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The impact of bank efficiency on risk management in Chinese commercial banks

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Abstract. Based on macroeconomic data and commercial bank data in China from 2007 to 2022, this paper analyzes whether the cost efficiency and profit efficiency of commercial banks influence their risk management behavior. The findings indicate the following: banks with better cost efficiency tend to restrain the impulse for risk expansion induced by loose monetary policies, whereas high profit efficiency incentivizes commercial banks to pursue high returns from high-risk activities, leading to an increase in risk-taking levels. Moreover, when the capital adequacy ratio is high, the restrictive effect of high cost efficiency on risk management decreases, while the stimulating effect of high profit efficiency becomes more pronounced.

Keywords: commercial banks, risk management, efficiency, macroeconomic policy

1. Introduction

As one of the core components of China's financial system, commercial banks play a crucial role in financial markets due to the vast amount of assets they hold. According to data from the China Banking and Insurance Regulatory Commission (CBIRC), the total assets of Chinese commercial banks have been continuously expanding from 2017 to 2022. By 2022, the total assets of China's commercial banks had reached 379.4 trillion yuan, with an annual growth rate exceeding 10% for two consecutive years. However, alongside this rapid expansion, risks have also emerged. The balance of non-performing loans has been increasing year by year, with a particularly sharp rise of 18.72% in 2019. Consequently, risk management in commercial banks faces significant challenges.

As a key pillar of China's financial system, commercial banks' risk management is essential for maintaining financial stability. With the continuous development and innovation of financial markets, commercial banks are exposed to growing risks. If these risks are not effectively managed, they may lead to financial instability or even financial crises. Therefore, the importance of commercial bank risk management cannot be overlooked. Studying the characteristics of commercial bank risk management and analyzing its influencing factors can help mitigate risk-taking behaviors and establish a sound risk management framework. This would enable commercial banks to identify, assess, and manage various types of risks, detect potential risks at an early stage, and implement corresponding measures. On the one hand, this approach effectively safeguards depositors' legitimate rights and interests; on the other hand, it prevents risk contagion and systemic risk escalation, thereby enhancing overall financial stability.

2. Literature review and research hypotheses

Commercial banks play a central role in the financial system by managing risk and providing credit. Their level of risk-taking is significantly influenced by national macroeconomic policies. Due to their credit intermediary function, commercial banks are highly responsive to monetary policy, which affects both their risk-taking behavior and operational efficiency. For example, during economic downturns, central banks may adopt expansionary monetary policies to increase market liquidity, impacting commercial banks in multiple ways. On the one hand, increased cash flow among businesses and individuals can support struggling enterprises, drive growth and profitability, and improve financial conditions. However, this signal may also lead banks to underestimate default risks, relax lending standards, and ultimately increase the non-performing loan (NPL) ratio. Additionally, optimistic economic expectations may reduce banks' sensitivity to risk, increasing their tolerance for higher risk exposure. On the other hand, expansionary monetary policies tend to lower banks' returns, which conflicts with their fixed financing costs. To maintain profitability, banks may respond by investing in higher-risk assets, thereby raising their overall risk exposure. Chinese scholars

have conducted extensive research on the impact of monetary policy on bank risk-taking. Zhang Qiang et al. (2013) found that expansionary monetary policies significantly increased the risk-taking behavior of Chinese banks, using the NPL ratio as the dependent variable to validate the robustness of their model [1]. Wang Jinbin and Li Bo (2017) also supported the conclusion that loose monetary policies encourage banks to take on more risk [2]. Other studies have explored the factors influencing this relationship. For instance, Tang Wenjin and Huang Ling (2021) pointed out that intensified banking competition enhances the transmission efficiency of risk-taking channels. They found that structural monetary policies primarily influence risk-taking through large banks and that this effect is more pronounced in regions with faster economic growth [3]. From the above literature, it is evident that the prevailing academic consensus suggests that expansionary monetary policy tends to increase the risk-taking levels of commercial banks, and this effect is significant. Therefore, this study examines how bank efficiency influences risk management behavior from the perspective of macroeconomic policy.

