

Funding Liquidity and Bank Risk-Taking: Empirical Evidence from China

Yong Ma, Zhen Li*

Liquidity risk has a significant impact on the prudent operation of financial institutions and the stability of financial system. Funding liquidity risk has played an important role in banking crises in history. This paper uses the data of 338 commercial banks in China from 2002 to 2016 to analyze the relationship between funding liquidity and bank risk-taking. The findings show that: (1) Banks with lower funding liquidity risk take more risks, which is evidenced by lower Z-score and capital adequacy ratio, as well as higher risk-weighted asset ratio and liquidity creation. (2) Funding liquidity risk has an impact on the factors of bank risks. Lower funding liquidity risk increases bank profitability and reduces capital level. (3) Funding liquidity risk can affect bank risk-taking behavior through the intermediary effect of bank loans. (4) With a lower funding liquidity risk, larger asset and higher leverage ratio can restrain banks from taking more risks, and the banks can take less risks during the international financial crisis or higher economic risk periods.

Keywords: funding liquidity, bank risk, intermediary effect, heterogeneity

1. Introduction and Literature Review

Liquidity risk has an important impact on the prudent operation of financial institutions and the stability of the financial system. Lack of sufficient liquidity may plunge financial institutions into difficulties, and in serious cases may lead to liquidity crisis. Factors such as maturity mismatch of commercial banks' assets and liabilities, sensitivity to changes in interest rates, etc., will cause serious liquidity risk exposure (Rose and Hudgins, 2012). Before the international financial crisis in 2008, there was no globally unified liquidity regulatory framework, and the contagion of liquidity risk among banks became an important inducement of systemic risk. In view of this, all countries in the world viewed strengthening liquidity regulation as an important part

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of financial regulatory reform after the crisis. In December 2010, the Basel Committee on Banking Supervision issued *Basel III*, which introduced two liquidity supervision standards, liquidity coverage ratio (LCR) and net stable funding ratio (NSFR), to measure the liquidity risk of banks in the short term and long term respectively. In January 2014, China Banking Regulatory Commission promulgated *The Measures for Liquidity Risk Management of Commercial Banks (for Trial Implementation)*. Since then, China's banking industry has gradually adjusted its asset liability business structure to meet the regulatory standards of liquidity risk and enhance its ability to resist liquidity risk. As an important manifestation of liquidity risk, funding liquidity risk plays an important role in all previous banking crises (Drehmann and Nikolaou, 2013). As whether the latest requirements of *Basel III* on funding liquidity will reduce the risk-taking of commercial banks and improve the stability of the whole banking system is still unclear, further study is needed.

In order to study the relationship between funding liquidity and bank risk-taking, this paper first defines funding liquidity and funding liquidity risk. According to previous studies, funding liquidity is usually defined as the ability to raise cash by selling assets or borrowing new money in the short term (Brunnermeier and Pedersen, 2009). The International Monetary Fund (IMF, 2008) defines funding liquidity as the ability of solvent institutions to pay agreed amounts in a timely manner. The Basel Committee on Banking Supervision (BCBS, 2008) believes that liquidity is the ability to finance increased assets and meet obligations at maturity without incurring unacceptable losses. Referring to Drehmann and Nikolaou (2013), this paper defines funding liquidity as the ability to pay off debts immediately, and defines funding liquidity risk as the possibility that banks cannot pay off debts immediately in a specific period. The central banks of eurozone member countries conduct short-term main refinancing operations (MROs) in the form of standard bidding to provide liquidity to the banking system. Although the commercial banks' offer will expose the banks' liquidity risk (Drehmann and Nikolaou, 2013), the short-term MROs data are internal confidential data and not available, and the People's Bank of China does not include this policy tool in its open market operation. Consistent with Acharya and Naqvi (2012), Khan *et al.* (2017), this paper regards investors' deposits as bank funding liquidity, which can protect banks from operational risk. The increase of deposits means the improvement of funding liquidity, or the reduction of funding liquidity risk.

This paper mainly uses the theoretical prediction of Acharya and Naqvi (2012) to provide theoretical evidence support for banks to absorb a large number of deposits, reduce funding liquidity risk, and encourage them to take more risks. Acharya and Naqvi (2012) put forward a theory of bank loan, that is, to study how the internal agency problem affects the loan pricing. In practice, bank executives and managers are motivated to make too many loans because their pay increases with the increase of loans. Acharya and Naqvi (2012) prove that when the behavior or hard work of bank

executives and managers is not visible, the incentive linked with the amount of loans can be regarded as the optimal contract result of principal-agent problem to some extent, however, it will also cause banks to take too many risks. It is assumed that the client can conduct a costly audit afterwards to verify whether the bank manager has taken excessive radical actions such as reducing loan interest rate and approving excessive loan. Acharya and Naqvi (2012) show that, although the client may wish to implement strict audit policy in advance, the cost of audit means that the bank audit is the best choice after the event only when the liquidity shortage suffered by the bank is large enough. All in all, the ideal compensation for managers is to increase the number of loans to make them work hard, but if the bank manager underestimates the risk of investment (approves too many loans), then when the bank faces a serious liquidity shortage, the bank manager will face the risk of being punished. Therefore, when the bank liquidity is sufficient, the managers will reasonably expect that there will be loose audit policy, thus ignoring that the bank may face insufficient liquidity afterwards. That is to say, too many deposits make bank managers overconfident, relax loan standards, increase the number of loans to take too many risks, and lay a hidden danger for the bank's possible future crisis.

