the banking industry and even the financial sector, regulators are more stringent on large banks, there are stricter regulatory requirements for systemically important banks, higher capital requirements are conducive to improving the level of risk management of banks (Berger & Di Patti ,2006), and small and medium-sized banks have a more lenient regulatory environment. In addition, financial regulation has standardized the terms and conditions of digital financial products to match product yields with risk levels, reducing the impact on small and medium-sized banks.

The intervention of financial regulation can improve the level of bank risk management and promote banks to conduct prudent operation, and also guide the healthy development of digital finance, the prudential supervision of the state can guide commercial banks to rationally use digital technology and inhibit the generation of new types of risks.

This leads to the following hypotheses in this paper:

H3: Financial regulation can dampen the enhancing effect of digital finance on commercial bank risk-taking.

3.Empirical analysis

3.1 Study design

3.1.1 Model setup

(1) Baseline regression model

In order to test the proposed hypotheses and examine the impact of digital finance on commercial banks' risk taking, this paper sets up the following dynamic panel model:

$$Risk_{it} = \alpha_0 + \alpha_1 Risk_{it-1} + \alpha_2 DFI_{it} + \alpha_3 control_{it} + \mu_t + \lambda_i + \varepsilon_{it}$$

Where the explanatory variable $Risk_{it}$ is the level of risk taking of the ith bank in period t, the explanatory variable $Risk_{it-1}$ is the risk-taking level of commercial banks in the previous period, the explanatory variable DFI_{it} is the level of digital financial development, and λ_i denotes the control variables, the λ_i and μ_t denote control area and time fixed effects, respectively, and ε_{it} denotes the random error term.

(2) Moderating effect test model

In order to further test the moderating effect of financial regulation on the relationship between digital finance and commercial bank risk-taking, and to verify how the impact of digital finance on commercial bank risk-taking varies with changes in financial regulation, the cross-multiplier terms of digital finance and regional financial regulatory intensity are introduced on the basis of the benchmark regression model, and the

model is constructed as follows:

$$Risk_{it} = \beta_0 + \beta_1 Risk_{it-1} + \beta_2 DFI_{it} + \beta_3 FSE_{it} + \beta_4 DFI_{it} \times FSE_{it} + \beta_5 control_{it} + \mu_t + \lambda_i + \varepsilon_{it}$$

3.1.2 Selection of variables

(1) Explained Variables

Existing studies on the measurement of commercial bank risk-taking generally use the non-performing loan ratio, Z-value and risk-weighted asset ratio to express. Among them, the NPL ratio reflects the credit risk of commercial banks, the Z-value is mainly used to measure the bankruptcy risk of commercial banks, and the risk-weighted asset ratio measures the proportion of high-risk assets of commercial banks, which can reflect the overall level of risk-taking of banks. In this paper, risk-weighted asset ratio is used as a variable of commercial bank risk-taking, while NPL ratio and Z-value are used as alternative variables of risk-taking in the robustness test.

(2) Explanatory variables

Regarding the indicators for measuring the development of digital finance in China, the most widely used in existing studies is the research results of the Digital Finance Research Center of Peking University, in addition to the construction of the index using the text mining method and using the scale of third-party payment as a proxy variable. This paper adopts the digital financial development index of the Digital Finance Research Center of Peking University (Guo Feng et al., 2020) as a proxy for the explanatory variables, and conducts empirical studies using provincial-level data of the digital financial inclusion index, digital financial coverage breadth index, digital financial use depth index, and digitization degree index, respectively.

(3) Control variables

Considering the influence of bank micro factors and macroeconomic factors on the regression results, and drawing on existing related studies (Li Shuangjian and Tian Guoqiang, 2020, etc.), this paper selects control variables affecting the risk-taking level of commercial banks from the micro level of commercial banks and the level of the country's macroeconomic development, respectively, including the asset size, capital adequacy ratio, cost-income ratio, return on assets, and GDP growth rate.