The relationship between bank efficiency and risk-taking has been widely studied, but existing findings remain inconclusive. Some scholars suggest a positive correlation, while others propose a non-linear relationship. For example, Ye Shiliang (2015) conducted an empirical study and found that bank efficiency is positively correlated with risk-taking, indicating that a moderate increase in risk-taking can enhance bank efficiency [4]. However, Tan Zhengxun and Li Lifang (2016) argued that the impact of bank risk-taking on efficiency is not linear but follows an inverted U-shaped relationship. They also examined how monetary policy influences bank efficiency through risk-taking channels [5]. Similarly, Zhou Jing and Tao Shigui (2019), from the perspective of structural monetary policy, highlighted that policy tools can affect both bank risk-taking and efficiency. They found that the impact of risk-taking on profit efficiency is also non-linear, following an inverted U-shape [6]. Moreover, Yu Jingjing et al. (2019) pointed out that market competition influences bank efficiency and risk behavior by affecting risk-taking levels. Their findings suggest that competition can constrain high-risk banks while enhancing efficiency for low-risk banks [7]. These studies have significantly contributed to the understanding of the relationship between bank risk-taking and efficiency, providing a solid theoretical foundation for further research in this paper

Building on the above literature review, it is evident that academia has already established the significant impact of monetary policy on commercial bank risk management. Generally, expansionary monetary policies lead to increased risk-taking by commercial banks, and this effect may be realized through multiple transmission channels. Furthermore, risk and efficiency—two critical aspects of commercial bank operations—share a complex relationship. Existing research primarily focuses on how risk-taking or monetary policy influences bank efficiency. Some scholars have also attempted to analyze how certain bank characteristics affect risk management responses to monetary policy changes using moderation effect models. For example, previous studies have suggested that variables such as capital adequacy ratio may influence how monetary policy affects commercial bank risk-taking. However, few studies have examined whether differences in cost efficiency and profit efficiency lead to varying levels of risk-taking among commercial banks when facing the same monetary policy. This paper introduces bank efficiency as a moderating variable in the relationship between monetary policy and risk-taking, aiming to further explore this dimension.

The research framework is inspired by Tan Zhengxun and Li Lifang, who briefly analyzed the impact of cost and profit efficiency on banks' risk-taking behavior. Their findings suggest that cost efficiency negatively affects risk-taking, whereas profit efficiency has a positive effect. They attributed these effects to the "bad management" hypothesis and the "high-risk, high-return" hypothesis. Building on their work, this study takes a broader perspective, arguing that the relationship between bank efficiency and risk-taking is not limited to how risk-taking influences efficiency. Rather, efficiency itself may also shape banks' risk management behavior. This paper analyzes the mechanisms through which efficiency moderates the impact of monetary policy on risk-taking. Since previous studies have suggested that risk-taking can serve as a mediating channel affecting bank efficiency, it would not be appropriate to approach this issue solely from a mediation effect perspective. Instead, considering that prior research has examined capital adequacy as a moderating factor in the transmission of monetary policy effects on bank risk-taking, this study investigates whether efficiency plays a similar moderating role. From the perspective of cost efficiency, this metric reflects the proportion of inputs that contribute to output. High-cost efficiency implies a lower proportion of non-performing assets, such as loan impairment provisions or bad debt reserves. Consequently, when commercial banks have an incentive to expand their risk exposure, higher cost efficiency may act as a constraint, limiting excessive risk-taking. On the other hand, profit efficiency measures a bank's ability to maximize its output from available resources. Higher profit efficiency indicates that a bank can fully utilize its resources, and the pursuit of profits may lead banks to prioritize high returns over potential future losses. As a result, higher profit efficiency may incentivize banks to take on greater risk. By incorporating efficiency as a moderating variable, this study aims to provide a deeper understanding of how commercial banks' efficiency levels influence the relationship between monetary policy and risk-taking behavior, filling a gap in the existing literature.

Based on the above analysis, this study proposes the following hypotheses:

Hypothesis 1: High-cost efficiency in commercial banks can effectively curb the increase in risk-taking induced by expansionary monetary policy. Conversely, high profit efficiency will amplify the increase in risk-taking triggered by expansionary monetary policy.

Beyond efficiency, this study acknowledges that cost efficiency and profit efficiency are not the sole determinants of commercial banks' risk management behavior. As discussed earlier, while efficiency influences banks' risk management decisions, other factors may either strengthen or weaken this effect. One such factor is the capital adequacy ratio. When a commercial bank has a high capital adequacy ratio, it possesses greater resilience against future risks. Under such conditions, the restrictive effect

of high-cost efficiency on risk management may diminish, while the incentivizing effect of high profit efficiency may become more pronounced.

Hypothesis 2: Other factors influence the role of commercial bank efficiency in risk management. Specifically, when the capital adequacy ratio is high, the restrictive effect of high-cost efficiency on risk management may weaken, while the incentivizing effect of high profit efficiency may strengthen.

