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A Study on the Effect of Systemic Importance Bank Capital Structure on Liquidity Risk

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Abstract: Based on the microdata of 19 systemically important banks in my country from 2010 to 2021, this paper adopts a dynamic panel model to empirically test the impact of systemically important banks' capital structure on liquidity risk from the perspective of the overall capital structure and composition. The results show that the increase in capital adequacy ratio, tier-1 capital adequacy ratio, and the proportion of tier-2 capital bonds will reduce the liquidity risk. The impact of the tier-1 capital adequacy ratio on liquidity risk is more significant than that of tier-2 capital bonds. This paper uses the capital adequacy ratio to study the impact of bank capital structure as a whole on liquidity risk, and tier-1 capital adequacy ratio, and Tier-2 capital debt ratio to study the impact of bank capital structure on liquidity risk. This paper studies the impact of capital adequacy ratio, tier-1 capital adequacy ratio and Tier-2 capital debt ratio on the liquidity risk level of systemically important banks from the perspective of the overall and composition of capital structure. Studying the management of bank capital structure to improve the management level of bank liquidity risk is helpful to enhance the competitiveness of commercial banks, maintain the stability of the financial system and promote the development of supporting the real economy.

Keywords: Systemically Important Banks; Capital Structure; Liquidity Risk; Principal Component Analysis

1. Literature Review

1.1 Foreign literature review

Wang H et al. (2018) believed that the value of illiquid assets would be reduced when the market liquidity risk increased and proposed a "new trade-off theory" of capital structure on this basis. Sarwar Bilal (2020) builds a simultaneous adjustment model to prove that banks' higher capital adequacy ratio will reduce liquidity risk but it will also cause their preference for risky assets. Anginer D et al. (2021) found that regulators would set strict capital regulation requirements after the financial crisis but would also relax capital regulation requirements in other areas. Overall, the regulator requires banks to have more “high-quality” capital to reduce liquidity risk. Chen TH et al. (2021) believe that the higher the capital ratio held by commercial banks, the more liquidity they can create for the market and the lower the market liquidity risk under the influence of shadow banking. Shaofang Li (2022) believes that the higher the capital adequacy ratio of a commercial bank, the more competitive the bank will be to reduce liquidity risk. However, the debt capital of a commercial bank can better resist the liquidity risk during the financial crisis during a financial crisis.

1.2 Domestic literature review

Capital is an adjustment to liquidity risk in the short term when commercial banks are exposed to liquidity risk. In the long run, capital adjusts for the time lag effect of liquidity risk. Dai Junxun and Tao Chunxi (2016) use a simultaneous equation model to empirically test domestic risk-taking behavior under the dual constraints of capital and liquidity. The results show that there is a negative correlation between changes in risk commitment and changes in capital and liquidity. Wu Fang (2019) believes that there is a single panel threshold effect in the capital structure of China's listed commercial banks. If the capital adequacy ratio is increased, the bank liquidity risk will increase in the short term but a high capital adequacy ratio will inhibit the liquidity risk in the long term. Luo Yu and others (2020) believe that the capital adequacy and concentration ratio higher than that of Basel III should be reduced to enhance competitiveness and reduce the negative impact of the capital adequacy ratio. Wang Xiaoting and Ma Bin (2020) believe that capital adequacy ratio and liquidity ratio have pro-credit cycle characteristics while net stable capital ratio has anti-credit cycle characteristics. After introducing mutual terms, the relationship between bank capital ratio and liquidity ratio is significantly negative, and they are influenced by changes in the asset cycle. Cecilia Han (2021) studied the capital structure of commercial banks and the interaction mechanism between leverage ratio and liquidity risk. He believed that the capital requirements for macro-prudential supervision and leverage assessment should put forward higher requirements for the liquidity risk management of commercial banks. Liu Chong et al. (2021) believe that low-risk capital can resist liquidity risk and prevent operation failure and risk transmission caused by the occurrence of the risk.