(4) Moderating variables

Drawing on existing studies (Tang Song et al., 2020; Gu Haifeng and Gao Shuiwen, 2022), this paper constructs an indicator of regional financial regulatory intensity to serve as a moderating variable, and selects the logarithm of the regional financial regulatory expenditures as a measure to indicate the corresponding level of regional financial regulatory expenditures.

The definitions and calculations of specific variables are shown in Table 1.

Table 1 Definition of variables

Variable type	variable symbol	variable name	Description and calculation methods
Commercial bank risk-taking	RA	Risk-weighted asset ratio	Risk-weighted assets/total assets
	NPL	non-performing loan ratio	Non-performing loan balance/total loans
	Z	Insolvency risk	ROA standard deviation / (ROA + EA)
Level of development of digital finance	DFI	Digital Inclusive Finance Index	Peking University Digital Inclusive Finance Index
moderator variable	FSE	Financial regulatory intensity	Expenditures on provincial financial regulation in logarithmic terms
control variable	Size	asset size	Total bank assets taken in logarithms
	CAR	capital adequacy ratio	Total capitalization/risk-weighted assets
	CIR	Cost-to-income ratio	Operating costs/operating income
	ROA	return on assets	Net profit/total assets
	GDPgrowth	GDP growth rate	GDP growth rate

3.1.3 Descriptive statistics

The descriptive statistics of the model variables are shown in Table 2.

Table 2 Descriptive statistics of variables

variable name	average value	(statistics) standard deviation	minimum value	maximum values
RA	0.670	0.423	0.389	0.861
NPL	1.627	1.025	0.232	7.506
Z	150.2	156.9	120.5	171.3
DFI	2.773	1.806	0.335	5.092
FSE	0.008	0.008	0.001	0.039
Size	20.92	1.509	19.02	25.19
CAR	13.24	2.353	5.106	23.05
CIR	0.159	0.330	0.128	0.213
ROA	0.897	0.382	0.034	2.053
GDPgrowth	6.709	2.021	2.312	9.501

3.2 Empirical analysis

3.2.1 Analysis of the impact of digital finance on commercial banks' risk-taking

Table 3 shows the results of the empirical test of the impact of the level of digital financial development on the risk-taking of commercial banks, considering that the level of risk in the previous period will have an impact on the risk-taking of commercial banks in the current period, the lagged one period of the explanatory variables is added as an explanatory variable in the model, and the empirical analysis is carried out by using the GMM method.

Table 3 Digital Finance and Commercial Bank Risk Taking

	RA			
	(1)	(2)	(3)	(4)
L.RA	0.465***	0.425***	0.046***	0.050***
	(0.036)	(0.006)	(0.006)	(0.007)
DFI	0.056***			
	(0.002)			
Breadth		0.069***		
		(0.003)		
Depth			-0.037***	
			(0.004)	
Digital				-0.033***
				(0.003)
control variable	Yes	Yes	Yes	Yes
_cons	0.368***	0.069***	0.079***	0.072***
	(0.005)	(0.004)	(0.006)	(0.012)
time fixed effect	Yes	Yes	Yes	Yes
individual fixed effect	Yes	Yes	Yes	Yes
AR(1)	0.046	0.029	0.021	0.003
AR(2)	0.569	0.649	0.587	0.531
Sargan Test	0.697	0.783	0.712	0.796
N	1026	1026	1026	1026

Note: The data in the upper row of results for each variable are regression coefficients and the data in the lower row are standard errors. ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively.

Column (1) is regressed using the composite index of digital financial development as the main explanatory variable, and the results show that the regression coefficient is significantly positive at the 1% level, indicating that digital financial development is significantly and positively correlated with the risk-weighted asset ratios of commercial banks, and that digital financial development significantly enhances the risk-taking behavior of commercial banks. Columns (2)-(4) further conduct regression analysis for the breadth of coverage, depth of use and degree of digitization of digital financial development, respectively, and the results show that the enhancement of breadth of coverage significantly enhances commercial bank risk-taking, while the enhancement of depth of use and degree of digitization reduces the level of risk of commercial banks, which may be attributed to the fact that the use of digital technologies, such as big data, can enhance the risk management capabilities of commercial banks, and thereby reducing the level of bank risk taking.