3. Data and empirical design

This paper collects micro-level data from Chinese commercial banks and macro-level monetary policy data, sourced from the Bank Focus, Wind, and CCER databases. The bank data has been processed to remove samples with excessive missing values, ultimately covering 142 Chinese banks.

The primary focus of this paper is to examine how bank efficiency influences the changes in commercial banks' risk-taking levels in response to monetary policy. Therefore, four key categories of data are required: dependent variables (risk indicators), monetary policy variables, control variables, and efficiency variables (derived through factor analysis). Specifically:

(1) Selection of dependent variables: The indicators used to measure the risk management status of commercial banks vary across different studies. Based on previous research, the main indicators include: The Z-score (Xu Mingdong and Chen Xuebin, 2012[8]), which measures bankruptcy risk. However, considering that Chinese commercial banks often benefit from implicit government guarantees, the actual probability of bankruptcy is relatively low, so this indicator was not adopted. Another common indicator is the ratio of risk-weighted assets to total assets of commercial banks (Jiang Shuxia and Chen Yuchan, 2012[9]), which is calculated by dividing equity capital by the capital adequacy ratio. However, this indicator does not effectively reflect the risk management level of commercial banks. Referring to Yu Jingjing (2019), this paper adopts the loan impairment status as the measure of commercial banks' risk management and uses the non-performing loan (NPL) ratio as the relevant indicator for robustness testing [5]. (2) Selection of monetary policy variables: Following the approach of previous studies, this paper selects M2 (log-transformed in empirical analysis) as the proxy variable for monetary policy. (3) Selection of control variables: The control variables in the model include micro-level data at the bank level, such as the return on assets (ROA), equity capital, total assets, and cost-to-income ratio of commercial banks. Additionally, macroeconomic variables are introduced, considering that the degree of risk-taking and efficiency levels of commercial banks are closely linked to the economic cycle. Therefore, GDP growth rate and inflation rate (e.g., CPI) are incorporated as macroeconomic variables. (4) The relevant factors used to measure efficiency will be introduced in the next section.

The variable descriptions are shown in Table 1:

Table 1. Variable description

Variable Types	Variable Names	Variable Abbreviation	Variable Description	Data Source
Dependent Variable	Loan Impairment Loss Rate	Suntosum	Loan Impairment Loss / Total Loans	BankFocus
Independent Variable	Broad Money Supply	lnM2	Logarithm of M2	Public Information
Moderating Variable	Cost Efficiency	cost_eff_a11	Theoretical Minimum Cost Relative to Actual Cost	Independent Calculation
	Profit Efficiency	profit_eff_a11	Actual Profit Relative to Theoretical Maximum Profit	Independent Calculation
Control Variables	Consumer Price Index	cpi	Consumer Price Index	BankFocus
	GDP Growth Rate	gdpgr	Annual GDP Growth Rate	BankFocus
	Cost-to-Income Ratio	ctr	Total Expenditure / Total Income	BankFocus
	Equity Capital	LnE	Logarithm of Equity Capital	BankFocus
	Return on Assets	ROA	Return on Assets	BankFocus
	Total Assets	lnASSET	Logarithm of Total Assets	BankFocus

The descriptive statistics are shown in Table 2:

Table 2. Descriptive statistics

VARIABLES	N	mean	sd	min	max
cpi	2,400	102.6	1.615	99.30	105.9
gdpgr	2,400	0.112	0.0528	0.0300	0.230
lnE	1,858	14.27	1.504	11.39	19.10
cost_eff_a11	731	0.425	0.0819	0.205	0.642
profit_eff_a11	730	0.731	0.223	0.0136	0.987
suntosum	1,808	0.00958	0.00694	-0.0254	0.0725
lnM2	2,400	13.95	0.567	12.86	14.73
lnasset	1,858	16.81	1.604	13.49	21.57
ctr	1,858	0.435	0.156	0	1.640
roa	1,857	984,150	497,780	-323,784	3.078e+06

4. Empirical analysis

4.1. Moderating effect model

Based on the analysis above, this paper establishes the following moderating effect model:

$$risk_{it} = \alpha_0 + \alpha_1 lnM2_{it} + \beta X_{it} + \varepsilon_{it} \quad (1)$$

$$risk_{it} = \alpha_0 + \alpha_1 lnM2_{it} + \alpha_2 CE_{it} + \alpha_3 CE_{it} * lnM2_{it} + \beta X_{it} + \varepsilon_{it} \quad (2)$$

$$risk_{it} = \alpha_0 + \alpha_1 lnM2_{it} + \alpha_2 PE_{it} + \alpha_3 PE_{it} * lnM2_{it} + \beta X_{it} + \varepsilon_{it} \quad (3)$$

The equation above is used to further verify the impact of monetary policy on the risks faced by commercial banks in the updated dataset. The equation below is used to verify the moderating effect of commercial banks' risk-free efficiency on the changes in risk-taking choices triggered by monetary policy. Initially, this paper refers to the approach of Yu Jingjing et al. (2019), temporarily using a panel fixed-effect model to explore the general relationships between the variables [7].

