

Application Research on Dynamic Liquidity Risk Stress Test of Commercial Banks Based on Gravity Model

Xu LIAO^a, Ziyu Zhou^b

School of Business Administration, Northeastern University, Shenyang, Liaoning, 111004, China

^ayuzu_lxu@163.com, ^b1641724344@qq.com

Keywords: Gravity model, Commercial banks, Dynamic liquidity risk, Stress testing

Abstract: Dynamic liquidity risk is the most fundamental risk faced by banks. Stress testing is a quantitative analysis method for tail risks. Among various dynamic liquidity risk management tools, liquidity stress testing is a very effective management tool, and its in-depth study will help commercial banks fully understand the degree of losses they will suffer in future extreme events. On the basis of establishing the gravity model of assets and liabilities, this paper takes commercial banks as the research object and the excess deposit reserve ratio as the index to measure the dynamic liquidity risk, and makes an empirical study on the liquidity stress test of commercial banks, and analyzes the empirical results of stress test in detail. According to the results of stress test, this paper gives the countermeasures of dynamic liquidity risk management of commercial banks from three angles.

1. Introduction

For a long time, the banking industry has accumulated a set of relatively mature and effective technologies for managing daily risks. The traditional method of dynamic liquidity risk management is implemented through a series of relatively static indicators, such as loan-to-deposit ratio, asset flow ratio, cash ratio and other indicators [1-2]. At present, the dynamic liquidity risk management of China's commercial banks mainly adopts this traditional way. However, with the continuous opening of the financial market and the increasing internationalization of the domestic financial market, it is necessary to use dynamic methods to manage the dynamic liquidity risk of banks.

As one of many risks in the business process of commercial banks, dynamic liquidity risk is often caused by the occurrence of other risks of commercial banks, and it is the ultimate manifestation of risks faced by commercial banks in the daily business process. The outbreak of the financial crisis and a series of adverse effects on the global scale fully show that the dynamic liquidity risk can not be ignored. It is of great significance for commercial banks to strengthen the management of dynamic liquidity risk, prevent the occurrence of dynamic liquidity risk and reduce its harm degree.

2. Literature Review

With regard to the research on the causes of dynamic liquidity risk, the literature [3] found that many macroeconomic policies will change in the process of financial market integration, such as monetary policy, exchange rate system, financial regulations, government debt and deficit, capital inflow and outflow, etc. Literature [4] analyzes the influencing factors of dynamic liquidity risk and transaction cost by means of VaR and mean-variance method, and concludes that two types of market influences, permanent and temporary, are important influencing factors of dynamic liquidity risk and transaction cost. Literature [5] studies the relationship between liquidity and transaction costs in its articles, and establishes how banks can maintain sufficient liquidity while keeping transaction costs minimized.

On the application level. Literature [6] focuses on the applicability of the mainstream stress testing model of international banks in China, and designs an index to interpret liquidity as a dependent variable. Literature [7] also selects the measurement model, selects the ratio of deposit and loan as the dependent variable, and takes various macroeconomic factors as the independent variable to conduct an empirical study on dynamic liquidity risk. Literature [8] designed a macro stress test model integrating dynamic liquidity risk, credit risk and market risk, and empirically analyzed the banking system of China with the annual report data published by Industrial and Commercial Bank of China, Agricultural Bank of China, Bank of China, China Construction Bank and Bank of Communications, and concluded that the systematic dynamic liquidity risk of the banking system is very low.

Generally speaking, the research on stress testing in China only stays at the level of taking stress testing as a tool of risk management, which is only suitable for measuring a single risk. The measurement technology and level are low, and a comprehensive stress testing system has not been formed. Most of them learn from the mature stress testing theory abroad, which is far from the applied research on stress testing in developed countries.

3. Test Methods and Procedures

3.1 Gravity Model of Assets and Liabilities

In this paper, the definition of liquidity of assets is the ability to convert a large amount of assets into cash at a reasonable price within a certain period of time. It consists of three factors: first, the time factor, that is, how much time it takes for assets to be converted into cash. The shorter the time, the stronger the liquidity of assets, and the longer the time, the weaker the liquidity of assets. Second, the price factor, that is, the price difference before and after asset conversion. The larger the price difference, the worse the liquidity of assets, and the smaller the price difference, the stronger the liquidity of assets. Third, the quantity factor, that is, the amount of assets converted on the basis of a given time and price, and the amount also implies the frequent degree of transactions.

