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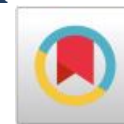
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A RESEARCH ON RISK CONTAGION OF CHINESE INTERBANK MARKET

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Abstract:

The paper investigates contagion risk of interbank market via matrix method with a complete network structure. We make a study of contagion risk and the proportion of failed bank assets by exploiting the two conditions of the core capital adequacy ratio is less than 6% and the loss is higher than the bank's tier 1 capital, and compares the size of the difference of liquidity ratio before and after the risk. The results show that we can more accurately obtain the order of bank failures based on the above three criteria. Meanwhile, (not) vulnerable banks and the sequence of importance of Bank of Communications, Minsheng Bank, Shanghai Pudong Development Bank and Industrial Bank are given in the banking system.

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1. Introduction

The risk of the banking industry that is the core of a national financial system has fundamental differences with other financial industries. A typical example is the financial crisis caused by the subprime mortgage crisis in the United States in 2008. There were many countries where banks have been bankrupt, but there was no bank failure in China. The factor contributing to this phenomenon has two aspects. It is not only because the extent of China's opening up is limited at that time, even though China has joined WTO in 2001, but also because the Chinese government timely and effectively put money to help people get rid of the dilemma. However, with the development of economy, the trade links between China and the world's major economic systems are becoming more and more close, and the proportion of foreign trade in the economy is getting higher and higher, so the possibility that the crisis spreads to our country through the trade channel is also growing. In order to stabilize the development of the economy, the country must pay attention to maintain the stability of the banking development. Therefore, it is necessary to do a good job of forecasting and response. Once there is a bank failure, it is demand of timely and effective taking some measures to impede the spread of risk between banks to prevent the risk from expanding into a financial crisis.

At present, the research on the risk contagion of interbank market has triggered the extensive attention. For example, Furfine[1], Upper[2], Sheldon[3] and Junlu Ma[4] et al. make a study of the risk contagion of the America interbank market, the German interbank market, the Swiss interbank market and the Chinese interbank market via the matrix method, respectively. This paper also uses the matrix method to investigate the risk contagion and give the size and the time of the contagion. In particular, the order of bank failures is established based on a new techique.

The paper is organized as follows. In the next section, we introduce the complete network structure and matrix method. In the following section, we give detection conditions of contagion risk. In the subsequent section, we carry out some numerical simulation experiments on contagion risk. We conclude with a summary of our findings.

2. The Model

Because Chinese banking industry only opens the total claims and debts, there is no disclosure of specific borrowing data between individual banks, so we cannot determine the structure of banking network. But along with the continuously go deep into of the research, the scholar [5] has found that complete network structure, it means that each bank and other banks have a lending relationship, is the most unfavorable to risk contagion. Meanwhile, with the stable development of banking industry in China, its structure has gradually become a complete network structure model. In view of this, the complete network structure model is used to analyze the risk of banking industry in this paper. At the same time, we assume that the banking system is made up of N banks and lending relationships in the interbank market with a complete network structure can be characterized by the following matrix $X \in R^{N \times N}$:

$$
X = \begin{bmatrix} x_{11} & \cdots & x_{1j} & \cdots & x_{1N} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{i1} & \cdots & x_{ij} & \cdots & x_{iN} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{N1} & \cdots & x_{Nj} & \cdots & x_{NN} \end{bmatrix} \begin{matrix} \sum i \\ a_1 \\ \vdots \\ a_i \\ \vdots \\ a_N \end{matrix}
$$
$$
\overline{\sum_j l_1 \cdots \quad l_j \quad \cdots \quad l_N} \qquad (1)
$$

where x_{ij} represent the credit exposure of bank j with respect to bank i. we know the interbank assets a_i and liabilities l_j of each bank as follows:

$$
\Sigma_j^N x_{ij} = a_i \text{ and } \Sigma_t^N x_{ij} = l_j. \qquad (2)
$$

This paper uses Lingo11 software to solve X.

3. Detection Condition

This section mainly introduces two methods to determine the risk contagion between banks and puts forward a new method to estimate the order of bank failures caused by contagion, as follows.