2. The theoretical analysis and measurement model design

2.1 Theoretical analysis

From the perspective of the liquidity demand channel, commercial banks' loan pricing is relatively low when capital is sufficient, and banks charge relatively low-interest rates. From the perspective of information asymmetry theory, lower interest rates will be more competitive for borrowers with better credit. From this point of view, the capital structure of a commercial bank will affect the loan structure and pricing behavior, which will affect the quality of credit assets. The quality of credit assets is an important manifestation of whether bank assets will be realized at a reasonable price. The decline in the quality of credit assets of a commercial bank will affect the bank's liquidity and weaken the bank's liquidity, thus causing the bank's liquidity risk.

From the perspective of liquidity supply channels, investors believe that commercial banks with sufficient capital send the signal that the bank is a high-quality bank to investors. According to the signaling theory, investors will trust banks with adequate capital and good capital structure. Banks with adequate capital and good capital structure will obtain more financing channels, and will obtain funds from the money market and capital market at a lower capital cost to supplement bank liquidity. Banks will face relatively small financing liquidity risk.

The increase of the tier-1 capital adequacy ratio of commercial banks is consistent with the analysis of bank liquidity risk by the increase of capital adequacy ratio. Tier-1 capital of commercial banks includes core tier-1 capital and other tier-1 capital. Tier-1 capital is a capital instrument that can be used unconditionally to absorb losses. It has a stronger risk absorption capacity. According to the signaling theory, the improvement of the tier-1 capital adequacy ratio of commercial banks can better mitigate the bank’s liquidity risk. Therefore, hypothesis 1 and hypothesis 2 are proposed in this paper:

Assumption 1: The increase in the capital adequacy ratio of systemically important banks will reduce the bank liquidity risk.

Assumption 2: The increase in the tier-1 capital adequacy ratio of systemically important banks will reduce the bank’s liquidity risk.

In 2009 and 2013, the CBRC issued bank capital management regulations such as the Notice on Perfecting the Capital Replenishment Mechanism of Commercial Banks (Draft for Consultation) and the Measures for the Administration of Capital of Commercial Banks (Trial), which urges commercial banks to issue subordinated bonds to supplement bank capital. Subordinated bonds have ushered in a period of rapid growth. According to the data of subordinated bonds of commercial banks in the wind database, the annual issuance of write-down type secondary capital bonds was 91.7 billion by the end of 2010, and 120.573 billion by the end of 2021. Over 11 years, the growth rate of Tier-2 capital bonds was as high as 20.07%. Since subordinated bonds are widely held by commercial banks in our country, the fast-growing subordinated bonds may help banks to replenish capital but it may also aggravate the phenomenon of subordinated bond holding among commercial banks. Therefore, the issuance of secondary capital bonds does not play a role in easing the liquidity risk of banks. And, hypothesis 3 is proposed in this paper:

Assumption 3: The proportion of SIB tier-2 capital bonds may be negatively correlated with liquidity risk.

2.2 Sample selection and data sources

This paper uses the balanced panel data of 19 systemically important banks in China from 2010 to 2021 for regression analysis. The variable data are semi-annual data. Bank financial data are derived from the China Taian CSMAR database, Wind database, and annual reports of commercial banks. Money supply, GDP, and market interest rate data are derived from the People's Bank of China and the National Bureau of Statistics respectively. The 19 sample banks include 6 state-controlled large commercial banks, 9 joint-stock commercial banks, and 4 city commercial banks.

2.3 Measurement model setting

In order to test the impact of capital structure on the liquidity risk of commercial banks in China, this paper uses the model set by Shrieves and Dahl (1992) for reference, and comprehensively considers the impact of micro-characteristics and macro-characteristics of commercial banks such as commercial banks' asset returns, income structure, credit quality, and asset size. The dynamic panel model is set as follows:

(1) $Risk_{i,t} = \beta_0 + \beta_1 CAR_{i,t} + \beta_2 ROA_{i,t} + \beta_3 CRR_{i,t} + \beta_4 NPL_{i,t} + \beta_5 LNTA_{i,t} + \beta_6 FM_{i,t} + \beta_7 R_{i,t} + \mu_i + \varepsilon_{i,t}$

