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Research Paper

DOES BANK LIQUIDITY MATTER IN THE LOAN SUPERVISION EFFECT OF BANK CAPITAL ADEQUACY RATIO?

Jie Gao || School of Banking and Finance

ABSTRACT

The requirement of bank's capital adequacy ratio did not prevent the occurrence of financial risk, and then the requirement of bank's liquidity came into view. Then, the impact of bank capital and liquidity on bank loan changes is a real problem faced by regulators and banks themselves. In this context, we study whether the impact of capital adequacy ratio on loan changes is related with the bank's liquid asset ratio by constructing theoretical model and empirical analysis method. Our study first shows that the impact of bank's capital adequacy ratio on loan changes is related with liquid asset ratio. We find that off-balance sheet loan commitments offset the parts impact of liquid asset ratio and capital adequacy ratio on loan changes, and small and medium-sized banks are less affected by liquid asset ratio. Under the condition that banks hold certain liquid assets, bank's liquid asset ratio is positive with the influence of the capital adequacy ratio on loan changes. Finally, we put forward suggestions from the perspective of bank risk management and bank capital and liquidity supervision.

KEYWORDS :Liquid Assets Ratio, Capital Adequacy Ratio, Bank Loans, Loan

INTRODUCTION

As early as 1988, Basel made strict requirements for banks' capital adequacy ratios; however, since then there have been financial crises and even the global financial crisis. After the global crisis, bank liquidity has been taken seriously and brought into the regulatory framework, so the common regulatory effects of bank capital adequacy ratios and liquidity should be taken into account by regulators when making decisions, as well as by bank managers.

Bank capital adequacy ratio is mainly used to guard against and defuse financial risks. Under the supervision of bank capital, bank capital adequacy ratio affects the loan quantity and loan structure, and the lack of bank liquidity will not only lead to the individual liquidity risk of banks, but also the outbreak of banking systemic risk, so it should be noted that banks may have the incentive to issue loans when they have sufficient liquidity. After the global financial crisis, the Basel Committee adopted Basel III, the new international regulatory framework, which raised capital adequacy requirements and strengthened liquidity management. Accordingly, China as a country with banks as the main financial institutions has gradually improved the regulatory framework with capital supervision and incorporated new international regulatory indicators. China has made specific provisions on capital and liquidity supervision indicators in the Measures for the Management of Capital of Commercial Banks (2012) and the Measures for the Management of Liquidity Risks of Commercial Banks (2018). There was a shortage of money in 2013. In addition, there have been a lot of liquidity tickets recently, which hides the importance of bank liquidity to bank asset allocation, so it is necessary to study the impact of bank capital adequacy ratio on bank loans at different liquidity levels.

Based on the existing research of the impact of bank capital adequacy ratio on loans, this paper uses the data of commercial banks in China to study the role of liquidity asset ratio in the effect of bank capital adequacy ratio on the change of bank loans. In addition, this paper not only considers the loans on-balance sheet, but also considers the off-balance sheet loan commitments, because the off-balance sheet business can be converted to on-balance sheet business under certain conditions. The remainder of the paper is organized as follows. Section 2 reviews the literature and proposes the innovative points. Section 3 introduces the theoretical model and puts forward the hypothesis. Section 4 discusses the data, presents the definitions of the variables and the methodology used in our study. Empirical model results and robustness are detailed in Section 5. Section 4 concludes the study with some additional remarks.

2. Literature Review

Capital is the blood of real economy operation. Nearly 80% of the funds of China's non-financial enterprises come from bank loans (Jiang & Liu, 2016). Quantifying the impact of bank capital level on the loan size is one of the most basic issues to verify the link between the financial sector and the real economy and it has been paid more attention, but the research of impact of liquidity on changes of loan size is relatively less. Existing studies of bank capital-loan movements has not reached a consistent conclusion, and the "capital crowding out" (Bernanke et al., 1991; Aiyar et al., 2016, etc.) focuses on the risk weight differences in the calculation of capital adequacy ratios to drive commercial banks to adjust their asset allocation channels and analyze the impact of commercial banks' capital levels on loan size. The "risk absorption" (Košak et al., 2015; Jiang & Liu, 2016) perspective focuses on the analysis of the ability of capital adequacy ratios to prevent risks. There is also literature on the differentiated impact of commercial bank capital levels on loan size (Lepetit et al., 2015; Peng & Wu, 2014).

2.1. The "Capital Crowding out" Effect

Among the results of the research on the impact of bank capital ratio on loan changes, one of the main viewpoints is that capital regulation will lead to the reduction of bank loans, that is, "capital crowding out". On the one hand, from the perspective of capital regulation, capital requirements are regarded as the threshold for banks to issue loans to the real economy, and banks need to give weight to retain sufficient capital according to the asset risk. The loss of loans results in a shortage of bank capital, which limits the ability of banks to make loans, that is, capital constraints aggravate the reduction of loan supply (Bernanke et al., 1991; Aiyar et al., 2016). Chinese scholars believe that increasing the capital adequacy ratio will reduce the avaliability of bank loans, and capital constraints have a greater impact on banks with relatively insufficient capital (Liu, 2005). On the other hand, from the perspective of bank asset structure, because the discount of government bonds (0% - 1.6%) is lower than that of loans (8%) in the required capital ratio, banks reallocate assets to government bonds in order to meet the capital regulatory requirements (Wagster, 1999). Chinese research shows that when banks' capital adequacy ratio increases, bank balance sheet will be adjusted. In order to improve capital adequacy ratio, banks tend to increase the proportion of low-risk assets such as bonds and reduce the loan supply to the real sector (Guo & Mo, 2006). The negative result is based on the risk weighted calculation method of regulatory capital ratio. The assets with small risk weight are more conducive to the banks to meet the regulatory capital requirements, so the allocation of bank government bonds squeeze out bank loans.