4.2. Efficiency calculation of commercial banks

This paper follows the main methods from existing literature, selecting the stochastic frontier approach in parameter estimation to measure the cost efficiency of commercial banks. In this context, we approximate the cost efficiency of commercial banks as the ratio of theoretical minimum cost to actual cost. Similarly, profit efficiency is understood as the ratio of actual output to theoretical maximum output. Next, we need to determine the factors for calculating efficiency. Only by accurately describing the inputs and outputs of commercial banks and selecting appropriate factors can the efficiency calculation be more effective. Therefore, based on the experience from previous literature, this paper selects the prices of loanable funds, labor, and fixed assets as input factors, and loan balance, other profitable assets, and non-interest income as output factors. It is important to note that the purpose of this paper is to study the moderating role of bank efficiency in the impact of monetary policy on the risk management of commercial banks. Therefore, when calculating, we aim to exclude risk-related factors from the efficiency calculations to a certain extent. Referring to the approach of Tan Zhengxun and Li Lifang, the total loans were replaced with net loans by subtracting non-performing loans. The specific factors are shown in Table 3 below:

Table 3. Factor description

Indicator Type	Symbol	Indicator Meaning	Indicator Calculation
Input	w1	Price of loanable funds	Interest expenses on deposits / Average balance of deposits
	w2	Labor cost price	Personnel expenses / Total assets
	w3	Price of fixed assets	Non-interest expenses / Total fixed assets
Net Input	z		Equity
Output	Y1	Loan balance	Annual loan balance
	Y2	Other profitable assets	Includes short-term, long-term investments, and other securities investments

Table 3. Continued

	Y3	Non-interest income	Fees, commissions, and other operating income
Actual Total Cost	TC	Actual total cost=Service fees + Interest expenses + Operating expenses	
Actual Profit	π	Actual profit=After-tax profit	

Next is the selection of the objective function. Based on previous literature, the Douglas function and the transcendental logarithmic function are commonly used, with the latter being more popular due to the presence of second-order effects. Referring to the method of Yu Jingjing et al. (2019), maximum likelihood estimation is used to compute the required cost and profit efficiencies for this study [7].

It should be noted that the results of this paper show slight differences from those in previous literature, mainly in terms of cost efficiency. The results here are relatively lower, and several reasons for this can be considered. First, by excluding non-performing loans, the total input cost function was not adjusted, which led to larger error terms and caused the efficiency estimates to be biased downward. On the other hand, the sample selection strategy in this paper differs, as it was based on the extent of data missingness. The sample is larger compared to previous literature and includes some commercial banks with lower cost or income efficiency, resulting in biased results. However, Yao Shujie et al. [10] (2011) and Tan Zhengxun and Li Lifang have analyzed this strategy and concluded that including non-performing loans in the model would cause a significant inflation effect on cost efficiency, leading to an overestimation of cost efficiency. Therefore, the efficiency estimates in this paper are tentatively accepted for further analysis.

4.3. Analysis of fixed effect model results

The results are shown in Table 4. First, looking at the results in the first column, we can observe that the coefficient of the monetary policy variable is significantly positive at the 95% confidence level. This confirms the general conclusion made by previous literature based on our selected dataset: that an accommodative monetary policy leads to an increase in the risk levels of commercial banks. Additionally, the coefficient of the economic growth variable is significantly negative, which also supports the hypothesis mentioned in some previous studies that economic recession drives commercial banks to take on more risks in order to improve profits. The expenditure-to-income ratio in the preceding column is significantly negative, indicating that the financial status of commercial banks is closely related to their risk management. One hypothesis proposed in this paper is that if a commercial bank's financial condition deteriorates, it will tend to reduce risk in order to avoid potential bankruptcy.