(2) $Risk_{i,t} = \beta_0 + \beta_1 Tier1_{i,t} + \beta_2 Tier2_{i,t} + \beta_3 ROA_{i,t} + \beta_4 CRR_{i,t} + \beta_5 NPL_{i,t} + \beta_6 LNTA_{i,t} + \beta_7 FM_{i,t} + \beta_8 R_{i,t} + \mu_i + \varepsilon_{i,t}$

i and t represent the observed value of bank i in phase t; Risk is an explanatory variable of liquidity risk; CAR, Tier-1 and Tier-2 are explanatory variables; β_0 is intercept term; ROA, CRR, NPL, and LNTA are bank-level control variables; Financial deepening index and market interest rate are macro-level control variables; μ_i represents the bank's heterogeneity that does not change over time; $\varepsilon_{i,t}$ is the perturbation term. The model variables are selected and calculated as follows

1. Principal component analysis

At present, liquidity risk is mainly measured by the indicator analysis method, which includes static indicators and dynamic indicators. Static indicators can only measure the liquidity risk level of commercial banks on a single focus. The data used in the calculation of each static indicator are historical and it cannot achieve pre-prediction. It can only reflect the existing risks. The dynamic indicators pay more attention to the future conditions of the banks. By predicting the inflow and outflow of funds in the future, the possible fund gaps can be calculated. According to the size of the fund gaps, precautions can be taken in advance to avoid further aggravation of the fund gaps. Commercial banks can predict the possible liquidity gap in the future in advance and supplement it in time to achieve the effect of prevention in advance. However, the relevant indicators only consider the issue of maturity in the process of measuring dynamic indicators but it does not reflect the actual maturity of the debt maturity extension and default payments. Therefore, this indicator has limitations.

It is difficult for a single indicator to describe the liquidity situation of the whole commercial bank. The liquidity level of China's commercial banks can be effectively measured by considering the conditions of various indicators. Principal component analysis (PCA) can simultaneously process multiple indicators with different properties. Through the method of orthogonal transformation, the number of indicators is reduced while retaining most of the information. The final data is obtained by weighing the indicators. Compared with the above indicators, principal component analysis is a more comprehensive, objective and comprehensive approach. It makes up for the shortcoming that a single indicator is not comprehensive and does not conform to reality. To sum up, this paper will use the principal component analysis method to measure the liquidity RISK and select six indicators such as liquidity liabilities, liquidity assets, and the loan ratio of the largest ten customers as the processing indicators of the principal component analysis method, and express these indicators by X1, x2 ...... x6, and express the final comprehensive score by risk. The specific indicators are selected as shown in Table 1.

Table 1 Meaning of Liquidity Risk Indicators

Indicator name	Indicator definition
X1	Current liabilities/Current assets
X2	Current liabilities/Total liabilities

X3	Liquid assets/Total assets
X4	Loan Proportion of top 10 Customers
X5	Loan deposit ratio
X6	Inter-bank lending rate

Six data indicators of 19 listed banks from 2010 to 2021 were tested for model adaptability. KMO and Bartlett sphericity tests were used for this adaptability test. As can be seen from Table 2, the measurement result of KMO is 0.684, which exceeds the standard value of 0.5 (the standard value is set as 0.5 in the Theory and Application of Modern Statistical Analysis Methods), it indicates that the number of samples is sufficient for principal component analysis. The significance of Bartlett's sphericity test is 0.000, which is significant at the level of 1%. The rejection of the original assumption of the unit matrix of the correlation coefficient matrix indicates that the correlation coefficient matrix of these six index variables is significantly different from the identity matrix. There is a correlation among the index variables, which is suitable for principal component analysis.

Table 2 KMO and Bartlett Spheres Test

KMO value		0.684
Bartlett sphericity test	Approximate chi-square	1582.528
	df	21
	P value	0.000

In this paper, the principal component is extracted by the maximum variance method. It can be concluded from the results of the variance interpretation of principal components (Table 2) that the extracted eigenvalues of the first three principal components all exceed 1, and the cumulative contribution rate of variance is up to 80.533%. It can be seen that the first three principal components contain most of the original variable information, the extraction effect is better, and the missing information is less. Therefore, the first three principal components are adopted as the evaluation index for evaluating the liquidity risk level of commercial banks.