In addition, there are some studies that provide direct or indirect evidence for this paper. Myers and Rajan (1998), for example, find that for financial institutions, although more liquid assets improve their ability to raise cash in the short term, they may also reduce the ability of management to make credible commitments to protect investors' investment strategies. That is to say, banks must hold enough current assets to meet the needs of borrowers for cash, but more asset liquidity will reduce the ability of banks to raise external funds, which may increase the risk-taking of banks. Allen and Gale (2000) argue that asset bubbles are caused by agency relationships in the banking sector. Investors use funds borrowed from banks to invest in risky assets, which are relatively attractive because they can avoid losses in low yields by defaulting on loans. This kind of risk transfer causes investors to raise asset prices. When the positive credit expansion is not enough to prevent the crisis, financial vulnerability will appear. Gatev and Strahan (2006) find that banks have unique ability to hedge against market liquidity shocks. The inflow of deposits provides funds for the impact of loan demand after the decrease of market liquidity. When liquidity dries up and commercial paper spreads expand, banks will face capital inflow, which enables banks to meet the needs of lenders without reducing the current assets held by banks. That is to say, with the expansion of market interest margin, the loan growth rate and current assets of banks will rise. Berger and Bouwman (2009) test the theory of Acharya and Naqvi (2012) and verify the results, and find that high liquidity creation is accompanied by high risk. The focus of our study is not the behavior of lenders, but the behavior of bank executives and managers. Cheng *et al.* (2015) provide relevant evidence for this study. Based on the traditional principal-agent theory, risk-averse managers need higher pay

when they work in high-risk financial institutions, in order to compensate for the extra risks they take in equity. As a result, in order to achieve the higher compensation needed by managers to work in banks with higher risks, they may implement more radical loan strategies when there is sufficient liquidity (Cheng *et al.*, 2015).

It can be seen from Figure 1 that in the Asian financial crisis, the international financial crisis and their subsequent impact periods (2002—2004, 2007—2010), compared with the high-risk direct investment, investors prefer bank deposits, which drives the deposit asset ratio of China's banking industry significantly higher. In 2015, the deposit asset ratio of China's banking industry increased slightly, which may be the short-term effect of China's formal introduction of explicit deposit insurance system. The better protection of depositors' interests led to a small increase in bank deposits. Deposit insurance can be regarded as a put option on bank assets (Merton, 1977). Due to the existence of explicit or implicit deposit insurance system, excessive risk-taking by banks will make deposit insurance face moral hazard (Keeley, 1990), which is particularly obvious for developing countries like China (Duan *et al.*, 2018). Guo and Zhao (2017) find that after the introduction of explicit deposit insurance system, China's large non-state-owned commercial banks take more risks by increasing leverage and shadow banking business. Although deposits can protect banks from operational risks, with the increase of deposits, banks are motivated to overloan to take more risks, which is at the cost of deposit insurance, i.e. the lower funding liquidity risk provides banks with more motivation to take more risks (Khan *et al.*, 2017).

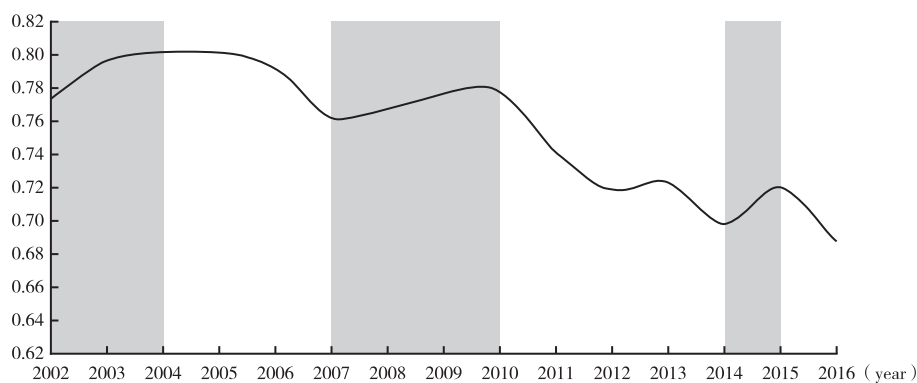


Figure 1. Deposit Asset Ratio of China's Banking Industry from 2002 to 2016

Source: Wind database and the authors' calculation.

Based on the data of 338 commercial banks in China from 2002 to 2016, this paper empirically analyzes the relationship between funding liquidity risk and bank risk-taking. In order to enhance the robustness of the benchmark model results, this paper tests the robustness based on different bank risk-taking proxy variables, not adding macro-control variables, not controlling the fixed effect of time. At the same time,

the methods of instrumental variable 2SLS estimation, propensity score matching estimation, system GMM estimation, one phase lag of independent variable and potential missing variable control are used to alleviate the endogeneity of benchmark model. In this paper, the above regression results are further discussed from three aspects. First of all, this paper analyzes the influence of funding liquidity risk on the factors of bank risk (Z-score), and finds that the decrease of funding liquidity risk will improve profitability, reduce bank risk, but also reduce capital level and improve bank risk, which is generally manifested as the increase of bank risk. Secondly, this paper studies whether the funding liquidity risk affects the risk-taking behavior of banks through loans. The results show that there is an intermediary effect with bank loans as the intermediary variable. The decrease of funding liquidity risk will lead to the increase of bank loans, and then improve the risk-taking level of banks. Finally, this paper further investigates whether there is heterogeneity in the impact of funding liquidity risk on bank risk-taking. The results show that when the funding liquidity risk is low, the overall stability and capital adequacy level of large banks are higher, and their risk of financial intermediation is lower, while the capital adequacy level of banks with high leverage is higher and their risk of financial intermediation is lower, and asset risk and financial intermediary risk are lower during financial crises while, the capital adequacy level of banks is higher and the risk of financial intermediary is lower during the periods of high economic risk.

