Systematic Risks and Risk Spillovers of Commercial Banks in China

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Abstract: From the perspective of risk spillovers and contagion, this paper constructs a ΔCoVaR model to measure the systemic risk of commercial banks in China. The result shows that the ΔCoVaR index better describes the risk spillovers effect of China's commercial banking systemic, and the ΔCoVaR index has a certain correlation with the real world economy, therefore has a better warning significance. Furthermore, this paper explores the influencing factors of the systemic risk of China's commercial banks through panel regression analysis. The results show that bank leverage ratio, logarithmic value of bank market value, bank's maturity mismatch and bank's market-to-book value ratio have significant impact on the systemic risk of financial banks.

1. Introduction

The financial crisis shows that there are significant negative externalities in the individual behaviors and risks of baking institutions. Such negative externalities mainly reflected in the risk spillovers and risk contagion(González-Hermosillo, 1996) caused by the interconnection of individual institutions. With the rapid development of modern banking industry, the connection between banking institutions is getting increasingly stronger and more complex. Once an individual bank encounters a crisis, its individual risk will quickly spread to other bank through direct or indirect connections, leading to the possibility of impact or even collapse of the entire banking system.

With the subversive impact of Internet Finance on the banking industry, the pressure on banking industry development has increased, and the transformation to informatization has generally begun. In recent years, due to the effects of factors such as the development of information technology and financial innovation, the relationships between banks have become increasingly close. Given that the risk spillovers caused by the interconnection between financial institutions is the mean reason behind the outbreak of systemic risk, it is of great warning significance to study the risk spillovers effect in China's banking industry. From the angle of risk spillovers and contagion, this paper measures the systemic risk of commercial banks, and focuses on exploring the influencing factors of systemic risk of commercial banks in China.

2. Literature Review

At present, the methods internationally used to measure the systemic risk are network model analysis, Contingent Claims Analysis(CAA) and tail measurement.

The main idea of network analysis method is to select the bilateral bank exposures and transaction data to establish the network relationship between banks, and to simulate the risk contagion among institutions base on the network shape inter-bank market, and therefore to measure the accumulated risk in each bank network. Since the actual data of the bilateral exposure is generally hard to require, Upper and Worms(2004) proposed the maximum entropy method to estimate the bilateral relationship between banks via total exposure of a single bank to the outside. The choices of empirical data can be mainly divided into two categories, one is based on inter-bank lending market, selecting inter-bank lending data(Upper and Worms, 2004); the other is based on payment and settlement market, using inter-bank payment and settlement data(Becher et al., 2008).

Contingent claims are refers to the future earnings depend on the value of other assets. Based on the application of option pricing method in the analysis of company's assets structure, Gray, Merton and Bodie(2007) formally proposed the contingent claims method, the core of which is to divide asset value into equity value plus debt face value minus debt-guarantee, while equity can be seen as asset-based call option and debt-guarantee is regarded as asset-based put option. Then balance sheet data and stock price data are used to analyze the default risk. Gray and Jobst(2010) continued to diversify the CAA and proposed the System Contingent Claims Analysis(SCCA) to examine the system default risk of the entire financial system.

Another important method to measure systemic risk is tail measurement. Adrian, Brunnermeier(2016) proposed conditional value at risk(CoVaR) on the basis of value at risk(Var) is one of the most popular tail measurements at present. CoVaR reflect the overall value at risk of the financial system under the condition that a particular financial institution is in trouble, and further defines the difference between the overall value at risk of financial system under the crisis conditions and usual conditions by Δ CoVaR, so as to reflect the contribution of a particular financial institution to the overall risk of financial system. This method has the inherent advantage in the study of the combination of individual risk and systemic risk. This paper attempts to characterize the spillovers effect of banking system in China by estimating the ΔCoVaR of China's listed commercial banks.