2.2. The "Risk Absorption" Effect

After the global financial crisis in 2008, scholars began to pay attention to the behavior of banks about the crisis. Capital adequacy ratio is an important tool for banks to absorb risks. The literature on the impact of bank capital level on loan changes is more concerned about this crisis sample period. Moreover, with the deepening of the research on bank capital, the quality and quantity of capital have been paid more and more attention. These studies divide the capital requirements according to the capital quality level and find that the bank capital with different quality levels has different impact on loan issuance, which reflects that capital has a certain absorptive capacity for loan risk. High-quality capital can help banks to make loans during the financial crisis, while low-quality capital can inhibit loan issuance. Specifically, core tier 1 capital and tier 1 capital play an important role in encouraging banks to make loans during the financial crisis. In the financial crisis and a short period after it, banks with higher tier 1 capital ratio have higher loan growth rate in the next year (Gambacorta & Marques-Ibanez, 2011; Carlson et al., 2013; Košak et al., 2015), and the positive effect of bank level capital on bank loans in developing countries is particularly significant during the crisis (Košak et al., 2015). Chinese scholars take China's commercial banks as samples to study the impact of different capital regulatory tools on bank lending behavior. The results show that capital adequacy ratio inhibits bank lending, while core capital adequacy ratio encourages banks to make loans. The impact of both factors is enhanced in the financial crisis period (Jiang & Liu, 2016). Therefore, high-quality capital is very important for bank loan risk absorption and loan expansion.

2.3. The Differential Influence of Bank Capital on Loan Changes

In addition to the above two cases, there are also studies that consider the impact of capital ratio on bank loans under the condition of bank heterogeneity. Chinese scholars have studied according to the characteristics, scale and level of bank capital. In terms of capital characteristics, in the face of the same capital constraints, banks with different capital characteristics in different economic periods will show different risk preferences and behavior choices. When the regulatory authorities raise the requirements of capital adequacy ratio, banks with low capital adequacy ratio and flexible capital characteristics (capital adequacy ratio does not meet the requirements but can be achieved through self-adjustment in the short term) will have different risk preference and behavior choice. When banks face the same capital constraint, during the economic depression (prosperity), loans will be reduced (increased). While banks with low capital adequacy ratio and rigid capital characteristics (capital adequacy ratio fails to meet the requirements, and it is difficult to achieve through self-adjustment in the short term) will tighten credit (Dai et al., 2009). In terms of bank types, regulatory pressure has a more significant impact on credit expansion of urban and rural commercial banks (Wang & Wu, 2012). In terms of capital level, with the implementation of the capital supervision hard constraint, the capital adequacy ratio of banks with insufficient capital increases capital level by increasing capital or reducing risk assets. Banks with sufficient capital tend to hold more risk assets. In general, banks with lower capital adequacy ratio reduce the speed of credit expansion, and capital constraints make commercial banks with insufficient capital issue more low capital consumption loans, such as personal loans, while commercial banks with sufficient capital tend to issue high capital consumption loans, such as credit loans (Wang & Wu, 2012; Peng & Wu, 2014; Yang, 2015).

Based on the existing research, this paper studies the effect of the bank's liquid asset ratios on the loan changes caused by capital adequacy ratios. The possible innovations are as follows. Firstly, through the improvement of the existing model, a theoretical model suitable for this research problem is proposed. Secondly, the existing research from the perspective of bank loan structure (such as personal loans and corporate loans) and non-bank loans asset allocation including bank loans and government bonds and so on studies the impact of bank capital adequacy ratios on bank loans. This paper from the same regulatory perspective of bank capital adequacy ratio studies the impact of bank capital adequacy ratio on bank loans. The third is about the selection of indicators. This paper not only studies the net loan, but also studies the off-balance sheet loan commitment1. On the one hand, because China's commercial banks mainly influence and serve the real economy through net loans, it is of great significance to study the impact of capital adequacy ratio on net loans. On the other hand, due to the low risk weight and low capital occupation of off-balance sheet loan commitment, it can be transformed into on-balance sheet business under certain conditions.

3. Theoretical Model and Research Hypothesis

Based on the model set by Dai et al. (2009) and Brei and Schclarek (2015), this paper introduces capital and loan changes into the model. The composition of the balance sheet is shown in Table 1. Assuming that the bank can make intertemporal investment choices, as a financial intermediary of deposit taking and lending.

Banks' returns based on the mean and variance of portfolio are expected to be the following:

$$E(U)=E(RP)-\gamma 2V(RP)E(U)=E(RP)-\gamma 2V(RP) \quad (1)$$

where RPRP is the portfolio return and γγ is the risk aversion coefficient ($\gamma>0\gamma>0$).

In period 0, the utility maximization of banks can be expressed as follows:

$$\max E(R)I+L-\gamma 2I2V0(R)s.t.I+L\ll D0+C0$$
$$\max E(R)I+L-\gamma 2I2V0(R)$$

$$s.t.I+L\ll D0+C0 \quad (2)$$

where E(R)E(R) is the expected value of return *R*, V0(R)V0(R) is the variance based on period 0 information, and $-\gamma 2I2V0(R)-\gamma 2I2V0(R)$ is the negative utility brought by loan risk. Balance sheet constraints mean that deposits and bank capital are invested in loans and liquid assets.

Assets	Liabilities
Liquid assets (*L*)	Deposit (*D*)
Loan (*I*)	Capital (*C*)

Table 1. Composition of balance sheet of commercial banks.

In period 1, the capital of the bank changes, the loan change scale is ΔΔ, the risk level perceived by the bank, the loan with scale $1-\delta 1-\delta$ ($0\le\delta\le10\le\delta\le1$) is converted into risk-free current assets, in order to simplify the calculation, It is assumed that the current conversion coefficient for converting loans into liquid assets is 1. The problem of maximizing bank utility in period 1 can be expressed as follows:

$$\max\delta E(R)\delta(1+\Delta)I+L+(1-\delta)(1+\Delta)I-\gamma 2\delta 2(1+\Delta)2I2V1(R)s.t.D0-D1\ll L+(1-\delta)(1+\Delta)I\max\delta E(R)\delta(1+\Delta)I+L$$

$$+(1-\delta)(1+\Delta)I-\gamma 2\delta 2(1+\Delta)2I2V1(R)s.t.D0-D1\ll L+(1-\delta)(1+\Delta)I \quad (3)$$

where $D0-D1D0-D1$ represents the deposits withdrawn from the bank by customers in period 1, and the balance sheet constraint of period 1 satisfies $(1+\Delta)I\delta\leq D1+C1(1+\Delta)I\delta\leq D1+C1$.

If the liquid assets *L* is large, the loan *I* should be small to meet the constraint conditions, and the upper limit of the value range of $\delta(1+\Delta)\delta(1+\Delta)$ is larger. Therefore, when the capital increases, if there are more liquid assets in the previous period, the loan proportion in the asset allocation in the next period will be more, and the proportion of converted liquid assets $(1-\delta)(1+\Delta)(1-\delta)(1+\Delta)$ will be smaller.