Compared with the existing research, this paper makes useful exploration and innovation in four aspects. Firstly, in terms of literature, there are few studies on the relationship between funding liquidity risk and bank risk-taking, especially on the empirical analysis of China's banking industry. Based on the data of China's banking industry, this paper systematically examines the impact of funding liquidity risk on bank risk-taking, and measures bank risk-taking from the perspectives of banks' overall stability, capital adequacy level, asset risk, financial intermediary risk, etc. Therefore, while enriching bank liquidity risk management research, we also provide an important supplement for bank risk-taking behavior analysis. Secondly, in terms of risk composition, this paper makes an important expansion of the existing research. We use the factors such as the return on equity, equity to asset ratio and the volatility of return on equity as the components of bank Z-score to test the impact of funding liquidity risk on the components of bank risk. Thirdly, in the aspect of intermediary effect, this paper attempts to compensate for the lack of intermediary influence mechanism in the existing empirical literature. By using the intermediary effect test procedure proposed by Baron and Kenny (1986) and Wen *et al.* (2004), we investigate whether the funding liquidity risk affects the bank's risk-taking behavior through loans. Fourthly, in terms of heterogeneity analysis, this paper further analyzes whether there is asymmetry in the impact of funding liquidity risk on bank risk-taking in terms of bank size, leverage ratio, financial crisis or high-risk economic period. The analysis of perspectives such

as high leverage and high economic risk further enriches the empirical evidence of Khan *et al.* (2017).

The structure of the rest of this paper is as follows: the second part is research design, including the description of main variables, model setting and sample selection; the third part is empirical analysis and test, including benchmark model regression, robustness test and endogeneity treatment; the fourth part is expanded discussion, including risk composition analysis, intermediary effect test and heterogeneity impact; the fifth part is conclusions and policy recommendations.

2. Research Design

2.1. Description of Main Variables

2.1.1. Proxy Variables of Bank Risks

Based on the practice of Laeven and Levine (2009), this paper uses Z-score to measure the overall stability of commercial banks. The formula is as follows:

$$Z\text{-score} = (ROE + EquityToAsset) / \sigma(ROE) \quad (1)$$

where, *ROE* is the return on equity, *EquityToAsset* is the equity to asset ratio, $\sigma(ROE)$ is the 3-year moving standard deviation of the return on equity. To avoid the influence of the peak and fat tail of *Z-score*, this paper takes the natural logarithm of *Z-score*. The greater the value of *Z-score*, the smaller the total default risk and the stronger the stability of commercial banks. In addition, this paper uses the 2-year, 4-year and 5-year moving standard deviation of *ROE* to calculate *Z-score*, and the regression results are consistent with the 3-year moving standard deviation of *ROE*. At the same time, in the stability test, referring to the practice of Zhang and Wang (2012), this paper uses capital adequacy ratio (*CapitalRatio*) instead of the equity to asset ratio (*EquityToAsset*) for calculation of *Z-score* to measure the overall stability of commercial banks.

Capital adequacy can capture important aspects of bank risks (Zhu and Yang, 2016) and help banks increase their probability of survival to assess the extent to which they absorb potential losses (Berger and Roman, 2013). This paper uses the capital adequacy ratio to measure the capital adequacy level of banks, and uses the ratio of net capital of banks to risk-weighted assets, which includes credit risk-weighted assets, market risk-weighted assets, operational risk-weighted assets and capital bottom line adjustment. Commercial banks have a high negative capital effect on risk. The higher the capital adequacy ratio, the lower the risk of banks (Lee and Hsieh, 2013). The negative correlation between bank capital and risk can be explained by the “moral hazard

hypothesis”, that is, due to the existence of explicit or implicit deposit insurance system, banks with insufficient capital bear excessive risk (Demirgüç-kunt and Kane, 2002). In the stability test, this paper uses core capital adequacy ratio (*Tier1Ratio*) to replace capital adequacy ratio (*CapitalRatio*) to measure the capital adequacy level of banks.

In the existing literature, risk-weighted asset ratio is widely used to measure the quality of bank assets, and non-performing loan ratio is often used to measure bank credit risk. Both risk-weighted assets ratio and non-performing loan ratio can measure the risk of bank assets. The former is expressed by the ratio of risk-weighted assets to total assets, which measures the bank’s active asset risk-taking, and the latter is expressed by the ratio of non-performing loans to total loans, which measures the bank’s passive asset risk-taking. Risk-weighted assets are calculated according to the Basel capital regulatory rules and can be determined when loans are issued. The higher the ratio of risk weighted assets, the stronger the willingness of banks to purchase high-risk assets. Non-performing loans are the number of loans identified as possible default problems after the issuance of loans. The higher the non-performing loan ratio, the more risk assets the bank may default. In this paper, risk-weighted asset ratio (*RWAToAsset*) is used as the main risk proxy variable of bank assets, and non-performing loan ratio (*NPLRatio*) is used for robustness test.