3. Model

The value at risk of individual bank i in quantile q can be expressed as VaR_q^i, so the value at risk of the financial system when the individual bank is in trouble is $\mathrm{CoVaR}_q^{\mathrm{system}|X^i=\mathrm{VaR}_q^i}$, therefore can be expressed as follow:

$$\Pr(X^{\mathrm{system}} \leq \mathrm{CoVaR}_q^{\mathrm{system}|X^i=\mathrm{VaR}_q^i} | X^i = \mathrm{VaR}_q^i) = q \tag{1}$$

Then the degree of risk contribution ΔCoVaR of individual bank to the financial system can be expressed as follow:

$$\Delta\mathrm{CoVaR}_q^{\mathrm{system}|i} = \mathrm{CoVaR}_q^{\mathrm{system}|X^i=\mathrm{VaR}_q^i} - \mathrm{CoVaR}_q^{\mathrm{system}|X^i=\mathrm{Median}^i} \tag{2}$$

Referring to Adrian and Brunnermeier(2016), using transaction data in financial markets, the model of ΔCoVaR can be set as follow:

$$X_t^i = \alpha^i + \gamma^i M_{\text{t-1}} + \varepsilon_t^i \tag{3}$$

$$X_t^{\mathrm{system}} = \alpha^{\mathrm{system}|i} + \beta^{\mathrm{system}|i} X_t^i + \gamma^{\mathrm{system}|i} M_{\text{t-1}} + \varepsilon_t^{\mathrm{system}|i} \tag{4}$$

Among them, X_t^i represents the return rate of individual bank i at moment t, X_t^{system} represents the return rate of financial system at moment t, $M_{\text{t-1}}$ represents other state variables of financial system at

time t-1, $\beta^{\text{system}|i}$ represents the contagious effect of individual bank i on the financial system, and $\gamma^{\text{system}|i}$ represents the impact of other external shocks on the financial system.

Formulas (5) and (6) are regressed at quantile q, the result is as follow:

$$\text{VaR}_t^i(q) = \hat{\alpha}_q^i + \hat{\gamma}_q^i M_{\text{t-1}} \tag{5}$$

$$\text{CoVaR}_t^q(q) = \hat{\alpha}_q^{\text{system}|i} + \hat{\beta}_q^{\text{system}|i}\text{VaR}_t^i(q) + \hat{\gamma}_q^{\text{system}|i} M_{\text{t-1}} \tag{6}$$

Therefore $\Delta\text{CoVaR}_q^{\text{system}|i}(q)$ can be expressed as:

$$\begin{aligned}\Delta\text{CoVaR}_q^{\text{system}|i}(q) &= \text{CoVaR}_t^q(q) - \text{CoVaR}_t^q(50\%) \\ &= \hat{\beta}_q^{\text{system}|i}(\text{VaR}_t^i(q) - \text{VaR}_t^i(50\%))\end{aligned} \tag{7}$$

4. Data Processing

This paper chooses the transaction and financial data of listed bank in the range of 2006M10-2018M06 and excludes the listed banks whose sample size is below one year. The data are from Shenzhen GTA Education Tech Ltd. and CEIC. A total of 23 listed banks are selected. This paper uses the daily return rate of listed banks as X_t^i, the return rate of listed financial industry index as X_t^{system}. Referring to Adrian and Brunnermeier(2016) and according to domestic data, other state variables $M_{\text{t-1}}$ of the financial system are shown in Table 1.

Table 1: State variable of financial system.

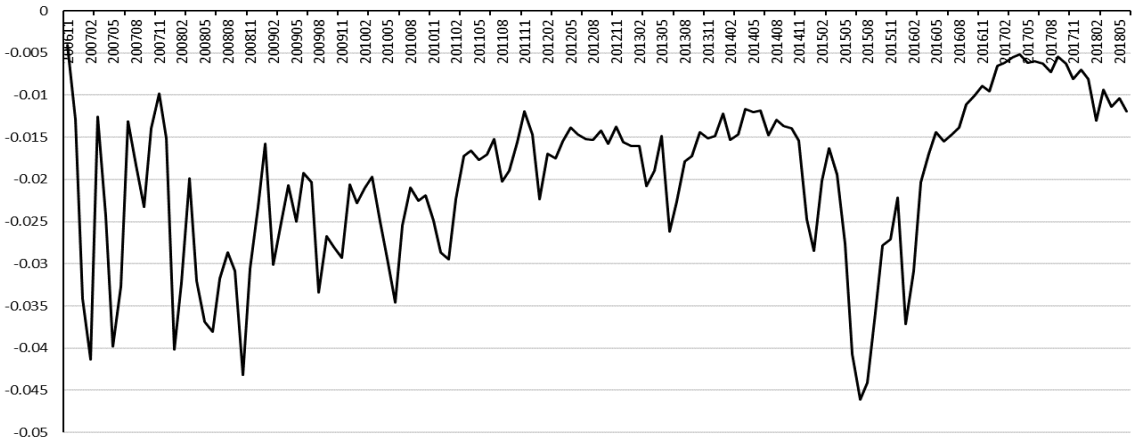
Variables	Market	Variable description
market yields	capital market	Using the closing price of CSI300 to calculate the yield rate.
market volatility	capital market	Using GARCH(1,1) to calculate the volatility of yield rate of CSI300.
credit spread	currency market	Difference between 10-year AAA corporate bond yield rate and 10-year Treasury bond yield rate.
yield curve	currency market	Difference between 10-year Treasury bond yield rate and 3-month Treasury bond yield rate.
liquidity	currency market	Difference between the 3-month Shanghai Interbank Offered Rate and 3-month Treasury bond yield rate.