- Method one

The first method[6] is that the bank's core capital adequacy ratio is less than 6%, which can be used as the criterion of risk contagion for the supervision department. The following is the discriminant formula:

$$\frac{E_j - \sum_i (\theta x_{ji} \alpha)}{RWA_j - \delta \sum_i (x_{ji} \alpha)} < 6\%, \tag{3}$$

where E_j represent the core asset of bank j, RWA_j represent the total risk-weighted asset of the bank j and δ refer to the weight coefficient of interbank asset with δ=0.2.

- Method two

The second method [2,7] is that the loss is higher than the bank's tier 1 capital, which can be used to determine whether the risk occurs. In the complete network structure model, if the bank j is failures, the bankruptcy condition of the bank i which has debt relationship with the bank j is

$$\theta x_{ij} > c_i, \tag{4}$$

where θ represent loss rate and c_i represent the bank's tier 1 capital. If the failed bank j fails to cause the bank k failures, however, with the subsequent development, the bank k will be failures under the joint actions of the failed banks caused by the bankruptcy of the bank j. Hence the bankruptcy condition of the bank k can be characterized by the following inequality:

$$\sum_j^N x_{ij} * \alpha_j * \theta \geq c_k, \tag{5}$$

where

$$\alpha_j = \begin{cases} 1, & \text{the bank } j \text{ is failures} \\ 0, & \text{the bank } j \text{ is not failures.} \end{cases}$$

- Method three

We give a method to judge the order of bank failures in this paper, it is more conducive to the supervision and management of regulatory agencies. We assume that the bank's liquid assets and liabilities are only interbank assets and liabilities. In this case, the bank's initial liquidity ratio is

$$r_i = A_i/L_i, \tag{6}$$

and the liquidity ratio after loss is

$$r_i^* = (A_i - \theta_{ji})/L_i. \tag{7}$$

Further, let

$$\lambda = r - r_i^* = \theta x_{ji}/L_i, \tag{8}$$

Then we can determine the order of the affected bank according to the size of λ and obtain the order of the bankrupt bank via the first two methods.

4. Numerical Simulation

This section combines the model and methods of the preceding section to simulate interbank risk contagion process.

- Data selection

According to the interbank lending monthly report of the September 2016, we can know that state-owed commercial banks, joint stock commercial banks and city commercial banks accounted for 70% of total turnover amount and accounted for 48% total number of transactions. Therefore, this article only selects the three types of banks to make an analysis. So we select balance sheets of four state-owned banks, six joint-stock banks, and five city commercial banks from RESSET (www.resset.cn) for further analysis. In this paper, the tier 1 capital is the general risk reserve item in the balance sheet. In addition, the interbank assets are the sum of deposits of interbank, lending funds and buying back the sale of financial assets. Accordingly, the interbank liabilities are the sum of deposits of interbank, borrowing funds and financial assets sold for repurchase.

- Interbank risk contagion

We assume that the joint-stock banks and city commercial banks may fail based on the principle of "too big to fail" in this section. Through the analysis we can see that only the four banks, namely, Bank of Communications (BCM), Minsheng Bank (CMBC), Shanghai Pudong Development Bank (SPDB) and Industrial Bank (CIB), will make the banking industry suffered heavy losses. On this account, we just simulate the risk contagion process of the four banks in our works.

An estimate of levels of risk contagion for 15 banks is made by two methods in previous section under this environment that BCM, CMBC, SPDB and CIB are failures with θ=100%. Three rounds of simulation results are shown in the following Table 1.

As can be seen from Table 1, these two methods can determine the occurrence of contagion. we also find that the number of bank failures obtained by the method one is less than that of the method two. And through the simulation of China Everbright Bank (CEB) and China Citic Bank (CCB), the same conclusion can be got. Because by utilizing the method two we can see that the failure of both banks led to the collapse of the Bank of Beijing (BOB), but the method one cannot detect the occurrence of risk contagion.

Table 1: Risk contagion betwwen banks
(i)represents the bank failed in the i-round risk of contagion with i=1,2,3.