If the charge gravity model is directly quoted, firstly, it is inconsistent with the facts, and the problem will be simplified. From the perspective of asset and liability management of commercial banks, it is necessary to consider whether an asset can match this liability, whether the asset can meet the requirements of liabilities or not, and whether the asset has fatal weaknesses that do not meet the minimum requirements of liabilities. Only when both of them meet, can such matching be stable. Therefore, the gravity model of assets and liabilities is constructed on the basis of the charge gravity model, and there will be both gravity and repulsion between the assets and liabilities, and the two sides will work together:

$$T_{12} = F_{12} = k \frac{Q_1 Q_2}{r_{12}^2} - k \frac{Q_1' Q_2'}{r_{12}^2} \quad (1)$$

The gravity model of bank assets and liabilities can be obtained, and the satisfaction of liabilities

to assets will make the two parties attractive:

$$F_{L_i \leftrightarrow A_j} : F_{L_i \leftrightarrow A_j} = k \frac{S_{L_i \rightarrow A_j} S_{A_j \rightarrow L_i}}{r^2} \quad (2)$$

Disappointment of liabilities to the asset side will cause repulsion between the two parties:

$$F'_{L_i \leftrightarrow A_j} : F'_{L_i \leftrightarrow A_j} = k \frac{T_{L_i \rightarrow A_j} T_{A_j \rightarrow L_i}}{r^2} \quad (3)$$

Combining the two forces, the resultant force $T_{L_i \rightarrow A_j}$ is the resultant force between the debt assets, which is defined as the matching degree here:

$$P = P_{L_i \leftrightarrow A_j} = F_{L_i \leftrightarrow A_j} - F'_{L_i \leftrightarrow A_j} \quad (4)$$

The greater the matching degree P , the greater the success rate of the combination of the two; The smaller the matching degree P is, the smaller the success rate of the combination is.

3.2 Setting Stress Scenarios

Considering the complexity and risk contagion of dynamic liquidity risk under the systemic crisis scenario, based on the above-mentioned standard stress scenario, this paper further considers the pressure scenario in which various risk factors are linked. By further refining the risk factors under pressure events, the pressure factors that lead to dynamic liquidity risk are classified into the following six categories: policy factors, asset quality decline, counterparty trust decline, deposit customer trust decline, off-balance sheet liquidity loss and market risk factors.

In this paper, the subprime mortgage crisis in the United States is taken as the driving event, and the scenario of “the public credit rating of institutions is lowered by three grades” is taken as the basis of the multi-factor stress scenario design under the linkage of risk factors, and the scenario design under the linkage of risk factors is completed by combining the market risk factors shown in the financial crisis.

3.3 Carry out Pressure Test

(1) Stress testing under the impact of a single risk factor

Under the condition that other risk factors remain unchanged, stress test of a single risk factor shall be conducted. In a specific period, it is unlikely that these risk factors will occur at the same time, so it is necessary to carry out stress test of a single risk factor.

On the premise that other risk factors remain unchanged, when the statutory deposit reserve ratio increases, the results of stress test are shown in Table 1 and Table 2 below:

Table 1 Stress Test Results of State-Owned Commercial Banks

Scene	Scene 1	Scene 2	Scene 3
Pressure amplitude	Mild pressure	Moderate pressure	Heavy pressure
Excess deposit reserve ratio value	0.32%	0.17%	0.07%
Mahalanobis distance	6.33	6.69	7.01
Probability	0.089	0.081	0.074

Table 2 Stress Test Results of Joint-Stock Commercial Banks

Scene	Scene 1	Scene 2	Scene 3
Pressure amplitude	Mild pressure	Moderate pressure	Heavy pressure
Excess deposit reserve ratio value	2.77%	2.58%	2.55%