Combined with the optimal choice of bank investment $I=E(R)\gamma V0(R)I=E(R)\gamma V0(R)$ and $\delta=E(R)-1\gamma(1+\Delta)IV1(R)\delta=E(R)-1\gamma(1+\Delta)IV1(R)$, that is, banks avoid risks, the smaller the investment income in the previous period, the greater the fluctuation of investment income, and the smaller the expected income fluctuation, the increase of bank capital is more conducive to the increase of loans.

When the bank's liquid assets are sufficient, the bank has a higher ability to meet depositors' withdrawal of deposits, and the increase of bank capital significantly improves the bank's risk absorption capacity, and the "capital crowding out" effect is weaker than the "risk absorption" effect (Coval & Thakor, 2005), and bank loan expands; when bank liquidity is scarce, banks may not be willing to take more risks even if they have sufficient capital. At this time, the "capital crowding out" effect is stronger than the "risk absorption" effect (Gorton & Winton, 2017). In addition, Cornett et al. (2011) believed that liquidity dried up during the global financial crisis from 2007 to 2008, and banks with more illiquid assets increased asset liquidity and reduced loans. Berrospide (2013) found that more than a quarter of the decrease in bank loans during the crisis was due to liquidity prevention motivation. Liu (2005) thinks that the influence of capital constraint on bank loan changes is different among banks with different capital levels. Therefore, we try to make the following assumptions.

Hypothesis 1a: The effect of bank capital adequacy ratio on loan changes is related to bank liquid asset ratio.

Hypothesis 1b: The liquid asset ratio of banks positively promotes the impact of bank's actual capital adequacy ratio on loan changes.

Bank off-balance sheet loan commitment can also provide funds for the lender, so off-balance sheet loan commitment shares the impact of bank loan. China's commercial banks have significant differences in asset size and business types. Large banks are systemically important banks with the characteristics of "too big to fail" and strong capital replenishment ability. Therefore, compared with large banks, loan changes of small and medium-sized banks are more affected by capital adequacy ratio and liquid asset ratio. Therefore, the following assumptions are made.

Hypothesis 2: The impact of bank capital adequacy ratio and liquid asset ratio on bank credit (loan and off-balance sheet loan commitment) is less than that of bank loan, and the impact on small and medium-sized banks is more significant.

Hypothesis 3: When the liquid asset ratio is very small, the liquid asset ratio has a negative effect on the impact of bank capital adequacy ratio on loan changes.

We verify the hypotheses by using panel data model. Panel data is a two-dimensional data composed of time series and cross-sectional data. Panel data considers both cross-sectional and time dimensional data. Using panel data analysis can control the unobservable bank specific effect, time specific effect and get more effective results. The next part uses panel model for empirical analysis.

4. Data Description and Empirical Model Construction

4.1. Data Description

This paper analyzes the data of 207 commercial banks in China from 2003 to 2017 (from BankFocus) and macroeconomic data, which mainly includes real GDP and overnight interbank lending rate (from the CEInet statistics database). Non-commercial banks such as policy banks, securities companies, trust companies and asset management companies are excluded. Commercial banks with serious data loss and merged banks are excluded. All bank specific variables are processed in the 1st and 99th percentile to reduce the impact of outliers on the research results.

4.2. Empirical Model Construction and Estimation Method

To confirm hypothesis 1a, econometric models refer to Brei et al. (2013) and Kim and Sohn (2017) and adjust them. Therefore, the basic empirical model of this paper is as follows:

$$LOANGi,t=\beta 0+\beta 1LOANGi,t-1+\beta 2CAPi,t-1+\beta 3LIQi,t-1+\beta 4Xi,t-1$$

$$+\beta 5\Delta GDPt+\beta 6\Delta SHIt+\varepsilon i,tLOANGi,t=\beta 0+$$

$$\beta 1LOANGi,t-1+\beta 2CAPi,t-1+\beta 3LIQi,t-1+\beta 4Xi,t-1+\beta 5\Delta GDPt+\beta 6\Delta SHIt+\varepsilon i,t \quad (4)$$

This paper introduces the cross effect of bank capital adequacy ratio and liquid asset ratio, so that the coefficient of bank capital adequacy ratio changes with the liquid asset ratio is the one to focus on. Construct the following model to test hypothesis 1b.

$$LOANGi,t=\alpha 0+\alpha 1LOANGi,t-1+\alpha 2CAPi,t-1+\alpha 3LIQi,t-1+\alpha 4CAPi,t-1$$

$$\times LIQi,t-1+\alpha 5Xi,t-1+\alpha 6\Delta GDPt+\alpha 7\Delta SHIt+$$

$$\varepsilon i,t$$

$$LOANGi,t=\alpha 0+\alpha 1LOANGi,t-1+\alpha 2CAPi,t-1+\alpha 3LIQi,t-1+\alpha 4CAPi,t-1$$

$$\times LIQi,t-1+\alpha 5Xi,t-1+\alpha 6\Delta GDPt+\alpha 7\Delta SHIt+\varepsilon i,t \quad (5)$$

The dependent variable was set as bank credit, and hypothesis 2 was verified by model (6) and (7).

$$CREDITGi,t=\gamma 0+\gamma 1CREDITGi,t-1+\gamma 2CAPi,t-1+\gamma 3LIQi,t-1+\gamma 4Xi,t-1+\gamma 5\Delta GDPt+\gamma 6\Delta SHIt$$

$$+\varepsilon i,t$$

$$CREDITGi,t=\gamma 0+\gamma 1CREDITGi,t-1+\gamma 2CAPi,t-1+\gamma 3L$$

$$IQi,t-1+\gamma 4Xi,t-1+\gamma 5\Delta GDPt+\gamma 6\Delta SHIt+\varepsilon i,t \quad (6)$$

$$CREDITGi,t=\delta 0+\delta 1CREDITGi,t-1+\delta 2CAPi,t-1+\delta 3LIQi,t-1+\delta 4CAPi,t-1\times LIQi,t-1+\delta 5Xi,t-1+\delta 6\Delta GDPt+\delta 7\Delta SHIt+\varepsilon i,t$$

$$CREDITGi,t=\delta 0+\delta 1CREDITGi,t-1+\delta 2CAPi,t-1+\delta 3LIQi,t-1+\delta 4CAPi,t-1\times LIQi,t-1+\delta 5Xi,t-1+\delta 6\Delta GDPt+\delta 7\Delta SHIt+\varepsilon i,t \quad (7)$$