Financial intermediation is used to realize the conversion of term and liquidity, non-current long-term assets are financed by current short-term liabilities. Although the unique intermediary role of liquidity supply of commercial banks is conducive to their daily business activities, there are also inherent vulnerabilities (Xin and Tao, 2018). The maturity mismatch between assets and liabilities of commercial banks aggravates the financial intermediary risk faced by banks (Khan *et al.*, 2017). Berger and Bouwman (2009) propose a comprehensive index to calculate liquidity creation, which comprehensively reflects the liquidity maturity mismatch of commercial banks.¹ The more liquidity creation of commercial banks, the higher the risk of financial intermediation. Referring to Berger and Bouwman (2009), Xin and Tao (2018), and excluding the ones with poor data availability, we divide the bank’s balance sheet items into three categories of liquidity, quasi liquidity and illiquidity according to the liquidity size and give them different weights respectively. According to the classification of balance sheet items and their corresponding weights, the total amount of liquidity creation of the bank is obtained after weighted sum, and then the liquidity creation index is obtained by dividing the total assets of the bank. In this paper, liquidity creation (*LCToAsset*) is used as the proxy variable of financial intermediary risk. In the robustness test, asset liquidity creation (*ALCToAsset*) and liability liquidity creation (*LLCToAsset*) are used as the proxy variables of financial intermediary risk.

¹ Due to space limitations, detailed liquidity categories and weights of banking activities are omitted here, which are available upon request.

2.1.2. Proxy Variable of Funding Liquidity Risk

Acharya and Naqvi (2012) try to explain that sufficient liquidity may aggravate the risk-taking behavior of bank executives, resulting in excessive loans and asset price bubbles. They regard investors' deposits as bank liquidity, because in order to protect banks from run risk, banks need to take a certain proportion of deposits as liquidity reserve. Therefore, deposits are the main determinant of bank reserve, so they can choose deposits as bank liquidity. With reference to Acharya and Naqvi (2012), Khan, *et al.* (2017), this paper selects deposit asset ratio (*DepositToAsset*) as the proxy variable of funding liquidity risk. The higher the deposit asset ratio, the higher the funding liquidity of the bank and the lower the funding liquidity risk. More reliance on deposits to fund long-term assets will reduce the risk of bank runs in the short term. In the case of explicit or implicit deposit insurance, deposit can protect banks from operational risks. Deposit insurance can be regarded as the put option of bank assets. Due to the existence of deposit insurance, banks will be motivated to take more risks with the increase of deposits (Khan *et al.*, 2017). Table 1 shows the symbols and definitions of variables used in this paper.

Table 1. Definition of Main Variables

Variable	Description
<i>Z-score</i>	$\ln [(return\ on\ equity + capital\ asset\ ratio) / 3\text{-year\ moving\ standard\ deviation\ of\ the\ return\ on\ equity}]$
<i>Z-value</i>	$\ln [(return\ on\ equity + capital\ adequacy\ ratio) / 3\text{-year\ moving\ standard\ deviation\ of\ the\ return\ on\ equity}]$
<i>CapitalRatio</i>	Capital adequacy ratio = net capital / risk-weighted assets
<i>Tier1Ratio</i>	Core capital adequacy ratio = net core capital / risk-weighted assets
<i>RWToAsset</i>	Risk-weighted assets ratio = risk-weighted assets / total assets
<i>NPLRatio</i>	NPL ratio = NPL / total loan
<i>LCToAsset</i>	Liquidity creation = $[0.5 \times \sum (\text{non-current assets} + \text{current liabilities}) - 0.5 \times \sum (\text{current assets} + \text{non-current liabilities} + \text{owners' equity})] / \text{total assets}$
<i>ALCToAsset</i>	Asset-side liquidity creation = $(0.5 \times \sum \text{non-current assets} - 0.5 \times \sum \text{current assets}) / \text{total assets}$
<i>LLCToAsset</i>	Liability-side liquidity creation = $[0.5 \times \sum \text{current liabilities} - 0.5 \times \sum (\text{non-current liabilities} + \text{owners' equity})] / \text{total assets}$
<i>DepositToAsset</i>	Deposit asset ratio = total deposits / total assets
<i>TotalAssets</i>	Capital scale = $\ln (\text{total assets (yuan)})$
<i>ROA</i>	Return on assets = net profit / average value of total assets at the beginning and end of the year
<i>NIIToIncome</i>	Proportion of non-interest income = non-interest income / operating income
<i>IncomeDiversity</i>	Income diversification = $1 - [\text{net interest income} - \text{non-interest income}] / \text{operating income}$