Table 3 Explanation of variance of principal components

Component part	Initial eigenvalue			Rotation front difference interpretation rate			Interpretation rate of variance after rotation		
	Eigenvalue	Variance%	Cumulative variance%	Eigenvalue	Variance%	Cumulative variance%	Eigen value	Variance %	Cumulative variance%
X1	2.170	36.167	36.167	2.170	36.167	36.167	1.923	32.050	32.050
X2	1.655	27.583	63.750	1.655	27.583	63.750	1.784	29.733	61.783
X3	1.007	16.783	80.533	1.007	16.783	80.533	1.125	18.750	80.533
X4	0.807	13.450	93.983						
X5	0.321	5.350	99.333						
X6	0.040	0.667	100.000						

Table 4 Composition Matrix Diagram

	F1	F2	F3
X1	-0.626	-0.233	0.084
X2	-0.017	0.359	0.874
X3	0.549	0.404	-0.008

X4	-0.320	0.494	-0.058
X5	0.452	-0.449	0.116
X6	-0.003	0.456	-0.461

According to the component score coefficient matrix in Table 4, three eigenvalue expressions can be determined as follows:

(1) F1=-0.626*x1-0.017*x2+0.549*x3-0.32*x4+0.452*x5-0.003*x6

(2) F2=-0.233*x1+0.359*x2+0.404*x3+0.494*x4-0.449*x5+0.456*x6

(3) F3=0.084*x1+0.874*x2-0.008*x3-0.058*x4+0.116*x5-0.461*x6

According to the variance contribution rate of the principal components in Table 3, the comprehensive score of liquidity risk level is constructed. The comprehensive score is obtained by the product of variance interpretation rate and component score and then accumulated calculation. It can be determined that the expression of liquidity risk level is:

RISK=0.449*F1+0.343*F2+0.208*F3 (4)

2. Interpreted variables

(1) Capital adequacy ratio (CAR): the ratio of total capital to risk-weighted assets, using CAR as a measure of total capital.

(2) Tier-1 capital adequacy ratio: the ratio of Tier-1 capital to risk-weighted assets, using Tier- 1 capital adequacy ratio as a measure of core capital.

(3) Tier-2: the ratio of Tier-2 capital to total capital, using the Tier-2 debt as a measure of Tier-2 capital.

2.4 Control variables

The variables adopted in this paper at the bank level are asset return rate, cost-to-income ratio, non-performing loan rate, and asset size, which respectively represent the bank's asset income, income structure, credit quality, and asset status. The macro-level control variables are mainly the financial deepening index and market interest rate.

The influence variables selected in this paper and their meanings are summarized in the following table.

Table 5 Design and Definition of Variables

Variable name	Variable identification	Calculation method	Data source
liquidity risk	RISK	Principal component analysis	Author's calculation
Capital adequacy ratio	CAR	Total capital/risk-weighted assets	Wind database
Tier-1 capital adequacy ratio	Tior1	Level 1 capital/risk weighted assets	Wind database
Percentage of Tier-2 Capital Bonds	Tier2	Level 2 capital/total capital	Author's calculation
return on total assets	ROA	Net profit/average net assets	Wind database
Cost-to-revenue ratio	CRR	Operating expenses/revenue	Wind database
Non-performing loan rate	NPL	(subordinated loan+doubtful loan+loss loan)/each loan	Wind database
asset size	LNTA	Natural logarithm of total assets	Wind database
Financial deepening indicator	FM	Quarterly M2/ quarterly GDP	Author's calculation
market rate	R	Benchmark lending rate	Wind database

3. Empirical analysis

3.1 Descriptive statistics

Table 6 is a descriptive statistic of each empirical variable in this paper. As can be seen from Table 6, there are 456 observation data for 19 sample commercial banks. The maximum value of liquidity risk is 1.922, the minimum value is -1.758, and the average value is -0.015 with a fluctuation range of 12.57%. The liquidity risk levels of the sample banks are quite different. The ratio of tier-1 capital adequacy ratio to capital adequacy ratio is about 0.8, and its standard deviation is same. It can be speculated that the changes in these two variables tend to be the same. Tier-2 capital bonds accounted for a maximum of 4.95% and a minimum of 38.6%. As can be seen from the calculation in the following table, the ratio of Level 2 capital to Level 1 capital is not high and its average value is about 25%.