Hypothesis 3 is tested by introducing the dummy variable *d* which represents different liquid asset ratios. Calculate the average value (μLIQμLIQ) and standard deviation (σLIQσLIQ) of the liquid asset ratio and the average value of the liquid asset ratio of each bank (μLIQiμLIQi). Since the main concern is the low liquid asset ratio and the distribution of the liquid asset ratio is right biased, in order to ensure a certain number of values of 0 and 1 in the dummy variable*d*, three types of dummy variable*d* are set: when the liquid asset ratio is less than the average value (μLIQi<μLIQμLIQi<μLIQ), *d* is taken as 1, otherwise 0;When the ratio of liquid assets is less than the mean minus 0.5 standard deviations (μLIQi<μLIQ−0.5σLIQμLIQi<μLIQ−0.5σLIQ), *d* is taken as 1, otherwise 0; when the liquid assets ratio is less than the average minus 1 standard deviation (μLIQi<μLIQ−σLIQμLIQi<μLIQ−σLIQ),*d* is taken as 1, otherwise 0.

Where*i* is the bank and*t* is the year. LOANGi,tLOANGi,t is the loan growth rate of the bank*i* in the*t* year, and CREDITGi,tCREDITGi,t is the credit growth rate of the bank*i* in the*t* year. CAPi,t−1CAPi,t−1 is the capital adequacy ratio of the bank*i* in the t−1t−1 year, LIQi,t−1LIQi,t−1 is the cur liquid asset ratio of the bank*i* in the t−1t−1 year, Xi,t−1Xi,t−1 is the bank characteristic variables including the bank size, bank profitability and loan loss provision. ΔGDPtΔGDPt is the GDP growth rate change in the*t* year, ΔSHItΔSHIt is the market interest rate change in the *t* year, expressed by the change of Shanghai interbank offered rate, αiαi is the bank level fixed effect that has not been observed. The residual term εi,tεi,t represents an unobservable disturbance. According to the conclusion of the above part of the theoretical model, the liquid asset ratio of banks in the previous period affects the changes of bank loans, and the endogenous role of variables is considered. Therefore, all bank characteristic variables in the model lag one period to reduce the possible endogenous bias.

In this paper, the dynamic system moment method (SGMM) is used to ensure the validity and consistency of the estimation. Firstly, because bank loans are correlated on the time axis, the dynamic panel model is used. Secondly, if fixed effects are directly used for estimation, the results are not uniform, which will lead to dynamic panel bias. SGMM method is more suitable for large N small T data processing, Brei et al. (2013) and Gambacorta and Mistrulli (2004) believe that as long as there is no second-order sequence correlation and effective tool variables are used, SGMM estimation efficiency is higher, and the estimator can ensure the validity and consistency. Therefore, this paper uses the SGMM for empirical research.

4.3. Selection of Model Variables

The meanings, symbols and calculation methods of variables used in this analysis are shown in Table 2.

Variable type	Variable symbol	Variable meaning	Variable calculation method
Dependent variable	$LOANG_{i,t}$	Loan growth rate	(Total loans of the current year - total loans of the previous year)/Total loans of the previous year
	$CREDITG_{i,t}$	Credit growth rate	(Total credit of the current year - total credit of the previous year)/Total credit of the previous year
Independent variable	$CAP_{i,t-1}$	Capital adequacy ratio	Capital/Risk assets
	$LIQ_{i,t-1}$	Liquid assets ratio	Liquid assets/Total assets
Bank characteristic variables	$ASSET_{i,t-1}$	Bank size	Natural logarithm of total assets
	$ROAA_{i,t-1}$	Bank profit	Net income/Total assets mean value at the beginning of the year and at the end of the year
	$LOSSRE_{i,t-1}$	Loan loss reserve ratio	Loan loss reserves/Total loans
	$NONLOAN_{i,t-1}$	Non-performing loan ratio	Non-performing loans/Total loans
Macro control variables	ΔGDP_t	Changes in GDP growth rate	(GDP growth rate of the current year - GDP growth rate of the previous year)/GDP growth rate of the previous year
	ΔSHI_t	Changes in market interest rates	(Overnight interbank offered rate of the current year - Overnight interbank offered rate of the previous year)/Overnight interbank offered rate of the previous year

Table 2. Variable meaning and calculation method.

1) Dependent variable

The dependent variables include the growth rate of bank loans (LOANGi,tLOANGi,t) and the growth rate of credit (CREDITGi,tCREDITGi,t). When banks are unwilling to lend, borrowers can use off-balance sheet loan commitments. Drawdown of off-balance sheet loan commitments increased on-balance sheet net loans (Cornett et al., 2011). The off-balance sheet business can be transformed into on-balance sheet business. The off-balance sheet business enters the denominator of capital adequacy ratio by multiplying the risk conversion coefficient. Therefore, the off-balance sheet loan commitment may be related to the change of bank loan. Therefore, loan growth rate (LOANGi,tLOANGi,t) and credit growth rate (CREDITGi,tCREDITGi,t) are used as dependent variables.

2) Independent variable

Main explanatory variables. The main explanatory variables include bank capital adequacy ratio (CAPi,t−1CAPi,t−1), liquid asset ratio (LIQi,t−1LIQi,t−1), and the multiplier of capital adequacy ratio and liquid asset ratio. Bank capital adequacy ratio is from BankFocus database calculated according to the regulatory requirements of capital adequacy ratio. Banks with sufficient capital can more effectively absorb the negative impact on bank loans (Kapan & Minoiu, 2013), so the expected sign of capital adequacy ratio (CAPi,t−1CAPi,t−1) is positive. This paper adopts the calculation method of liquid assets ratio in BankFocus database, that is, liquid assets ratio = liquid assets/total assets, in which liquid assets are composed of cash and deposits with the central bank, bank loans and advances and primary assets of fair value. According to the theoretical model, the bank's asset liability constraints are met (1+Δ)Iδ≤D1+C1(1+Δ)Iδ≤D1+C1. When the capital increases, if the liquid asset ratio of the bank in the previous period is larger, the loan proportion in the asset allocation in the next period will increase. Therefore, it is expected that the bank with higher liquid asset ratio will make more loans when the capital increase.