Variable	Description
<i>IsListed</i>	Dummy variable of whether it is a listed bank or not
<i>HHI</i>	The competitiveness of the bank's location is obtained by summing up the square of the number of branches in the bank's location to obtain the Herfindahl-Hirschman Index (HHI). National banks use national data, and local banks use prefecture-level city data.
<i>GDPPerCapital</i>	ln (GDP per capita of bank location). National banks use national data, and local banks use prefecture-level city data.
<i>DepositToAssetOther</i>	Average value of deposit asset ratio of other banks of the same type in the current year
<i>LoanToAsset</i>	Loan to asset ratio = total loans / total assets
<i>ROE</i>	Return on equity = net profit / average value of owners' equity at the beginning and end of the year
<i>EquityToAsset</i>	Equity asset ratio = owners' equity / total assets
<i>SDROE</i>	Volatility of return on equity = 3-year moving standard deviation of return on equity
<i>IsBig</i>	Dummy variable of whether it is a large bank. If the total assets of the bank throughout all the years are greater than the quarter of the sample space, the value is 1. Otherwise, the value is 0.
<i>IsHighLeverage</i>	Dummy variable of whether it is a bank with high leverage. If the leverage ratio (debt to total assets) of the bank in all years is greater than one quarter of the sample space, the value is 1, otherwise the value is 0.
<i>IsCrisis</i>	Dummy variable of whether it is in the international financial crisis. The value from 2008 to 2009 is 1, otherwise it is 0.
<i>IsMacRisk</i>	Referring to Chen <i>et al.</i> (2016), this paper divides the economic cycle into three specific categories: the upsurge period, the recession period and the normal period. <i>IsMacRisk</i> is the dummy variable of whether it is in the period of high economic risk, that is, when the economy is in the period of upsurge or recession, the value is 1; otherwise, the value is 0. National banks use national data, local banks use prefecture-level city data.

2.2. Model Settings

To analyze the impact of liquidity risk on the risk-taking of commercial banks, this paper uses the Ordinary Least Squares (OLS) estimation method to establish a benchmark model:

$$BankRisk_{bt} = \alpha + \beta Liquidity_{bt} + \gamma Controls_{bt} + \theta_t + \varepsilon_{bt} \quad (2)$$

where, the explained variable $BankRisk_{bt}$ represents the risk-taking of the bank b in the period t . In the model, we use the Z-score of natural logarithm to measure the overall risk of the bank, the capital adequacy ratio (*CapitalRatio*) to measure the capital adequacy level of the bank, use the risk-weighted asset ratio (*RWToAsset*) to measure the asset risk of the bank, and use the liquidity creation (*LCToAsset*) to

measure the financial intermediary risk. Core explanatory variable $Liquidity_{bt}$ represents liquidity risk. Referring to Acharya and Naqvi (2012), Khan *et al.* (2017), this paper uses deposit asset ratio ($DepositToAsset$) as the proxy variable of liquidity risk. The larger the deposit asset ratio is, the greater the bank's funding liquidity and the smaller the funding liquidity risk. Control variable $Controls_{bt}$ includes bank-level asset scale ($TotalAssets$), return on assets (ROA), non-interest income ratio ($NIIToIncome$), income diversity ($IncomeDiversity$), dummy variable of whether it is a listed Bank ($IsListed$). Macro environment variables include competitiveness (HHI) and per capita GDP ($GDPPerCapital$). α is the intercept term, θ_t is the time effect of commercial banks, ε_{bt} is a residual term. In order to solve the possible problem of sequence correlation, this paper uses heteroscedasticity robust standard error to cluster at the bank level.

In order to analyze whether the change of funding liquidity risk affects the banks' risk-taking through loans, this paper uses the intermediary effect test procedure proposed by Baron and Kenny (1986), Wen *et al.* (2004) to test the intermediary effect of bank loans as the mediator. The specific regression model is shown in equation (2) and equations (3) and (4).

$$Loan_{bt} = \alpha + \delta Liquidity_{bt} + \gamma Controls_{bt} + \theta_t + \varepsilon_{bt} \quad (3)$$

$$BankRisk_{bt} = \alpha + \beta' Liquidity_{bt} + \beta_1 Loan_{bt} + \gamma Controls_{bt} + \theta_t + \varepsilon_{bt} \quad (4)$$

where, $Loan_{bt}$ represents bank loans, with the ratio of loans to assets ($LoanToAsset$) as the proxy variable. Figure 2 provides details of the intermediary effect test procedure of bank loans.

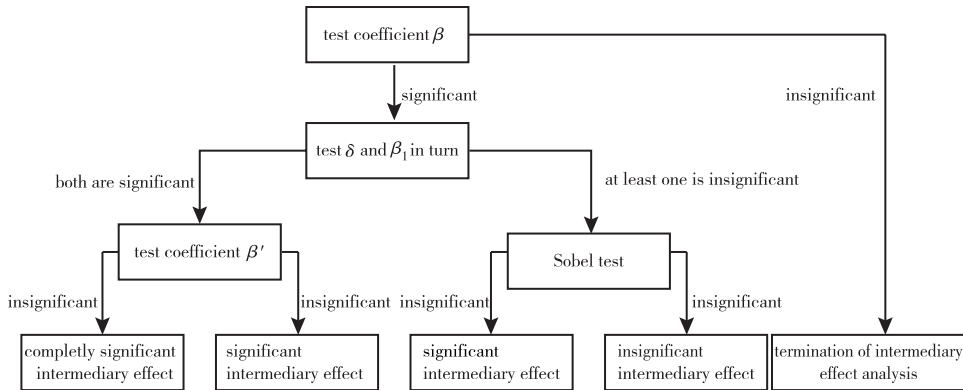


Figure 2. Test Procedure of Intermediary Effect

In order to further study whether the impact of funding liquidity risk on the risk-taking of different types of banks in different periods is different, this paper adds into the benchmark model dummy variables such as whether it is a large bank, whether it is