Table 6 Descriptive Statistics of Variables

Variable name	Sample size	Average/Mean value	Standard deviation	Minimum value	Maximum
RISK	456	-0.015	0.591	-1.758	1.922
CAR	456	12.565	1.747	eight	18.02
Tier1	456	10.143	1.690	6.4	14.94
Tier2	456	19.438	5.073	4.950	38.600
ROA	456	0.764	0.289	0.238	1.475
CRR	456	30.049	8.489	0.49	72.681
NPL	456	1.245	0.440	0.16	4.36
LNTA	456	29.170	1.008	26.554	31.191
FM	24	7.292	0.653	6.152	8.553
R	24	4.892	0.641	4.35	6.1

3.2 Correlation test

A correlation test is an analysis and test of whether there is a correlation between two or more variables. The correlation test is performed with stata15 and the results are shown in the following table.

Table 7 Variable Correlation Coefficient Matrix

	RISK	CAR	Tier1	Tier2	ROA
RISK	1.000				
CAR	-0.573***	1.000			
Tier1	-0.530***	0.937***	1.000		
Tier2	0.103**	-0.230***	-0.552***	1.000	
ROA	-0.048	0.147***	0.112**	0.041	1.000
CRR	0.447***	-0.361***	-0.369***	0.162***	-0.036
NPL	-0.535***	0.320***	0.339***	-0.175***	-0.160***
LNTA	-0.466***	0.642***	0.675***	-0.360***	0.052
FM	-0.388***	0.369***	0.430***	-0.323***	-0.604***
R	0.409***	-0.433***	-0.476***	0.283***	0.364***
	CRR	NPL	LNTA	FM	R
CRR	1.000				
NPL	-0.352***	1.000			
LNTA	-0.160***	0.307***	1.000		
FM	-0.356***	0.496***	0.330***	1.000	
R	0.237***	-0.647***	-0.333***	-0.709***	1.000

Note: *, * *, * * * indicate that the Pearson correlation coefficient test is significant under the statistical levels of 10%, 5%, and

1%, respectively.

In this correlation test, RISK represents the score of liquidity risk. The smaller the score, the less risk the bank is exposed to. As can be seen from the above table, capital adequacy ratio and tier-1 capital adequacy ratio are negatively correlated with liquidity risk and are significant within the 1% confidence interval respectively. This indicates that the higher the capital adequacy ratio and tier-1 capital adequacy ratio are, the lower the liquidity risk the banks will face. And, the correlation direction is the same as the theoretical speculation above. The proportion of secondary capital bonds has a negative correlation with liquidity risk, which is significant in the 5% confidence interval. It can be seen that the rapid growth of secondary bonds replenishes bank capital and alleviates bank liquidity risk. There is a negative correlation between total asset size and liquidity risk under the significance of 1%, indicating that the larger the total asset size, the lower the liquidity risk.

3.3 Empirical results and analysis

The empirical results of capital structure on liquidity risk are shown in Table 8. Model (1) is an empirical result of the overall capital structure on liquidity risk. Model (2) is an empirical result of the liquidity risk posed by capital structure.

Through model (1), we can see that the impact of the capital adequacy ratio on liquidity risk is negative and significant at a 1% significance level. The above empirical results verify the test 1 proposed in this paper: the increase of capital adequacy ratio of systemically important banks will reduce bank liquidity risk. Every 1% increase in capital adequacy ratio will reduce the bank liquidity risk by 0.1 bp when We judge from the results of the benchmark regression. It can be seen from model (2) that the impact of the tier-1 capital adequacy ratio and Tier-2 capital debt ratio on liquidity risk is negative and significant at the significance level of 1%. Assumptions 2 and 3 hold water. The impact of tier-1 capital adequacy ratio on liquidity risk is more significant than that of tier-2 capital bonds, and the impact of tier-1 capital adequacy ratio on liquidity risk is 3.8 times that of tier-2 capital bonds when we judge from the results of benchmark regression.