5. Analysis of Model Result

According to the ΔCoVaR model constructed in this paper, the ΔCoVaR values of major listed commercial banks in China are obtained, and the average ΔCoVaR values of our banking system can be obtained by weighted average. Specific changes are shown in Figure 1. As can be seen from Figure 1, the spillovers effect of banking systemic risk in China is the most intense during the 2008 international financial crisis and the 2015 stock market crash. This is because that commercial banks, whose major business scope is public deposits, loans, settlements and so on, are financial enterprises for profit. Commercial banks are the backbone of China's financial industry, and play a very important role in China's economy. During the stock market crash, the value of pledge in the stock pledge loan business carried out by commercial banks rapidly decreased, which led to a sharp increase in the non-preforming assets of commercial banks, along with the increase in risk of default and in bad debts of banks, all of which would cause a severe risk spillovers effect.

Before the outbreak of international financial crisis in 2008, China's stock market experienced a big bull market, reaching a historical peak of 6224.04 on October 16,2007. With the outbreak of international financial crisis in 2008, the global financial market turmoil triggered by the financial crisis has had a negative transmission effect on China's domestic financial market, directly exacerbating the turmoil in China's domestic financial market, and the Shanghai Composite Index once fell below 1700 points. During the financial crisis of 2008, the absolute value of the average

ΔCoVaR of the banking system in China was massive, which indicated that the spillovers effect of commercial bank system was extremely high. At the same time, continued market turmoil has reduced the optimistic expectation of investors on Chinese market at the psychological level. On the other hand, the financial crisis led to a decline in China's imports and exports to the United States. Since



the United States is China's largest exporter and source of trade surplus, this has directly caused China's weak export. The adverse impact of financial crisis on China's exports directly affected China's economic growth, resulting in greater fluctuation in China's economy.

Figure 1: Average of ΔCoVaR value of China's banking system.

With the government introduced the "Four Trillion" stimulus plan, China's economy has recovered gradually, and the financial market has become stable. Therefore, the absolute value of the average ΔCoVaR of the banking system in China has gradually decreased, which indicated that the risk spillovers effect of commercial bank system has gradually weakened. However, in 2015, the absolute value of the average ΔCoVaR of the banking system in China increased significantly again and reached a historical peak, which is due to the reappear of the roller coaster market in China's financial market. The Shanghai Composite Index reached a peak of 5178.19 points on June 12,2015, followed by a sharp decline in China's capital market. The Shanghai Composite Index fell sharply from June to August 2015, falling from 5178.19 points to 2850.71 points in 53 trading days, a decline of more than 45%. During the same period, thousands of stocks in stock market have dropped, and multiple listed companies have chosen to avoid risks by stopping trading. Since most individual stocks have fallen by more than 50%, investors have suffered severe losses. The absolute value of the average ΔCoVaR of the banking system in China reached its historical maximum during this stock market crash, even greater than that during the financial crisis of 2008. This is because the financial market turmoil in China caused by the 2008 financial crisis is mainly caused by the transmission of external risks, while the stock market crash in 2015 was mainly caused by the changes of internal risks in China's financial market. In addition, China's economy has stepped into a new normal period and the economic growth has slowed down, so investors are even more worried. At this time, the spillovers effect of China's commercial banks was more serious.