Next, we focus on the two moderating models. As previously mentioned, our primary focus is on the interaction term coefficients of monetary policy with either bank cost efficiency or profit efficiency. In the second column of Table 4, the interaction term between commercial bank cost efficiency and monetary policy is significantly negative. Combining this with the positive coefficient of monetary policy in the first column, it can be concluded that higher cost efficiency in commercial banks suppresses the increase in risk-taking that results from the influence of monetary policy. According to the "poor management" hypothesis, when cost efficiency is high, the operating costs of the entire commercial bank are well-controlled, and additional costs, such as provisions for non-performing loans, are relatively low. When monetary policy is accommodative and commercial banks tend to expand risks, they need to overcome barriers such as lower loan loss provisions, thus preventing the tendency for risk expansion. The third column primarily analyzes the impact of profit efficiency. The data shows that the interaction term between commercial bank profit efficiency and monetary policy is significantly positive. Combining this with the positive coefficient of monetary policy in the first column, it can be concluded that the expansion of profit efficiency in commercial banks increases their risk-taking in response to monetary policy. This aligns with general understanding: when commercial banks' output rates increase, they are more confident in further expanding their business and attempting higher-risk activities. On the other hand, higher profit efficiency indicates that commercial banks are making full use of their input resources. The profit-seeking behavior means that when commercial banks have the demand to expand risks, high returns are more attractive than potential future losses, which may promote their risk-taking behavior and, in turn, raise their risk levels.

Table 4. Fixed effect model regression results

VARIABLES	(1) risk	(2) risk	(3) risk	(1) risk	(2) risk	(3) risk
lnM2	0.003	0.039	-0.020	0.011	0.050	-0.032
	(1.99)	(5.80)	(-3.17)	(2.57)	(2.70)	(-1.84)
cost_eff_a11		0.351			0.417	

Table 4. Continued

		(5.68)			(3.03)	
lnm2cos1		-0.022			-0.026	
		(-5.71)			(-3.01)	
profit_eff_a11			-0.351			-0.670
			(-4.33)			(-2.88)
lnm2pro			0.023			0.044
			(4.32)			(2.90)
Constant	-0.018	-0.585	0.346	-0.122	-0.746	0.562
	(-1.31)	(-6.10)	(3.97)	(-2.32)	(-3.23)	(2.43)
Control	YES	YES	YES	YES	YES	YES
Observations	1,457	654	653	1,417	660	659
R-squared	0.251	0.385	0.373	0.210	0.371	0.385
Numberofid1	141	77	77	141	77	77
BankFE	YES	YES	YES	YES	YES	YES
YearFE	YES	YES	YES	YES	YES	YES

4.4. System GMM results

The preceding sections used static panel regression analysis. However, as pointed out by numerous scholars in the literature analyzing the risk-taking behavior of commercial banks, issues such as heteroscedasticity and autocorrelation can lead to biased estimates. To verify the effectiveness of the moderating model, this paper follows prior research on the risk-taking of commercial banks and employs a two-step system Generalized Method of Moments (GMM) estimation method, incorporating lagged risk variables into the model for further consideration of the estimated results:

$$risk_{it} = \alpha_0 + \beta_1 risk_{it-1} + \alpha_1 lnM2_{it} + \beta X_{it} + \varepsilon_{it}$$

$$risk_{it} = \alpha_0 + \beta_1 risk_{it-1} + \alpha_1 lnM2_{it} + \alpha_2 CE_{it} + \alpha_3 CE_{it} * lnM2_{it} + \beta X_{it} + \varepsilon_{it}$$

$$risk_{it} = \alpha_0 + \beta_1 risk_{it-1} + \alpha_1 lnM2_{it} + \alpha_2 PE_{it} + \alpha_3 PE_{it} * lnM2_{it} + \beta X_{it} + \varepsilon_{it}$$

The results are shown in Table 5:

Table 5. GMM model regression results

VARIABLES	(1) risk	(2) risk	(3) risk	(4) risk	(5) risk
L.suntosum	0.683	0.301	0.195	0.436	0.490
	(7.38)	(1.88)	(1.29)	(5.31)	(6.26)
lnM2	0.003	0.016	-0.028	0.020	-0.016
	(2.77)	(3.04)	(-2.22)	(5.12)	(-2.96)
cost_eff_a11		0.078			
		(1.53)			
lnm2cos1		-0.006			
		(-1.71)			
profit_eff_a11			-0.454		
			(-2.49)		
lnm2pro			0.032		
			(2.62)		
L.cost_eff_a11				0.104	
				(3.70)	
lnm2lcos				-0.007	
				(-3.91)	
L.profit_eff_a11					-0.292
					(-3.72)
lnm2lpro					0.021
					(3.95)