Table 8 Benchmark Regression Model

	Model 1	Model 2
constant term	4.755***	6.232***
	(5.47)	(6.89)
CAR	-0.101***	
	(-5.74)	
Tier1		-0.114***
		(-5.39)
Tier2		-0.030***
		(-6.23)
ROA	-0.169	-0.225**
	(-1.61)	(-2.15)
CRR	0.012***	0.012***
	(4.24)	(4.43)
NPL	-0.469***	-0.448***
	(-7.42)	(-7.16)
LNTA	-0.073***	-0.100***
	(-2.73)	(-3.64)
FM	-0.093	-0.137**
	(-1.56)	(-2.29)
R	-0.067	-0.052
	(-1.26)	(-0.98)
observed value	456	456

Sample bank	19	19
Wald statistics	153.54***	388.88***
P − AR(2)	0.273	0.446
P − Hansen test	1.000	1.000

Note: Parameter estimation results are based on generalized moment estimation. The values in brackets are the T values adjusted by the robust standard error, *, * *, * * * are significant at the significance levels of 10%, 5%, and 1%, respectively. The lower part of the table gives the observations used in the model estimation and the number of sample banks.

3.4 Robustness test

In order to ensure the robustness of the estimation results, this paper uses the surrogate variable to test the robustness and uses Liquidity Coverage Ratio (LCR) as the surrogate variable of liquidity risk. The higher the liquidity coverage ratio, the more abundant the bank capital and the lower the liquidity risk. The relevant empirical results are shown in Table 9: the capital adequacy ratio and tier-1 capital adequacy ratio are significant at 1%, and the proportion of tier-2 capital bonds is significant at 10%; Capital adequacy ratio, tier-1 capital adequacy ratio and the proportion of Tier-2 capital bonds are positively correlated with liquidity coverage ratio, which verifies the robustness of the research conclusion.

Table 9 Robustness Test

	Model 1	Model 2
Constant term	-92.257 (-0.33)	47.172 (0.08)
LCR	21.870*** (3.07)	
Tier1		28.955*** (7.90)
Tier2		4.231* (2.50)
ROA	-27.908 (-1.44)	-43.392*** (-3.44)
CRR	2.032** (2.37)	1.843* (1.74)
NPL	25.292 (0.78)	21.979 (0.70)
LNTA	-7.889 (-0.53)	-12.926 (-0.74)
FM	0.992 (0.12)	-6.483 (-0.67)
R	16.908 (1.29)	13.815 (0.79)
Wald statistics	5388.50***	780.26***
P − AR(2)	0.218	0.223
P − Hansen test	0.592	0.556

4. Conclusion

The research conclusion of this paper indicates that the increase in capital adequacy ratio, tier-1 capital adequacy ratio, and the proportion of tier-2 capital bonds will significantly reduce the liquidity risk of banks. The impact of the tier-1 capital adequacy ratio on liquidity risk is more significant than the proportion of tier-2 capital bonds. The research conclusions of this paper are of great reference value to the implementation of structured liquidity risk management in systemically important banks and the formulation of regulatory policies by banking regulators. First, increasing the capital adequacy ratio and adjusting the proportion of medium-and high-risk assets is essential. From the empirical results, the capital adequacy ratio has a greater inhibitory effect on the liquidity risk of banks. Therefore, systemically important banks need to further increase their capital adequacy ratio to reduce liquidity risk. However, it is more difficult to increase net capital, especially level 1 net capital. It is possible to increase the capital adequacy ratio by lowering the denominator and adjusting the proportion of high-risk assets in risk-weighted assets, which can increase the capital adequacy ratio, and reduce the bank risk coefficient. Second, increasing the proportion of Tier-2 capital is important. The benchmark regression results show that the proportion of secondary capital bonds is more inhibitory than the liquidity risk of banks. From the descriptive statistics, the average proportion of Tier-2 capital and total capital of systemically important banks is 19.44%, which is still far from the 50% cap stipulated in the Basel Accord. Therefore, the proportion of Tier-2 capital can be appropriately increased. In addition, Tier-2 capital, a commercial bank in our country, has a relatively single type, mainly hybrid securities and long-term subordinated bonds. Therefore, the number of Tier-2 capital should be increased in order to reduce the liquidity risk of systemically important banks while a new type of Tier-2 capital should be added, which can supplement bank capital on the one hand and absorb losses in time when operational risks occur on the other.

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