a bank with high leverage, whether it is in the international financial crisis, whether it is in the period of high economic risk and their cross terms with liquidity variables to build the extended model:

$$\begin{aligned} BankRisk_{bt} = & \alpha + \beta Liquidity_{bt} + \beta_1 Dum_{bt} + \beta_2 Liquidity_{bt} \times Dum_{bt} \\ & + \gamma Controls_{bt} + \theta_t + \varepsilon_{bt} \end{aligned} \quad (5)$$

where, Dum_{bt} represents the heterogeneity of various banks' risk-taking in different periods, $Liquidity_{bt} \times Dum_{bt}$ is used to analyze whether the impact of funding liquidity risk on the risk-taking of different banks in different periods is asymmetric. In terms of different types of commercial banks, the dummy variable of whether it is a large bank (*IsBig*) is used first: if the total assets of the bank throughout all those years are greater than the quarter of the sample space, the value is 1, otherwise the value is 0; next the dummy variable of whether it is a bank with high leverage (*IsHighLeverage*) is used: if the leverage ratio (debt to total assets) of the bank throughout all the years is greater than the quarter of the sample space, the value of one quantile is 1, otherwise it is 0. In terms of commercial banks in different periods, the dummy variable of whether they are in the international financial crisis (*IsCrisis*) is first used: the value for 2008—2009 is 1, otherwise the value is 0; the dummy variable of whether they are in the period of high economic risk (*IsMacRisk*) is used next, when the economy is in the period of high risk (upsurge or recession), value is 1, otherwise the value is 0. This paper also control the year effect, and in order to solve the problem of sequence correlation, we use heteroscedasticity robust standard error and cluster at the bank level.

2.3. Sample Selection

This paper selects the data of the unbalanced panel of 338 commercial banks in China from 2002 to 2016 as the research sample. All the data are from Wind database, BankScope, and annual reports of commercial banks in China. We treated the initial samples as follows: (1) considering the object of this study, we excluded China Post Savings Bank and policy banks; (2) for the purpose of calculating the Z-score of bank risk-taking index, we excluded banks with data less than three consecutive years of return on equity (*ROE*), equity asset ratio (*EquityToAsset*), and capital adequacy ratio (*CapitalRatio*); (3) we excluded samples which have selected variables with missing values; (4) to eliminate the influence of outliers on the regression results, the variables selected were winsorized at the upper and lower 1% quantiles. According to the classification criteria of CBIRC at the end of 2018, 338 sample commercial banks include 5 large state-owned commercial banks, 12 joint-stock commercial banks, 120 urban commercial banks, 164 rural commercial banks and 37 foreign-funded corporate banks. By the end of 2016, the total assets of the banks selected accounted for 76.33%

of the total assets of financial institutions in the banking industry and 97.67% of the total assets of commercial banks. Therefore, the research sample used in this paper covers major commercial banks in China and is a particularly representative bank sample. Since the average age of the study sample is 7 years, in order to avoid potential sample selection problems, this paper tests the bank samples with the variables removed for less than 5 and 7 consecutive years respectively, and finds that the main conclusions remain stable. In addition, the regression results are consistent with the main conclusions of this paper.

3. Empirical Analysis and Test

3.1. Benchmark Model Regression

Table 2 reports the regression results of the benchmark model based on equation (2). In all the models, we use heteroscedasticity robust standard errors and cluster them at the bank level, include bank characteristic variables and macro environment variables, and control the time fixed effect to avoid the impact of other unobservable factors on bank risk-taking. It can be concluded that there is no multicollinearity problem as the value of variance inflation factor (VIF) of every model is less than 10. The results show that there is a significant negative correlation between funding liquidity risk and bank risk-taking, that is, the smaller the funding liquidity risk (the greater the deposit asset ratio, the greater the funding liquidity), the greater the risk-taking of commercial banks, which is consistent with the analysis of Acharya and Naqvi (2012), Khan *et al.* (2017). Specifically, there is a significant positive correlation between funding liquidity risk and the overall stability and capital adequacy level of banks, and a significant negative correlation between funding liquidity risk and bank asset risk, financial intermediary risk.

Table 2. Funding Liquidity and Bank Risk-Taking

Model	(1)	(2)	(3)	(4)
Explained variable	<i>Z-score</i>	<i>CapitalRatio</i>	<i>RWAToAsset</i>	<i>LCToAsset</i>
<i>DepositToAsset</i>	-0.665** (0.312)	-0.388*** (0.064)	0.177*** (0.046)	0.430*** (0.052)
Control variable	control	control	control	control
Time fixed effect	control	control	control	control
Adjust R ²	0.154	0.403	0.199	0.373
Sample size	1690	2249	2092	2346
Number of banks	333	336	330	338

Notes: OLS estimation is used in this table. The number in the table is the regression coefficient of the variable, and in the corresponding bracket is the clustering robust standard error at the bank level.