Table 5. Continued

Constant	-0.065	-0.238	0.386	-0.288	0.217
	(-3.35)	(-2.74)	(2.01)	(-4.93)	(2.63)
Control	YES	YES	YES	YES	YES
Observations	1,567	676	675	643	642
Numberofid1	142	77	77	76	76

In the first column of Table 5, only the monetary policy variable and the lagged risk variables are included. It can be observed that the coefficient of the monetary policy variable remains significantly positive, consistent with the results from the fixed-effect model shown earlier. This also suggests, from the perspective of money supply, that there is a channel through which monetary policy affects the risk-taking of commercial banks. When monetary policy is accommodative or during macroeconomic downturns, commercial banks tend to increase investment in risk assets such as loans, thereby assuming greater risk. Furthermore, the significance of the monetary policy coefficient increases, indicating the necessity of model improvement. On the other hand, by examining the coefficients of the lagged risk indicators, it is found that they are significantly positive, suggesting that there is a certain inertia and path dependence in the risk-taking behavior of banks in China, which further justifies the consideration of autocorrelation in the model.

Table 6. Test Results

Arellano-Bond	test	for	AR (1)	in	first	differences:	z=-4.65	Pr>z=0
Arellano-Bond	test	for	AR (2)	in	first	differences:	z=-0.5	Pr>z=0.617

The AR test results, as shown in Table 6, indicate that the first-order autocorrelation coefficient of the residuals is significantly non-zero, while the second-order autocorrelation coefficient has a p-value of 0.617, which cannot be rejected as zero. This result provides sufficient justification for selecting the two-step GMM estimation method and indicates that autocorrelation has been eliminated.

Next, this paper continues to explore how to introduce moderating effects into the GMM model. Referring to the approach used by Yu Jingjing et al. (2019), whose authors directly included the interaction term between monetary policy and capital adequacy ratio in the GMM model, this paper reports the results for cost efficiency and profit efficiency in columns 2 and 3, respectively. As shown in the table, the coefficient of the interaction term between cost efficiency and monetary policy remains negative, but its significance has decreased compared to the fixed-effect model. The coefficient of the interaction term between profit efficiency and monetary policy remains significantly negative, which largely supports the previous conclusions in this paper. Additionally, based on the above results and theoretical assumptions, the choice of risk-taking behavior by banks exhibits some inertia. If commercial banks are rational actors, they might adjust their risk levels based on known efficiency situations, leading to changes in risk management levels. Therefore, the efficiency variables included in the model should not be contemporaneous variables but lagged variables. Based on this, this paper constructs interaction terms between lagged cost efficiency, lagged profit efficiency, and monetary policy to further explore the relationships between these variables. As shown in the results of columns 4 and 5, the significance of the coefficients increases, and the signs remain unchanged. Additionally, the AR tests for these models show that the first-order autocorrelation coefficient is significantly non-zero, while the second-order autocorrelation coefficient cannot be rejected as zero, indicating the model's usability and corroborating the previous conclusions.

4.5. Robustness test

In this section, several robustness tests were conducted. First, the risk variables were replaced. As analyzed earlier, there are other indicators that can reflect the risk levels of commercial banks. In this part, the non-performing loan ratio was chosen as a substitute indicator. The results, shown in the first three columns of Table 7, are generally consistent with the baseline regression conclusions above, but the significance has decreased. This may be due to the sharp rise in non-performing loans in 2020, which drew attention and led to regulatory adjustments by commercial banks, thereby disturbing the model. On the other hand, the sample was divided for further analysis, mainly considering the potential impact of the COVID-19 pandemic on the cost efficiency and profit efficiency of banks. The data for 2019 and prior years were selected for analysis. The results, shown in Table 7, are generally consistent with the baseline regression results, which to some extent reflects the robustness and validity of the empirical model presented in this paper.