First failed bank	Method one: core capital adequacy ratio	Method two: tier 1 capital
Bank of Communication (BCM)	BOB(1), CEB(1), HXB(1); CMBC(2)，BON(2), SPDB(2); ABC(3), CIB(3), CMB(3), BOC(3), CCB(3).	BOB(1), HXB(1); CEB(2), CMBC(2), BON(2), BOC(2); CCB(3), NBCB(3), ABC(3), SPDB(3), CIB(3), CMB(3), CCB(3)
Minsheng Bank (CMBC)	BOB(1), HXB(1); CEB(2); BON(3), SPDB(3).	BOB(1); CEB(2), HXB(2); ICBC(3), BCM(3), BON(3), ABC(3), CMB(3), BOC(3).

Shanghai Pudong Development Bank (SPDB)	BOB(1), HXB(1); CEB(2); CMBC(3), BON(3).	BOB(1); CEB(2), HXB(2); BCM(3), CMBC(3), BON(3), ABC(3), CMB(3), BOC(3).
Industrial Bank (CIB)	BOB(1), CEB(1), HXB(1); CMBC(2), BON(2), SPDB(2); BCM(3), ABC(3), CMB(3), BOC(3), CCB(3).	BOB(1), CEB(1), HXB(1); ICBC(2), BCM(2), CMBC(2), BON(2), ABC(2), SPDB(2), CMB(2), BOC(2); CCB(3), NBCB(3), CCB(3).

By observing the results in the Table 1 vertically, we find that BCM, CMBC, SPDB and CIB show different towards the sustainability of the impact for the banking industry. BCM and CIB have only three contagions, but CMBC and SPDB have four contagions. From the persistence of contagion and the breadth of contagion, BCM and CIB are more important than CMBC and SPDB for the stable development of the banking industry.

By observing the results in the Table 1 horizontally, we find that the four banks firstly spread the risk to the BOB, followed by HXB (Huaxia Bank) and CEB. By comparing with other banks' balance sheet, we can find that the general reserve of BOB, HXB and CEB are relatively lower than other banks. At the same time we noticed that BOB's interbank assets accounted for 22% of total assets, HXB's interbank assets accounted for 11% of total assets and CEB's interbank assets accounted for 10% of total assets, while the proportion of other banks are below 10%. The larger proportion of interbank business may also be one of the main reasons why the three banks are vulnerable to interbank banks.

We further calculate the proportion of bank assets based on three rounds of simulation results. The results are shown in Fig 1.

According to Fig 1 we know that the proportion of bankruptcy bank assets obtained by method two is greater than the result of method one. So it is even more obvious that method one underestimates the severity of the contagion. The red line shows that BCM has the largest proportion of the assets of the failed bank, then is CIB, SPDB is in the third place, and CMBC is the lowest. The blue line shows that BCM and CIB have the largest proportion of the assets of the failed bank, the second is SPDB, and CMBC is the lowest. At the same time, the numbers of rounds of contagion are combined to get the conclusion that the contagion efficiency of BCM is maximum and it is more important in the banking system.
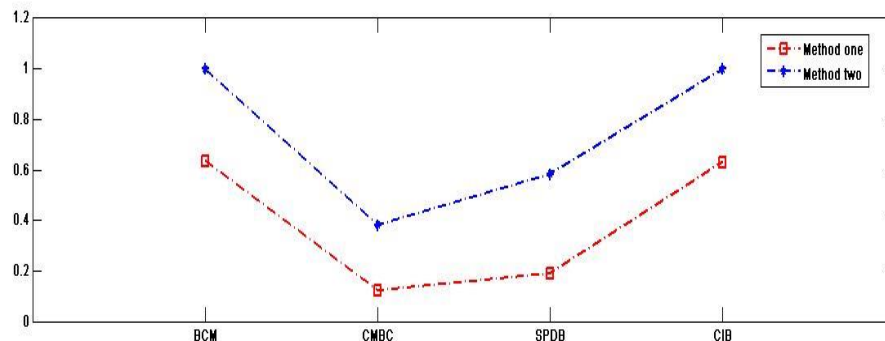