To further investigate whether the impact of digital financial development on commercial banks' risk-taking

has a heterogeneous effect depending on bank type, Table 4 further categorizes commercial banks into state-owned and joint-stock banks, urban commercial banks and rural commercial banks for heterogeneity tests respectively.

Table 4 Heterogeneity analysis of risk taking in digital finance and commercial banks

	RA							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L.RA	0.369***	0.343**	0.362***	0.316***	0.243***	0.350***	0.053***	0.426***
	(0.029)	(0.036)	(0.067)	(0.091)	(0.049)	(0.087)	(0.012)	(0.032)
DFI	-0.504***	1.801*						
	(0.069)	(0.902)						
Breadth			-0.066*	0.204**				
			(0.035)	(0.099)				
Depth					-0.250***	0.151***		
					(0.009)	(0.070)		
Digital							0.034***	0.881***
							(0.002)	(0.391)
control variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
_cons	0.233***	0.261***	0.108	0.190	0.969	0.891	0.524***	0.342***
	(0.051)	(0.032)	(0.100)	(0.130)	(0.731)	(0.623)	(0.190)	(0.162)
time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
individual fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AR(1)	0.023	0.008	0.019	0.036	0.024	0.002	0.030	0.021
AR(2)	0.344	0.214	0.628	0.396	0.657	0.625	0.287	0.356
Sargan Test	0.782	0.345	0.213	0.298	0.689	0.619	0.381	0.325
N	160	866	160	866	160	866	160	866

As can be seen from the regression results, different types of banks show significant heterogeneity in risk-taking behavior under digital financial development, and overall, the total index of digital financial development will reduce the risk-taking level of large state-owned banks and joint-stock commercial banks, but it will raise the risk level of city commercial banks and agricultural commercial banks, which may be due to the fact that the digital financial development has raised the level of competition in the banking industry, forcing small and medium-sized commercial banks to seek more profitable channels outside traditional businesses and diversify their businesses, which are generally more risky, so local commercial banks will go through a stage of increased risk level in the process of digital transformation, while large commercial banks are in a more advantageous position in the competition.

3.2.2 Analysis of the moderating effects of financial regulation

In order to further examine the moderating effect of financial regulation on the relationship between digital finance and commercial bank risk-taking behavior, this paper carries out empirical regression analysis on the moderating effect test model, and the regression results are shown in Table 5. As can be seen from the regression results, the increase in the intensity of financial regulation can significantly reduce the level of commercial bank risk-taking, and the regression coefficient of the cross-multiplication term of the indicators of

digital finance and the intensity of financial regulation is significant, with the opposite sign of the coefficient when considering the level of development of digital finance alone, and at the same time the role is more pronounced, which indicates that the enhancement of the intensity of local financial regulation can significantly constrain the risk-taking behavior of commercial banks.

Table 5 Digital Finance, Financial Regulation and Commercial Bank Risk Taking

	RA			
	(1)	(2)	(3)	(4)
L.RA	0.402***	0.542***	0.362***	0.583***
	(0.055)	(0.068)	(0.137)	(0.069)
DFI	0.314***			
	(0.040)			
Breadth		0.469***		
		(0.043)		
Depth			-0.490***	
			(0.031)	
Digital				-0.636***
				(0.035)
FSE	-4.326***	-3.261***	-5.648***	-7.359***
	(0.161)	(1.301)	(2.031)	(2.168)
DFI*FSE	-1.269***			
	(0.516)			
Breadth*FSE		-1.607***		
		(0.265)		
Depth*FSE			-2.943***	
			(1.003)	
Digital*FSE				-3.682***
				(1.610)
control variable	Yes	Yes	Yes	Yes
_cons	0.316***	0.835***	0.591***	0.613***
	(0.053)	(0.059)	(0.070)	(0.070)
time fixed effect	Yes	Yes	Yes	Yes
individual fixed effect	Yes	Yes	Yes	Yes
AR(1)	0.009	0.010	0.001	0.002
AR(2)	0.268	0.368	0.519	0.459
Sargan Test	0.361	0.462	0.625	0.731
N	1026	1026	1026	1026