3.2. Robustness Test and Endogeneity Treatment¹

In this paper, we use different bank risk-taking proxy variables, do not add macro-control variables and do not control the fixed effect of time to test the robustness, and find that there is still a significant negative correlation between funding liquidity risk and bank risk-taking. At the same time, we use two-stage least squares (2SLS) of instrumental variables, propensity score matching (PSM), system GMM, one-stage lag of independent variables and controlling potential missing variables to analyze the endogeneity, and find that the regression results are consistent with the benchmark model.

4. Extended Discussions

4.1. Analysis of Risk Composition

In Table 3, we use *ROE* as a component of *Z-score* to measure the bank's profitability, *EquityToAsset* to measure the bank's capital level, and *SDROE* to measure the bank's profitability volatility. The explanatory and control variables are still consistent with the benchmark model. In column (1), there is a significant negative correlation between funding liquidity risk and bank profitability. The possible reason is that with the increase of deposit funds, bank loans increase with the decrease of lending standards (Acharya and Naqvi, 2012), which will improve the profitability of banks (Köhler, 2012). In column (2), there is a significant positive correlation between funding liquidity risk and bank capital level, which is consistent with the result when the explanatory variable is capital adequacy ratio in the benchmark model. The results of columns (1) and (2) show that the funding liquidity risk has different effects on the profitability and capital level in the factors of bank risk (*Z-score*), which ultimately affects the overall stability of the bank. Specifically, the reduction of funding liquidity risk will improve profitability and reduce bank risk, but it will also reduce capital level and improve bank risk, which is generally reflected in the increase of bank risk (the sum of the coefficients of the components of *Z-score*, *ROE* and *EquityToAsset*, equals -0.105). In addition, in column (3), the volatility of return on equity (*SDROE*) as the denominator of *Z-score* is often used to measure the bank's risk-taking (Zhu and Yang, 2016). Although the coefficient of funding liquidity (*DepositToAsset*) is not significant, the sign of coefficient is positive, which indicates that there may be a positive correlation between the volatility of profitability and the risk-taking of banks.

¹ Due to space limitations, detailed regression results are omitted here, which are available upon request.

Table 3. Funding Liquidity and Bank Risk-Taking: Analysis of Z-score Components

Model	(1)	(2)	(3)
Z-score components			
Explained variable	<i>ROE</i>	<i>EquityToAsset</i>	<i>SDROE</i>
<i>DepositToAsset</i>	0.084*** (0.012)	-0.189*** (0.022)	0.011 (0.008)
Control variable	control	control	control
Time fixed effect	control	control	control
Adjust R ²	0.656	0.441	0.152
Sample size	2350	2350	1693
Number of banks	338	338	333

4.2. Intermediary Effect Test

In order to investigate whether the risk of funding liquidity affects the risk-taking of banks through loans, this paper uses loan to asset ratio (*LoanToAsset*) as an intermediary variable to test the intermediary effect. First of all, it can be seen from the above that there is a significant negative correlation between funding liquidity risk and bank risk-taking. In column (1) of Table 4, the results show that there is a significant negative correlation between funding liquidity risk and bank loans, that is, the smaller the funding liquidity risk, the larger the loan scale of commercial banks. This is consistent with the results of Brunermeier and Pedersen (2009), Drehmann and Nikolaou (2013), Chung *et al.* (2018), Wang and Yang (2014). In column (2), Sobel test statistic is 1.477, which is greater than the critical value of 0.97 at the 0.05 significance level. According to the intermediary effect test procedure in Figure 2, there is a significant intermediary effect with loan asset ratio (*LoanToAsset*) as the intermediary variable; in columns (3) and (5), there is a significant intermediary effect with loan asset ratio (*LoanToAsset*) as the intermediary variable; in column (4), there is a significant complete intermediary effect with loan asset ratio (*LoanToAsset*) as the intermediary variable. Therefore, there is an intermediary effect of taking bank loans as intermediary variables, and funding liquidity risk affects bank risk-taking through loans.

Table 4. Funding Liquidity and Bank Risk-Taking: Based on the Intermediary Effect of Bank Loans

Model	(1)	(2)	(3)	(4)	(5)
Explained variable	<i>LoanToAsset</i>	<i>Z-score</i>	<i>CapitalRatio</i>	<i>RWAToAsset</i>	<i>LCToAsset</i>
<i>DepositToAsset</i>	0.394*** (0.035)	-0.903*** (0.334)	-0.326*** (0.051)	-0.059 (0.047)	0.145*** (0.041)
<i>LoanToAsset</i>		0.485 (0.327)	-0.143*** (0.052)	0.513*** (0.055)	0.723*** (0.042)

Model	(1)	(2)	(3)	(4)	(5)
Control variable	control	control	control	control	control
Time fixed effect	control	control	control	control	control
Adjust R ²	0.414	0.155	0.416	0.339	0.561
Sample size	2349	1690	2249	2092	2345
Number of banks	338	333	336	330	338

4.3. Heterogeneity Impact¹

4.3.1. The Impact of Bank Size

This paper finds that when the funding liquidity risk is low, the overall stability and capital adequacy level of large banks are higher than that of small and medium banks, and the risk of financial intermediation is lower, which can be proved by high Z-score, capital adequacy ratio and low liquidity creation. Therefore, these results are similar to the findings of Khan *et al.* (2017), that is, in order to deal with the lower funding liquidity risk, the asset risk and overall risk of large banks are generally lower than that of small banks. Large banks take less risk in response to lower funding liquidity risk. It can be seen from the benchmark model that the improvement of income diversity will reduce the risk-taking level of banks. Due to the more diversified business model of large banks, as well as more stringent prudential supervision and regulatory constraints (Khan *et al.*, 2017), large banks may take less risk to cope with the lower funding liquidity risk. As to the robustness test, based on the perspective of the bank's business scope, we analyze whether the national banks have an impact on the relationship between funding liquidity risk and bank risk-taking, and find that the conclusions are basically consistent with the perspective based on bank size.