Bank characteristic variables. In addition to capital adequacy ratio and liquid asset ratio, other bank characteristic variables are included in vector Xi,t−1Xi,t−1. Bank size (ASSETi,t−1ASSETi,t−1) is

the natural logarithm of the total assets of banks. According to the theory of "too big to fail", large banks are motivated to take on more risks and provide more loans under the condition of government assistance. However, the diversification of large banks' investment portfolio will squeeze out some traditional loans. Therefore, the impact of asset size on loan changes is uncertain in theory and needs empirical verification. Bank profitability (ROAAi,t−1ROAAi,t−1) is the ratio of net income to the average value of total assets at the beginning of the year and the end of the year. On the one hand, the higher the capital quality and quantity support the bank to obtain more profits. On the other hand, the higher the profitability means that the bank needs to bear the greater asset risk. Therefore, the bank may reduce the loan to ensure the asset quality, and the relationship between profitability and bank loan is negative. Asset quality is represented by loan loss reserve ratio (LOSSREi,t−1LOSSREi,t−1) and non-performing loan ratio (NONLOANi,t−1NONLOANi,t−1). The worse the asset portfolio quality is, the more inclined the bank is to reduce loan issuance.

Macro control variables. Because of the inherent procyclicality of bank loans and the increasing demand for loans by economic growth, the expected sign of annual growth rate of real GDP (ΔGDPtΔGDPt) is positive. In addition, the increase of market interest rate reduces the demand for loans, so the impact of market interest rate change (ΔSHItΔSHIt) on bank loans is negative.

3) Descriptive statistics

Table 3 shows the descriptive statistics of variables. Loan growth rate, credit growth rate, capital adequacy ratio, liquid asset ratio and bank size, the main variables in the model, fluctuate greatly. Their standard deviations were 14.71, 16.46 and 12.30, respectively. The average of credit growth rate (17.56%) is lower than the average of loan growth rate (18.25%). The credit growth rate includes the changes of loans and off-balance sheet loan commitments. The use of loan commitment makes off-balance sheet business transfer to on-balance sheet assets. Therefore, the change of loan commitment offsets some loan changes. If the bank has higher off-balance sheet loan commitment, it may reduce loan provision. The statistical results of other variables except the main variables can be obtained from Table 3. Due to the differences in bank size, business capacity and customer attractiveness, large banks and small and medium-sized banks may differ for data sets. The results of descriptive statistics on variables of large banks and small and medium-sized banks are shown in Table 4.

Table 4 shows the descriptive statistics of large banks and small and medium-sized banks grouped by bank asset size. The average loan growth rate and credit growth rate of large banks (14.23% and 15.5%) are smaller than that of small and medium-sized banks (18.47% and 17.74%), but the volatility of loan

Variable symbol	Variable name (unit)	Mean	Std	Min	Med	Max	Data sources
$LOANG_{i,t}$	Loan growth rate (%)	18.25	14.71	−18.75	16.56	80.88	BankFocus
$CREDITG_{i,t}$	Credit growth rate (%)	17.56	16.46	−18.25	16.07	106.06	BankFocus
$CAP_{i,t-1}$	Capital Adequacy Ratio (%)	14.40	5.85	7.14	13.02	48.93	BankFocus
$LIQ_{i,t-1}$	Liquid assets ratio (%)	21.96	12.30	4.24	19.73	63.58	BankFocus
$ASSET_{i,t-1}$	Bank size	5.10	1.73	1.92	4.80	9.82	BankFocus
$ROAA_{i,t-1}$	Bank profitability (%)	0.93	0.45	−0.42	0.95	2.16	BankFocus
$LOSSRE_{i,t-1}$	Loan loss reserve (%)	2.86	1.13	0.51	2.75	6.87	BankFocus
$NONLOAN_{i,t-1}$	Non−performing loan ratio (%)	1.49	1.14	0.02	1.30	7.51	BankFocus
ΔGDP_t	Changes in GDP growth rate (%)	8.03	1.68	6.69	7.30	14.20	CEInet
ΔSHI_t	Market interest rate changes (%)	0.03	0.82	−1.11	0.34	1.510	CEInet

Table 3. Variable descriptive statistics.

Variable symbol	Variable name (unit)	Mean		Std		Min		Max	
		Large banks	small and medium-sized banks	Large banks	small and medium-sized banks	Large banks	small and medium-sized banks	Large banks	small and medium-sized banks
$LOANG_{i,t}$	Loan growth rate (%)	14.23	18.47	7.76	14.96	3.11	−18.75	50.39	80.88
$CREDITG_{i,t}$	Credit growth rate (%)	15.5	17.74	8.09	16.99	6.25	−18.25	42.89	106.06
$CAP_{i,t-1}$	Capital Adequacy Ratio (%)	12.91	14.48	1.48	5.99	9.41	7.14	15.50	48.93
$LIQ_{i,t-1}$	Liquid assets ratio (%)	13.55	22.40	4.95	12.42	5.34	4.24	26.70	63.58
$ASSET_{i,t-1}$	Bank size	9.31	4.88	0.46	1.47	8.27	1.92	9.82	9.11
$ROAA_{i,t-1}$	Bank profitability (%)	1.11	0.92	0.25	0.45	0.51	−0.42	1.47	2.16
$LOSSRE_{i,t-1}$	Loan loss reserve (%)	2.84	2.86	0.67	1.15	2.17	0.51	4.53	6.87
$NONLOAN_{i,t-1}$	Non−performing loan ratio (%)	1.98	1.46	1.17	1.14	0.75	0.02	5.13	7.51

Table 4. Variable descriptive statistics of different types of banks.

growth rate and credit growth rate of large banks (7.76 and 8.09) is smaller than that of small and medium-sized banks (14.96 and 16.99). Moreover, the credit growth rate of large banks (15.5%) is higher than the loan growth rate (14.23%), which indicates that the on-balance sheet loans and off-balance sheet loan commitments of large banks are increasing. For capital adequacy ratio and liquid asset ratio, small and medium-sized banks (14.48% and 22.40%) are higher than large banks (12.91% and 13.55%). One reason is that large banks are too big to be inverted, which means invisible protection when risks occur. Small and medium-sized banks must maintain sufficient capital and liquid assets to resist the impact. The other reason is that large banks have high reputation and customer attraction, large number of outlets, good customer base, and stronger capital replenishment and risk management capabilities, and small and medium-sized banks have no obvious advantages in these aspects. Therefore, the capital adequacy ratio and liquid asset ratio of small and medium-sized banks are higher. Considering the particularity of large banks in loan changes and other aspects, in the following part of the empirical study, in addition to the full sample, focuses on the analysis of small and medium-sized banks.