Table 7. Robustness test results

VARIABLES	(1) varc	(2) varc	(3) varc	(4) year	(5) year	(6) year
L.badrate	0.416	0.158	0.644			
	(2.46)	(1.55)	(5.47)			
lnM2	0.004	0.025	-0.008	0.004	0.020	-0.038
	(2.17)	(3.09)	(-1.00)	(3.23)	(2.80)	(-2.57)
cost_eff_a11		0.162			0.106	
		(2.61)			(1.89)	
lnm2cos1		-0.011			-0.008	
		(-2.64)			(-2.04)	
profit_eff_a11			-0.192			-0.603
			(-1.61)			(-2.73)
lnm2pro			0.014			0.042
			(1.72)			(2.80)
L.suntosum				0.564	0.145	-0.038
				(5.48)	(0.75)	(-0.22)
Constant	0.006	-0.364	0.107	-0.085	-0.341	0.465
	(0.26)	(-3.01)	(0.88)	(-4.36)	(-3.04)	(2.20)
Control	YES	YES	YES	YES	YES	YES
Observations	1,468	673	672	1,162	467	466
Numberofid1	142	77	77	142	71	71

4.6. Heterogeneity analysis

In response to the various issues discussed above, this paper will continue to explore further. The first step is to test whether our measure of efficiency can completely exclude factors related to risk. Based on the work of Tan Zhengxun and Li Lifang (2016), it is clear that the authors also found that the risk-taking behavior of commercial banks might influence their efficiency through certain channels. Therefore, it is worth verifying whether the lagged or squared terms of the risk factors might affect the efficiency measured in this study. The regression results, shown in the first two columns of the table below, reveal consistent results with previous literature. It remains evident that the coefficient of the squared term of the risk factors for profit efficiency is significantly negative, reflecting a U-shape characteristic. Although the coefficient related to cost efficiency in the regression is significantly negative, it is not entirely consistent with prior literature, suggesting that the attempt to exclude risk factors from the analysis has had some effect. On the other hand, this section also conducts further heterogeneity analysis to support the theoretical findings of the baseline regression. The capital adequacy ratio indicator for all samples is grouped by the median, dividing the sample into two groups based on their ability to withstand risk. The GMM moderating effect model regression is then conducted separately for these two groups, and the results are observed as Table 8 shown:

Table 8. Heterogeneity analysis results

VARIABLES	(1) year	(2) year	(3) year	(4) year	(5) year	(6) year
sun2	-22.546	-0.902				
	(-2.48)	(-3.84)				
L.cost_eff_a11		1.001				
		(1,122.34)				
L.suntosum		-0.015	0.228	0.170	0.172	0.176
		(-2.22)	(1.08)	(1.03)	(0.70)	(1.22)
profit_eff_a11		0.000			-0.610	-0.428
		(0.14)			(-2.71)	(-2.54)
cost_eff_a11	-		0.084	0.162		
	(-2.29)		(1.37)	(4.14)		
L.profit_eff_a11	1.052					
	(84.08)					

Table 8. Continued

lnM2			0.019	0.024	-0.039	-0.024
			(2.77)	(4.49)	(-2.54)	(-2.28)
lnm2cos1			-0.006	-0.011		
			(-1.53)	(-4.25)		
lnm2pro					0.042	0.030
					(2.80)	(2.64)
Constant	-0.076	-0.013	-0.274	-0.348	0.545	0.342
	(-2.35)	(-13.93)	(-2.45)	(-4.82)	(2.22)	(1.98)
Control	YES	YES	YES	YES	YES	YES
Observations	611	610	315	361	315	360
Number of id1	74	74	69	66	69	66

The results are shown in Table 8. From the perspective of cost efficiency, in the group with a higher capital adequacy ratio, the interaction term coefficient is not significant, indicating that high-cost efficiency does not have a significant suppressing effect on the impact of monetary policy. However, in the group with a lower capital adequacy ratio, the interaction term coefficient remains significantly negative, showing consistent results with the baseline regression. From the perspective of profit efficiency, the absolute value of the interaction term coefficient is larger in the group with a higher capital adequacy ratio. These results are consistent with the conclusions of the moderating effect model and the possible mechanisms proposed in this paper. A higher capital adequacy ratio often means that the company's financial situation is not under stress, and the risk constraints from cost control are not as high. For such banks, cost efficiency is not one of the main factors limiting their behavior. From the perspective of profit efficiency, the group with a higher capital adequacy ratio has more confidence in facing risks. The higher profit efficiency makes the risk expansion under a loose monetary policy more pronounced, fully verifying Hypothesis 2.

On the other hand, considering previous literature, China's commercial banks come in various types, including state-owned banks, joint-stock banks, urban commercial banks, rural commercial banks, etc. These different types of banks bear different responsibilities, have varying levels of governance, and differ in their main business areas. Thus, it may not be appropriate to generalize. From the apparent data, rural commercial banks tend to have higher non-performing loan ratios, indicating relatively weaker risk management capabilities and higher levels of risk-taking. Joint-stock banks and state-owned banks, on the other hand, have significantly lower non-performing loan ratios, suggesting that these banks may play a more critical role in maintaining the stability of the financial system, with better risk management capabilities. To test this hypothesis, the paper continues the heterogeneity analysis by grouping joint-stock banks and state-owned banks together, while grouping other commercial banks into a separate category. The empirical results are shown in Table 9.