4.3.2. The Impact of High Leverage

This paper finds that when the funding liquidity risk is low, the capital adequacy level of highly-leveraged banks is higher, and the risk of financial intermediation is lower, which can be proved by high capital adequacy ratio and low liquidity creation. These results are consistent with the existing literature, that is, as excessive leverage enlarges potential investment losses (Tasca *et al.*, 2014), shareholders will also suffer losses in the case of bank bankruptcy (Repullo, 2004), and banks with higher leverage

¹ Due to space limitations, detailed regression results are omitted here, which are available upon request.

will take less risk when they have more deposits. Therefore, highly-leveraged banks take less risk in response to lower funding liquidity risk.

4.3.3. The Impact of Financial Crisis

This paper finds that during the financial crisis, when the funding liquidity risk is low, the asset risk and financial intermediary risk of banks are lower, which can be proved by the lower risk-weighted asset ratio and liquidity creation. These results are consistent with the conclusions of Acharya and Mora (2015), Khan *et al.* (2017). Before the financial crisis, bank deposits were in a weaker position because investors believed that the risk of bank deposits was greater than that of financial instruments (Acharya and Mora, 2015). At the beginning of the crisis, due to the decrease of deposit inflow, banks would reduce new credit, and their future operating performance would deteriorate (Cohen *et al.*, 2014). After the outbreak of the crisis, investors became highly risk averse, while the government explicitly supported deposit insurance, and investors were more inclined to deposit funds in the bank (Acharya and Mora, 2015). Therefore, during the international financial crisis, bank risk decreases with the decrease of funding liquidity risk.

4.3.4. The Impact of Macroeconomic Risks

This paper finds that in the period of high economic risk, when the risk of funding liquidity is low, the capital adequacy level of banks is higher and the risk of financial intermediation is lower, which can be proved by high capital adequacy ratio and low liquidity creation. When the macroeconomic risk is high, investors cannot control the increase of enterprises or enterprise moral risk well, bank deposits are considered to be safer, and investors will reduce direct investment and hold more bank deposits (Acharya and Naqvi, 2012). However, when the economic risk is high, the sensitivity of bank managers to the repayment of economic risk is improved, the loan behavior may become more conservative, the loan standard is improved, the credit is tightened, the level of capital adequacy is improved, and the risk bearing of banks is reduced. Therefore, in the period of high economic risk, bank risk decreases with the decrease of funding liquidity risk.

5. Conclusions and Policy Suggestions

This paper uses the data of 338 commercial banks in China from 2002 to 2016 to study the impact of funding liquidity risk on bank risk-taking. The empirical results show that banks with lower funding liquidity risk will take more risks, while banks with higher deposits will have lower funding liquidity risk, because deposits can protect banks from operational risks in the presence of explicit or implicit deposit

insurance. In addition, sufficient liquidity can help banks avoid capital shortage, which may stimulate banks' risk-taking tendency and thus take higher risks. Further analysis shows that: (1) deposit growth will improve profitability and reduce bank risk, but it will also reduce capital level and improve bank risk, which is generally reflected in the rise of bank risk; (2) there is an intermediary effect that takes bank loan as an intermediary variable, that is, the decrease of funding liquidity risk will lead to the increase of bank loan, which will further increase bank risk; (3) when the risk of capital liquidity is low, the capital adequacy level of large banks and highly-leveraged banks is higher, and the risk of financial intermediation is lower; (4) during the financial crisis, the risk of assets and financial intermediation of banks is lower; at the same time, in the period of high economic risk, the capital adequacy level of banks is higher, and the risk of financial intermediation is lower.

The conclusion of this paper has a clear enlightenment to bank operators and government supervision departments. Firstly, because the lower funding liquidity risk may promote banks to take more risks, banks should avoid the excessive growth of short-term funding liquidity, maintain a moderate level of capital, and control the excessive risk-taking; secondly, because the funding liquidity risk may affect the risk-taking behavior of banks through loans, banks should better regulate the credit release and management, and reasonably control credit scale; thirdly, because large banks and highly leveraged banks usually face higher risk-taking, the government should strengthen the risk supervision of large banks and highly leveraged banks to avoid the systemic risk caused by excessive risk-taking of these banks; fourthly, the counter cyclical financial supervision still needs to be strengthened and improved as the external financial and economic impact is still likely to greatly affect the stability of banks although banks could actively reduce risk-taking in the international financial crisis or high-risk economic period. In summary, in order to deal with the potential funding liquidity risk, commercial banks should maintain long-term, stable and diverse capital sources, and at the same time, effectively control the excessive risk-taking by better regulating credit supply and loan management; and the government supervision departments should further improve the macro prudential policy tools under the framework of *Basel III*, and take various measures to strengthen the supervision of banks' liquidity and leverage ratio, so as to ensure that the overall risk of financial institutions can be controlled.

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