5. Empirical Results Analysis and Robustness Test

5.1. The Influence of Bank Capital Adequacy Ratio on Loan

The empirical results of the basic linear regression excluding the interaction between capital adequacy ratio and liquid asset ratio are shown in columns (1), (3), (5) and (7) of Table 5.

Variables	$LOANG_{i,t}$				$CREDITG_{i,t}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$LOANG_{i,t-1}/CREDITG_{i,t-1}$	0.405***	0.412***	0.405***	0.416***	0.285***	0.286***	0.274***	0.278***
	(−0.061)	(−0.063)	(−0.063)	(−0.064)	(−0.0579)	(−0.068)	(−0.058)	(−0.068)
$CAP_{i,t-1}$	0.245*	−0.947**	0.326**	−0.903**	0.128	−1.399***	0.251	−1.299***
	(−0.144)	(−0.424)	(−0.16)	(−0.446)	(−0.151)	(−0.389)	(−0.159)	(−0.426)
$LIQ_{i,t-1}$	0.117**	−0.370**	0.109*	−0.378**	0.005	−0.626***	−0.021	−0.644***
	(−0.054)	(−0.157)	(−0.057)	(−0.161)	(−0.075)	(−0.149)	(−0.078)	(−0.153)
$CAP_{i,t-1} \times LIQ_{i,t-1}$		3.044***		3.042***		4.013***		3.964***
		(−1.006)		(−1.032)		(−0.954)		(−0.982)
$ASSET_{i,t-1}$	0.191	0.0163	0.753*	0.367	0.081	−0.257	1.006*	0.424
	(−0.26)	(−0.228)	(−0.405)	(−0.352)	(−0.419)	(−0.337)	(−0.524)	(−0.457)
$ROAA_{i,t-1}$	0.943	1.399	1.206	1.5	3.275*	2.483	3.131*	2.376
	(−1.489)	(−1.426)	(−1.532)	(−1.397)	(−1.712)	(−1.798)	(−1.715)	(−1.835)
$LOSSRE_{i,t-1}$	1.414**	0.767	1.705***	1.021*	1.211	0.977	1.416*	1.179
	(−0.57)	(−0.52)	(−0.592)	(−0.541)	(−0.811)	(−0.75)	(−0.774)	(−0.722)
$NONLOAN_{i,t-1}$	−0.634	−1.099*	−0.596	−1.131*	0.0536	−0.5	0.167	−0.286
	(−0.514)	(−0.569)	(−0.535)	(−0.585)	(−1.237)	(−1.234)	(−1.242)	(−1.235)
ΔGDP_t	0.462	0.465	0.836*	0.79	−0.261	0.092	0.433	0.863
	(−0.412)	(−0.432)	(−0.46)	(−0.488)	(−0.616)	(−0.656)	(−0.676)	(−0.728)
ΔSHI_t	1.242***	1.479***	1.117**	1.393***	2.235***	2.302***	1.937***	1.995***
	(−0.425)	(−0.463)	(−0.438)	(−0.483)	(−0.671)	(−0.682)	(−0.713)	(−0.723)
AR(2)	0.318	0.267	0.338	0.298	0.969	0.969	0.965	0.912
Sargan test	0.161	0.137	0.08	0.074	0.86	0.908	0.824	0.835

Table 5. Regression results of the influence of bank capital adequacy ratio and liquid asset ratio on loan changes.

*** Indicates a significance level of 1%. ** Indicates a significance level of 5%. * Indicates a significance level of 10%. Standard errors are reported in parentheses.

Firstly, we find that the bank capital adequacy ratios have positive impact on bank loans and bank credit, and the impact on bank credit is less than that on bank loans. This shows that when the capital adequacy ratio is high, the bank thinks that it has a higher ability to absorb risk, so it increases lending. The result is consistent with the "risk absorption" effect. Columns (3) and (7) in Table 5 are the basic linear regression results of small and medium-sized banks. Compared with the whole sample, the capital adequacy ratio coefficient of small and medium-sized banks is larger. Because small and medium-sized banks are not "too big to fail" and are more cautious about taking risks. As shown in Table 4, the non-performing loan ratio of small and medium-sized banks is far lower than that of large banks (the average non-performing loan ratio of small and medium-sized banks is 1.46%, and the average non-performing loan ratio of large banks is 1.98%). The marginal effect of risk absorption of small and medium-sized banks by improving capital adequacy ratio is greater than that of large banks, and loan changes are more affected by capital adequacy ratio. When the credit growth rate is taken as the explained variable, the coefficient of capital adequacy ratio is smaller and not statistically significant. This is because when the bank is unwilling to provide loans due to low capital adequacy ratio, borrowers can still obtain loans through off-balance sheet loan commitments, and the bank's off-balance sheet credit expansion is less constrained by the supervision of capital level. Therefore, when the bank's capital adequacy ratio changes, the total changes of loans and off-balance sheet loan commitments are less affected.

Secondly, the liquid assets ratio has a positive effect on the change of bank loans, and the impact on bank credit is less than that on bank loans. Hypothesis 1a and hypothesis 2 are verified. In the whole sample and the sample of small and medium-sized banks, when the loan growth rate is a dependent variable, the coefficient of liquid asset ratio is positive and statistically significant. The coefficient of liquid asset ratio of small and medium-sized banks is small, but the difference is not large. According to the liquid asset ratio of banks different types in Table 4, the average liquid asset ratio of small and medium-sized banks is far greater than that of large banks (the average liquid asset ratio of large banks is 13.55%, and that of small and medium-sized banks is 22.40%). The marginal change of loan caused by liquid asset ratio is small. When the credit growth rate is taken as the dependent variable, the coefficient of liquid asset ratio is smaller and not statistically significant. When the loan expansion caused by the increase of liquid asset ratio gradually decreases, the borrower obtains loans through off-balance sheet loan commitment, offsetting the bank loan expansion, and the change of liquid asset ratio has little impact on the change of credit growth rate.