Figure 1: Proportion of bankruptcy bank assets

The order of the affected bank is given by method three as follows:

Table 2: λ

Bank bankruptcy value of λ	BCM λ_a	CMBC λ_b	SPDB λ_c	CIB λ_d
BOB λ_1	0.031682751	0.026118261	0.02396855	0.033486681
ICBC λ_2	0.007130393	0.005878116	0.005394229	0.007536283
CEB λ_3	0.013757431	0.011341318	0.010407791	0.014540764
HXB λ_4	0.016043289	0.013225465	0.012136924	0.016956698
CCB(China Citic Bank) λ_5	0.004810027	0.00396525	0.003638878	0.005083891
BCM λ_6	0	0.010353944	0.009501712	0.013274853
CMBC λ_7	0.010693984	0	0.008090196	0.01130285
BON λ_8	0.010586864	0.008727529	0.008009163	0.011189725
NBCB λ_9	0.004967151	0.004094864	0.003757894	0.005250077
ABC λ_{10}	0.008205022	0.006764037	0.006207195	0.008672106
SPDB λ_{11}	0.008486579	0.006996105	0	0.008969773
CIB λ_{12}	0.006665992	0.005495267	0.005042907	0
CMB λ_{13}	0.009923661	0.00818073	0.00750746	0.010488686
BOC λ_{14}	0.008667196	0.007145014	0.006556883	0.009160728
CCB(Construction Bank) λ_{15}	0.006203993	0.005114406	0.004693389	0.006557209

By observing the results in the Table 2 vertically and horizontally, we can get five unequal relations as follows:

$\lambda_1 > \lambda_4 > \lambda_3 > \lambda_7 > \lambda_8 > \lambda_{13} > \lambda_{14} > \lambda_{11} > \lambda_{10} > \lambda_2 > \lambda_{12} > \lambda_{15} > \lambda_9 > \lambda_5$ (BCM is first failure).

$\lambda_1 > \lambda_4 > \lambda_3 > \lambda_6 > \lambda_8 > \lambda_{13} > \lambda_{14} > \lambda_{11} > \lambda_{10} > \lambda_2 > \lambda_{12} > \lambda_{15} > \lambda_9 > \lambda_5$ (CMBC is first failure).

$\lambda_1 > \lambda_4 > \lambda_3 > \lambda_6 > \lambda_7 > \lambda_8 > \lambda_{13} > \lambda_{14} > \lambda_{10} > \lambda_2 > \lambda_{12} > \lambda_{15} > \lambda_9 > \lambda_5$ (SPDB is first failure).

$\lambda_1 > \lambda_4 > \lambda_3 > \lambda_6 > \lambda_7 > \lambda_8 > \lambda_{13} > \lambda_{14} > \lambda_{11} > \lambda_{10} > \lambda_2 > \lambda_{15} > \lambda_9 > \lambda_5$ (CIB is first failure).

$\lambda_d > \lambda_a > \lambda_b > \lambda_c$.

Now, I sum them up in 3 main points. By the five unequal relations, firstly, we can get the order of the banks affected by the bankruptcy of the four banks. And secondly, we find that the four banks initially spread the risk to the BOB, followed by HXB and CEB and CCB (Construction Bank) is least vulnerable to the impact of other banks, followed by the NBCB (Bank of Ningbo) and CCB (China Citic Bank). Lastly, from the fifth unequal relation, the impact of CIB on the banking system is the most serious, followed by the BCM, the third is CMBC, and SPDB rank last.

5. Conclusion

In this work we research contagion risk of interbank market by making use of complete network structure and matrix method. We not only make a analysis for the extent and duration of risk contagion and the impact of the entire banking assets based on the number of affected banks, the number of rounds of contagion and the proportion of the assets of the affected banks, but we also analyze the order of bank failures and the importance of Bank of Communications, Minsheng Bank, Shanghai Pudong Development Bank and Industrial Bank in the banking system. Our approach is better able to detect the risk contagion of interbank market so that it can promote the stable development of the banking industry. Our works have some reference value and significance for the study of the risk contagion of interbank market.

Acknowledgements

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