3.2.3 Robustness Tests

(1) Endogeneity test

In order to alleviate the endogeneity problem caused by reverse causality, this paper re-regresses the core explanatory variables one period after on the basis of the benchmark regression model, and the regression results are shown in Table 6, and for the purpose of altering the conclusions of the benchmark regression, the lagged one period of the total index of digital financial development, the breadth of coverage, the depth of use, and the degree of digitization will still have a significant positive impact on the risk-taking behavior of commercial banks.

Table 6 Endogeneity test

	RA			
	(1)	(2)	(3)	(4)
L.RA	0.468***	0.435***	0.069***	0.053***
	(0.038)	(0.006)	(0.007)	(0.007)
L.DFI	0.927***			
	(0.059)			
L.Breadth		0.856***		
		(0.047)		
L.Depth			-0.960***	
			(0.063)	
L.Digital				-0.420***
				(0.024)
control variable	Yes	Yes	Yes	Yes
_cons	0.593***	0.760***	0.039***	0.064***
	(0.040)	(0.053)	(0.073)	(0.024)
time fixed effect	Yes	Yes	Yes	Yes
individual fixed effect	Yes	Yes	Yes	Yes
AR(1)	0.001	0.001	0.001	0.001
AR(2)	0.691	0.657	0.631	0.665
Sargan Test	0.875	0.886	0.853	0.812
N	1026	1026	1026	1026

(2) Replacement of explanatory variables

To further test the robustness of the regression results, this part replaces the explanatory variables risk-weighted asset ratio with the non-performing loan ratio and the Z-value of bankruptcy risk of commercial banks, and the regression results are shown in Table 7. The findings are consistent with the benchmark regression results, indicating that the results of the benchmark model study in this paper are robust and reliable.

Table 7 Non-performing loan ratio and insolvency risk

	NPL			
	(1)	(2)	(3)	(4)
L.NPL	0.709***	0.779***	0.724***	0.763***
	(0.196)	(0.169)	(0.265)	(0.213)
DFI	0.460***			
	(0.088)			
Breadth		0.199***		
		(0.045)		
Depth			-0.769***	
			(0.226)	
Digital				-0.801***
				(0.294)
	Z			
	(1)	(2)	(3)	(4)
L.Z	0.296***	0.258***	0.169***	0.163***
	(0.005)	(0.003)	(0.004)	(0.007)
DFI	-22.69***			
	(6.381)			
Breadth		-28.13***		
		(5.971)		

Depth			56.13*** (10.64)	
Digital				26.19*** (5.640)

4. Conclusions and policy recommendations

This paper selects the data of 160 commercial banks in China from 2015 to 2023, and empirically analyzes the impact of digital finance on the risk-taking behavior of commercial banks using a systematic GMM dynamic panel model, and investigates the moderating effect generated by regional financial regulation. The results of the study show that the development of digital finance enhances the level of commercial bank risk-taking and presents significant heterogeneity among different types of banks, while the enhancement of regional financial regulation effectively inhibits this enhancement.

Based on the above findings, the following suggestions are made: first, under the development of digital finance, commercial banks should actively carry out digital transformation, broaden profit channels, implement diversified business strategies, improve risk management capabilities, and cope with the competition in the banking industry. Second, local financial regulators should strengthen the supervision of the application of digital technology in commercial banks, actively utilize digital technology for risk control and early warning, and establish a sound digital financial regulatory system, especially for small and medium-sized commercial banks with higher volatility and weaker risk response ability, local financial regulators should strengthen risk control, maintain sound operation of the banking industry, and prevent the emergence of systemic risks.

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