5.2. Regression Results with the Interaction of Capital Adequacy Ratio and Liquid Asset Ratio

In the regression model including the interaction of capital adequacy ratio and liquid asset ratio, the coefficient of interaction term of capital adequacy ratio and liquid asset ratio reflects the conditional effect of these two variables on loan growth rate and credit growth rate. As shown in Equations (8) and (9), the loan change caused by the change of unit capital adequacy ratio is related to the liquid capital ratio.

$$\partial LOANGi,t\partial CAPi,t-1=\alpha 2+\alpha 4LIQi,t-1 \quad (8)$$

$$\partial CREDITGi,t\partial CAPi,t-1=\delta 2+\delta 4LIQi,t-1 \quad (9)$$

The empirical results in columns (2), (4), (6) and (8) of Table 5 verify hypothesis 1b and hypothesis 2. The interaction coefficient of capital adequacy ratio and liquid asset ratio is significantly positive at 1% level when loan growth rate and credit growth rate are used as dependent variables. Columns (4) and (8) in Table 5 are the results of small and medium-sized banks with interactive items. The coefficient of interaction term of small and medium-sized banks is slightly smaller, that is, when the level of liquid assets of large banks and small and medium-sized banks is the same and the capital adequacy ratio increases, large banks issue more loans than small and medium-sized banks, which indicates that small and medium-sized banks are more cautious, but the average liquid asset ratio of small and medium-sized banks is higher than that of large banks. Therefore, the loan volatility of small and medium-sized banks is greater.

5.3. Analysis of the Influence of Capital Adequacy Ratio on Loan Changes under the Condition of Low Liquid Asset Ratio

Both the basic linear regression without the interaction between capital adequacy ratio and liquid asset ratio and the regression including the interaction term show that the liquid asset ratio promotes the loan changes. When the liquid asset ratio is low, the impact of capital adequacy ratio on loan changes may be negative. The empirical results of setting three different dummy variables of liquid asset ratio are shown in Table 6, which verifies hypothesis 3. In Table 6, column (1) shows the result of taking 1 for d when the ratio of liquid assets is less than the average value ($\mu LIQi<\mu LIQ\mu LIQi<\mu LIQ$); column (2) shows the result of taking 1 for d when the ratio of liquid assets is less than the average value minus 0.5 standard deviations ($\mu LIQi<\mu LIQ-0.5\sigma LIQ\mu LIQi<\mu LIQ-0.5\sigma LIQ$); column (3) shows the result of taking 1 for d when the ratio of liquid assets is less than the average value minus 1 standard deviation ($\mu LIQi<\mu LIQ-\sigma LIQ\mu LIQi<\mu LIQ-\sigma LIQ$). The main concern is the coefficient of $CAPi,t-1\times LIQi,t-1\times dCAPi,t-1\times LIQi,t-1\times d$. The empirical results show that when the ratio of bank liquid assets is low, the impact of interaction on bank loans is negative, and it does not become positive until the bank has sufficient liquidity.

5.4. Robustness Checks

This paper uses capital adequacy ratio ($CAPi,t-1CAPi,t-1$) to test the impact of capital adequacy ratio on loan changes in the effect of bank capital supervision. In addition to capital adequacy ratio, Basel Accord and China Banking and Insurance

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	$LOANG_{i,t}$	$CREDITG_{i,t}$	$LOANG_{i,t}$	$CREDITG_{i,t}$	$LOANG_{i,t}$	$CREDITG_{i,t}$
$LOANG_{i,t-1}/CREDITG_{i,t-1}$	0.399***	0.258***	0.422***	0.257***	0.407***	0.253***
	(0.0602)	(0.0689)	(0.0583)	(0.0682)	(0.0612)	(0.0661)
$CAP_{i,t-1}$	−1.169**	−0.781	−0.914**	−1.059***	−0.892**	−1.227***
	(0.482)	(0.543)	(0.439)	(0.381)	(0.424)	(0.347)
$CAP_{i,t-1} \times d$	0.682	−1.484	0.805	0.579	1.580	1.071
	(0.815)	(1.098)	(0.734)	(2.046)	(1.680)	(8.793)
$LIQ_{i,t-1}$	−0.354*	−0.342	−0.305*	−0.474***	−0.331**	−0.524***
	(0.188)	(0.274)	(0.160)	(0.175)	(0.160)	(0.158)
$LIQ_{i,t-1} \times d$	−0.181	−0.922	0.250	1.842	5.759**	5.039
	(0.537)	(0.755)	(0.512)	(1.538)	(2.357)	(16.01)
$CAP_{i,t-1} \times LIQ_{i,t-1}$	3.381***	2.548**	2.842***	2.976***	2.857***	3.154***
	(1.015)	(1.068)	(1.013)	(0.809)	(1.015)	(0.790)
$CAP_{i,t-1} \times LIQ_{i,t-1} \times d$	1.407	6.723	−2.591	−13.87	−48.20**	−47.40
	(4.101)	(5.661)	(4.000)	(11.48)	(20.37)	(127.8)
$ASSET_{i,t-1}$	0.350	1.376*	0.196	0.265	−0.0316	−0.302
	(0.558)	(0.945)	(0.276)	(0.461)	(0.224)	(0.301)
$ASSET_{i,t-1} \times d$	−0.517	−2.576***	−0.355	−1.671**	3.541***	9.798**
	(0.560)	(0.982)	(0.330)	(0.713)	(1.303)	(4.548)
$LOSSRE_{i,t-1}$	0.850	1.031	0.265	0.670	0.539	0.844
	(0.551)	(0.998)	(0.511)	(0.835)	(0.496)	(0.748)
$LOSSRE_{i,t-1} \times d$	−0.778	−0.265	0.0384	1.080	9.893***	0.364
	(0.719)	(1.370)	(0.851)	(1.465)	(2.159)	(19.23)
$ROAA_{i,t-1}$	2.715	0.272	1.577	1.764	1.641	1.369
	(1.837)	(2.447)	(1.480)	(2.075)	(1.427)	(1.752)
$ROAA_{i,t-1} \times d$	−5.290**	3.267	−3.166	2.230	14.76***	46.81
	(2.630)	(3.584)	(2.500)	(6.942)	(5.560)	(33.77)
$NONLOAN_{i,t-1}$	−1.040	−1.028	−0.394	−0.954	−0.723	−1.325
	(0.862)	(1.265)	(0.558)	(1.224)	(0.509)	(1.155)
$NONLOAN_{i,t-1} \times d$	0.260	−0.461	−1.153	−0.645	−1.027	16.87
	(0.941)	(1.987)	(0.772)	(2.027)	(1.455)	(24.08)
ΔGDP_t	0.452	0.226	0.498	0.170	0.492	0.188
	(0.380)	(0.651)	(0.421)	(0.630)	(0.426)	(0.657)
ΔSHI_t	1.414***	2.419***	1.390***	2.405***	1.350***	2.292***
	(0.448)	(0.720)	(0.463)	(0.702)	(0.465)	(0.699)
AR(2)	0.287	0.961	0.280	0.990	0.279	0.906
Sargan test	0.472	0.752	0.713	0.814	0.215	0.749

Table 6. Regression results under the condition of low liquid assets ratio.