Mahalanobis distance	6.31	6.74	7.03
Probability	0.092	0.084	0.080

Under the impact of a single risk factor, the excess deposit reserve ratio has little impact. For state-owned commercial banks, when the inter bank offered rate drops and the loan-to-deposit ratio rises to the severe stress scenario, the excess deposit reserve ratio drops below 0%, and other scenarios remain at a positive level. For joint-stock commercial banks, even in the case of severe impact, they can maintain a level above 2%. From the occurrence probability, the fluctuation range of state-owned commercial banks is between 7.2% and 9.5%, while that of joint-stock commercial banks is between 8% and 10%. Compared with state-owned commercial banks, the fluctuation range of occurrence probability of joint-stock commercial banks is narrow.

(2) Stress test under the impact of comprehensive risk factors

In actual economic life, commercial banks will not only be impacted by a single risk factor, but also be affected by multiple risk factors at the same time. Therefore, it is necessary to conduct stress tests under the impact of comprehensive risk factors. The stress test results when the inter bank lending rate decreases and the loan-to-deposit ratio increases are shown in Tables 3 and 4 below:

Table 3 Stress Test Results of State-Owned Commercial Banks

inter bank lending rate	Loan to deposit ratio		
	Mild pressure	Moderate pressure	Heavy pressure
Mild	0.32%	0.15%	-0.03%
Mahalanobis distance	6.27	6.47	6.77
probability;likelihood	0.091	0.092	0.087
Moderate	0.08%	-0.11%	-0.23%
Mahalanobis distance	6.22	6.36	6.68
probability;likelihood	0.093	0.097	0.085
Serious	-0.19%	-0.33%	-0.53%
Mahalanobis distance	6.47	6.43	6.69
probability;likelihood	0.093	0.091	0.779

Table 4 Stress Test Results of Joint-Stock Commercial Banks

Mild	Loan to deposit ratio		
	Mild pressure	Moderate pressure	Heavy pressure
Mahalanobis distance	2.77%	2.53%	2.38%
probability;likelihood	6.41	6.39	6.56
Moderate	0.096	0.094	0.085
Mahalanobis distance	2.51%	2.23%	2.01%
probability;likelihood	6.27	6.24	6.49
Serious	0.098	0.099	0.095
Mahalanobis distance	2.24%	2.01%	1.79%
probability;likelihood	6.49	6.40	6.59
Mild	0.095	0.090	0.859

Under the impact of falling inter bank lending rate and increasing loan-to-deposit ratio, joint-stock commercial banks are more vulnerable than state-owned commercial banks. Compared with the baseline situation, the level of excess deposit reserve ratio of state-owned commercial banks decreased by 0.5%-0.8%, while that of joint-stock commercial banks decreased by 0.5%-1%.

4. Analysis and Suggestion of Stress Test Results

4.1 Result Analysis

According to the regulatory requirements that the liquidity ratio should not be less than 25%,

these two types of commercial banks have good pressure effect. Among them, the liquidity ratio of state-owned commercial banks will be less than 25% only under severe stress test, and the probability of severe stress test is very small; Even under severe stress test, the liquidity ratio of joint-stock commercial banks is not lower than the requirement of liquidity ratio supervision index. This situation in stress test is consistent with the current liquidity situation of commercial banks in China. At present, there is still a serious excess liquidity ratio in commercial banks in China, which is also proved by the original data of the liquidity ratio of these two types of commercial banks.

With the lowering of the threshold for entering the inter bank borrowing market and the increasing diversification of inter bank borrowing entities, the inter bank lending rate will gradually become the benchmark interest rate in China, which can more truly reflect the demand for funds, and it is a good thing for the liquidity management of banks. Although the central bank has liberalized the inter bank lending market interest rate, it does not mean that the central bank will not take indirect measures to intervene in the inter bank lending market. Under the current situation that interest rate has not been fully marketized in China, it is inevitable that the inter bank lending rate will be affected by the central bank.