Table 9. Heterogeneity analysis results

VARIABLES	(1) year	(2) year	(3) year	(4) year	(5) year	(6) year
L.suntosum	0.905	1.088	-0.575	0.621	0.210	0.160
	(4.71)	(1.05)	(-1.25)	(7.27)	(1.16)	(0.96)
lnM2	0.000	0.015	-0.182	0.001	0.018	-0.023
	(0.31)	(0.46)	(-2.75)	(1.78)	(3.28)	(-2.40)
cost_eff_a11		0.008			0.085	
		(0.04)			(1.90)	
lnm2cos1		-0.002			-0.006	
		(-0.16)			(-2.11)	
profit_eff_a11	-0.390		-3.352			-0.390
	(-2.63)		(-2.88)			(-2.63)
lnm2pro	0.027		0.251			0.027
	(2.75)		(2.95)			(2.75)
Constant	-0.064	-0.245	2.001	-0.044	-0.257	0.334
	(-1.89)	(-0.52)	(2.43)	(-1.61)	(-3.23)	(2.26)
Control	YES	YES	YES	YES	YES	YES
Observations	163	131	131	1,416	545	544
Number of id1	12	10	10	131	67	67

From the results above, it can be observed that for urban commercial banks and rural commercial banks, the sign and significance of their coefficients remain consistent with the baseline GMM model. However, for joint-stock banks and state-owned banks, the coefficients related to cost efficiency are no longer significant. This phenomenon suggests that the conclusions of this paper are still robust for urban commercial banks and rural commercial banks. These types of banks may have more long-tail customers, which leads to relatively weaker risk management levels. On the other hand, for joint-stock banks and state-owned banks, there are clearly other influencing factors in their risk management. As larger banks, they play a more critical role in the financial system, are subject to more regulation, and have lower levels of risk-taking. Therefore, their risk management capabilities are relatively higher, and their efficiency has a weaker impact on their risk-taking behavior, providing additional evidence to support Hypothesis 2.

5. Conclusion

Based on macroeconomic data and commercial bank data from China between 2007 and 2022, this paper employs the current mainstream stochastic frontier methods to conduct a simple measurement of the cost and profit efficiency of Chinese commercial banks over the past 15 years. Additionally, a moderation effect model is established, using fixed effect models and two-step system GMM models to investigate how the cost and profit efficiency of Chinese commercial banks moderate the impact of monetary policy on their risk-taking behavior. This paper first validates the conclusions of previous literature, confirming that over the past 15 years, China's monetary policy has continued to affect the risk-taking behavior of its commercial banks. From the perspective of cost efficiency, companies with better cost efficiency typically have lower friction costs such as loan loss provisions, which constrain their risk-taking lending behavior. Furthermore, their financing costs are better controlled, and although their investment assets may suffer a decline in returns due to expansionary monetary policy, the lower financing costs still provide them with a buffer, reducing the demand for high-risk assets. Commercial banks with higher profit efficiency tend to be more confident in facing risk expansion, and are more strongly incentivized by the "high risk, high reward" dynamic. This paper validates the proposed hypothesis: that high-cost efficiency in commercial banks effectively restrains the increase in their risk-taking behavior caused by expansionary monetary policy, while high profit efficiency promotes an increase in their risk-taking behavior due to expansionary monetary policy. In addition, the subsequent heterogeneity analysis supports another hypothesis presented in this paper: the risk management levels of commercial banks are also influenced by other factors. A higher capital adequacy ratio may lead to less constraint from cost efficiency and a greater incentive from profit efficiency in risk management.

Commercial banks are a critical component of China's financial system, and their stability is essential for the country's financial development. It is necessary to control their risk-taking levels to prevent the collapse of the entire financial system due to bubble bursts. On one hand, improving cost control in commercial banks can effectively suppress the disorderly expansion of their risk-taking behavior while reducing friction costs. On the other hand, while profit efficiency is one of the goals that commercial banks pursue, it is unrealistic to suppress it entirely. Regulatory measures should be prioritized. During periods of loose monetary policy or economic recession, attention should be paid to the risk-taking levels of banks with high profit efficiency, ensuring they do not engage in reckless profit-seeking, and reminding them of their social responsibility to safeguard the stability of the financial system.

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