*** Indicates a significance level of 1%. ** Indicates a significance level of 5%. * Indicates a significance level of 10%. Standard errors are reported in parentheses.

Regulatory Commission also makes provisions on the tier one capital adequacy ratio. The risk absorbing ability of the tier one capital is stronger, and the tier one capital adequacy ratio is used to test. Table 7 reports the regression results, of which columns (1) and (2) are the full sample regression results, and columns (3) and (4) are the regression results of small and medium-sized banks. The regression results show that the liquid asset ratio has a significant positive effect on the impact of capital adequacy ratio on loan changes. There is no significant difference between the regression results of robustness tests and those in Table 5, which further illustrates the effectiveness of the results.

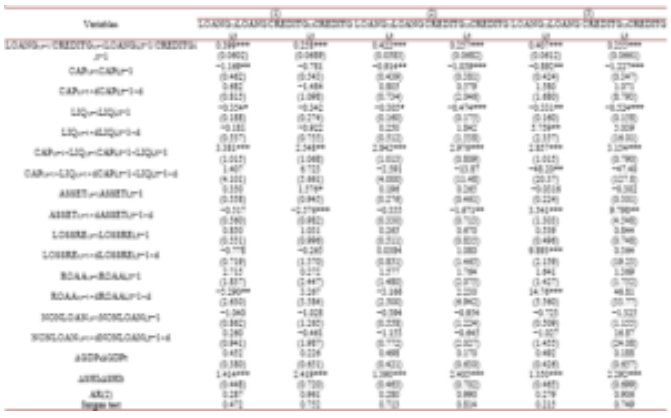

Table 7. Regression results of robustness tests.

*** Indicates a significance level of 1%. ** Indicates a significance level of 5%. * Indicates a significance level of 10%. Standard errors are reported in parentheses.

CONCLUSION

Based on the theoretical model and empirical analysis, this paper studies whether the impact of capital adequacy ratio on loan changes is related to the liquid asset ratio. The conclusion is as follows.

Firstly, the capital adequacy ratio of banks can promote the bank to issue loans, but it has less effect on the bank credit including bank loans and off-balance sheet loan commitments, while the capital adequacy ratio of small and medium-sized banks has a greater role in promoting bank loans and bank credit issuance. The relationship between the capital adequacy ratio and bank loans in China's commercial banks is in line with the "risk absorption" effect. The more capital, the more loans. As borrowers can obtain loans through off-balance sheet loan commitments, off-balance sheet business is transferred to on-balance sheet loan, and off-balance sheet loan commitment partially offsets the impact of capital adequacy ratio on bank loans. Because the large state-owned banks are too big to fail, the risk attitude of small and medium-sized banks is more cautious, and the non-performing loan ratio of small and medium-sized banks is far lower than that of large-scale banks. The marginal effect of "risk absorption" obtained by small and medium-sized banks by improving capital adequacy ratio is larger.

Secondly, the liquid assets of banks strengthen the role of capital adequacy ratio in promoting bank lending. Small and medium-sized banks are less affected by liquid assets. When the ratio of liquid assets is very low, bank's liquid assets react on the impact of capital adequacy ratio on bank lending. The liquid assets ratio of large banks plays a significant positive role in the impact of capital adequacy ratio on loan changes. When the liquid assets of large banks are small, the capital of large banks is used to increase liquid assets first, and when the liquid assets reach a certain level, capital supports the loan issuance. Small and medium-sized banks have a high ratio of liquid assets and loan changes are limited by the level of liquid assets.

The results of this paper have positive implications for capital management and supervision of commercial banks in China. Firstly, China's commercial banks should speed up the innovation of capital supplement tools and actively expand the channels of capital supplement. The capital adequacy ratio has a significant impact on the changes of bank loans. Commercial banks should pay attention to improving the capital adequacy ratio, especially small and medium-sized banks, to slow down the pressure of bank capital replenishment and ensure the banking industry's support to the real economy. The following methods can be adopted: retained earnings, listing financing, issuing additional shares, convertible bonds, introducing funds, insurance, annuity, etc., and relying on the domestic capital market and Hong Kong H-share market, we should expand the overseas capital market at the same time. Secondly, China's commercial banks should further ease liquidity, stimulate loan supply and increase profits. The liquid assets ratio of banks enlarges the influence of capital adequacy ratio on loan changes. In order to ensure the effectiveness of financial support policies for the real

economy, banks should enhance the liquidity of assets, dredge liquidity and stimulate loan supply. Thirdly, China's commercial banks should strengthen the management of off-balance sheet business and enhance their anti-risk ability. In this paper, when we consider off-balance sheet loan commitment, the results have changed, which shows that the off-balance sheet loan commitment and loan change are affected differently by capital adequacy ratio and other conditions, so we should pay special attention to this part.

In addition, capital supervision and liquidity supervision should be coordinated and inseparable. The positive impact of capital adequacy ratio on loan changes and the promotion of liquid asset ratio provide supporting evidence for capital management and liquidity management of commercial banks. The regulatory authorities should strengthen liquidity supervision, keep up with the pace of international supervision, put forward new regulatory index requirements, and formulate laws and regulations applicable to the domestic market. For example, when formulating relevant policies, banking regulatory authorities should not only consider the direct impact of capital regulation on banks, but also consider the combined impact of bank capital regulation and liquidity regulation, and put forward liquidity regulatory indicators linked with capital regulatory indicators, so as to prevent the outbreak of bank risks. In addition, the bank itself should do a good job of long-term capital utilization strategy and do a good job in the liquidity emergency and abnormal crisis situation. China's commercial banks should also timely follow up the regulatory requirements, actively explore and establish a monitoring system matching their own situation and improve the stability of the financial system and the ability to serve the real economy.

In summary, the paper studies whether the impact of capital adequacy ratio on loan changes is related with the bank's liquid asset ratio by constructing theoretical model and empirical analysis method. Although this paper has made some innovation and progress in research perspective and research content, but limited to research ability and research time, there is still room for further expansion. If the study can be carried out in a longer sample period in the future, then the conclusions of this paper will be more representative and comprehensive. Therefore, we need to further explore more advanced research methods in the follow-up research, accumulate more available data, and continuously track the related issues of this paper.

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