From the perspective of influencing factors, the statutory deposit reserve ratio and GDP growth rate are external factors that affect the liquidity of commercial banks, and both of them have a significant impact on the liquidity ratio of commercial banks. Although the liquidity ratio of the two types of commercial banks has strong pressure bearing capacity during the stress test, this is mainly due to the excess liquidity of commercial banks in China at present. This fully shows that the impact of the central bank's monetary policy (especially the statutory deposit reserve policy) and macroeconomic development on the liquidity of commercial banks can not be ignored.

4.2 Countermeasures and Suggestions Based on Stress Test Results

(1) Strengthen the supervision of various liquidity indicators

To supervise the liquidity of commercial banks, we should not judge that the liquidity of commercial banks meets the regulatory requirements only by one indicator, but comprehensively analyze the regulatory indicators that measure the liquidity. At present, liquidity coverage ratio, net stable capital ratio, liquidity ratio and loan-to-deposit ratio are the four main liquidity supervision indicators. For these four regulatory indicators to measure liquidity, we should not focus on any single indicator, but combine the four indicators and comprehensively analyze them.

(2) Strengthen data accumulation and improve data quality

Whether from data collection or quantitative impact, the establishment of models for liquidity stress testing challenges the quality and quantity of data. Commercial banks shall, in accordance with the standard format required by the banking regulatory authorities, refer to the practices in the industry, emphasize the routine and highlight the particularity. On the premise of ensuring the quality of relevant data, collect the required data as comprehensively as possible.

(3) Attach importance to macro stress test of dynamic liquidity risk in banking industry

As the supervisor of the banking industry, the banking supervision department not only needs to urge banks to pay attention to and strengthen the stress test under the extremely unfavorable macroeconomic situation in the dynamic liquidity risk management, in order to maintain the micro-stability of banks; It is also necessary to evaluate and analyze the impact of these extreme shocks on the overall liquidity of the banking industry in order to ensure the macro-stability of the banking system.

5. Conclusion

Dynamic liquidity risk management stress test is an important means in risk management of

commercial banks. Compared with traditional dynamic liquidity risk management methods, stress test is helpful to quantify the “single tail” danger and is a necessary supplementary mechanism for risk management. The gravity model of assets and liabilities established in this paper can help bank managers to quantitatively analyze the problems of dynamic liquidity risk management caused by different asset-liability periods, and reduce the dynamic liquidity risk by improving the matching success rate of assets and liabilities under the condition of meeting the liability requirements to the maximum extent.

References

- [1] Zheng Jinyu and Han Xiaoyu. *Five Challenges of Commercial Bank on Liquidity Risk Supervision*. *banker*, no. 007, pp. 14-17, 2019.
- [2] Bobakulov, B. *ACTUAL ISSUES OF PROVIDING LIQUIDITY OF COMMERCIAL BANKS*. *International Finance and Accounting*, vol. 2018, no. 1, pp. 6-6, 2018.
- [3] Bai J, Krishnamurthy A, Weymuller C H. *Measuring Liquidity Mismatch in the Banking Sector*. *Journal of Finance*, vol. 73, no. 1, pp. 51-93, 2018.
- [4] Li B, Xiong W, Chen L, et al. *The impact of the liquidity coverage ratio on money creation: A stock-flow based dynamic approach*. *Economic Modelling*, no. 67, pp. 193-202, 2017.
- [5] Krichene, Aida. *Using a naive Bayesian classifier methodology for loan risk assessment: Evidence from a Tunisian commercial bank*. *Journal of Economics Finance & Administrative Science*, vol. 22, no. 42, pp. 3-24, 2017.
- [6] Huang Hongxing. *The situation and difference of liquidity risk management in commercial banks*. *Bankers*, no. 007, pp. 18-20, 2019.
- [7] Liu Ruiwen, Huang Hongbin, Cao Lisha, et al. *Empirical Study on Internal Control Effect of the State-owned Commercial Bank in Promoting Risk Prevention*. *journal of hunan finance and economics university*, vol. 033, no. 006, pp. 30-38, 201.
- [8] Zhong H. *Commercial Bank Ownership Structure and Risk Preference*. *Journal of Mathematical Finance*, vol. 7, no. 2, pp. 437-444, 2017.