6. Analysis of Influencing Factors

In order to explore the influencing factors of systemic risk of commercial banks in China, this paper constructs a panel data for regression analysis. The variables used are shown in Table 2. Among them, γ_i is the individual fixed effect; μ_t is the time effect, i.e. the year dummy variables from 2008 to 2018; ε_{it} is the residual.

$$\Delta \mathrm{CoVaR}_{it} = \alpha_0 + \alpha_1 \mathrm{lev}_{\mathrm{it}-1} + \alpha_2 \mathrm{lnme}_{\mathrm{it}-1} + \alpha_3 \mathrm{mis}_{\mathrm{it}-1} + \alpha_4 \mathrm{mb}_{\mathrm{it}-1} + \alpha_5 \mathrm{std}_{\mathrm{it}-1} + \alpha_6 \mathrm{beta}_{\mathrm{it}-1} + \gamma_i + \mu_t + \varepsilon_{it} \quad (8)$$

Table 2: Variables for panel regression.

Variables	Symbol	Variable description
bank leverage ratio	lev	Ratio of bank's total assets to owners' equity.
logarithmic value of bank market value	lnme	Logarithmic value of bank market value.
bank's maturity mismatch	mis	Ratio of bank's deposits to total debt after deducing the cash.
bank's market-to-book value ratio	mb	Ratio of market value of bank to booked value of bank.
volatility of bank's yield rate	std	Quarterly volatility of bank's daily yield rate.
bank's beta	beta	Quarterly mean of beta value based on bank's daily yield rate.

In this paper, EViews software is used to use the cross-sectional weighted generalized least squares method under fixed effects model. According to (6), regression analysis of the panel data of China's commercial banks from 2007 to 2018 is made. The results is shown in Table 3, including results of panel regression of whole sample, state-owned banks and non-state-owned banks.

Table 3: Result of panel regression.

	(1)whole sample	(2)state-owned banks	(3)non-state-owned banks
Variables	delta_covarq	delta_covarq	delta_covarq
lev	-0.00008***	-0.00025	-0.00014***
	(-2.745)	(-0.482)	(-4.665)
lnme	-0.00258**	-0.01185***	-0.00420***
	(-2.374)	(-3.348)	(-3.898)
mis	-0.00342*	-0.02218***	0.00061
	(-1.657)	(-3.800)	(0.321)
mb	-0.19870	2.26448***	0.36822
	(-0.613)	(4.025)	(1.153)
std	-0.09240*	-0.08147	-0.06181
	(-1.933)	(-1.334)	(-1.459)
beta	-0.00070	-0.00233	-0.00053
	(-1.489)	(-0.894)	(-1.223)
Constant	0.03084	0.23222***	0.05442***
	(1.47)	(3.009)	(2.742)
Observations	722	162	560
R-squared	0.910	0.847	0.926
Number of stkcd	25	4	21

Notes: Inside the parentheses are T statistics, *** p<0.01, ** p<0.05, * p<0.1.

For whole samples and non-state-owned banks, the regression coefficient of bank leverage ratio are negative and significant at 1% level, indicating that bank leverage ratio has a significant impact on the systemic risk of commercial banks; but for state-owned banks, bank leverage ratio has no significant impact on the systemic risk of commercial banks. Bank leverage ratio reflects debt level of commercial banks, and excessive leverage ratio will cause panic of the market and public toward commercial banks. It is widely believed that excessive leverage caused by excessive risk-taking by financial institutions is one of the most important reasons behind the financial crisis. State-owned banks belong to state-owned enterprises, directly controlled and supported by the country and have a large scale. Therefore, the sensitivity of risk spillovers degree of state-owned banks towards the leverage ratio of state-owned banks is low, so the regression coefficient is not significant.

The regression coefficient of the logarithmic value of bank market value is negative, which is significant at 5% confidence level for whole sample and is significant at 1% confidence level for state-owned banks and non-state-owned banks. The market value of banks is an important comprehensive index to measure the scale of banks, and can reflect the state of operation of banks to a certain extent. Considering that the larger the market value of bank, the larger the scale of the bank, the more links of business and other aspects between the bank and other commercial banks, the more serious the interaction is, it is reasonable to conclude that the spillovers effect will gets strong along with the market value of bank gets larger, and the coefficient is negative.

For whole sample, the regression coefficient of maturity mismatch of banks is negative, significant at the confidence level of 10%; for state-owned banks, the regression coefficient of maturity mismatch of banks is also negative and significant at 1% confidence level; for non-state-owned banks, the regression coefficient of maturity mismatch of banks is not significant. Maturity mismatch in financial industry is reflected in the short-term source of funds and long-term usage of funds. Since for a long time China's economy growth has depends on investment, the characteristics of low capital and long liabilities of state-owned banks are obvious, therefore the regression coefficient of maturity mismatch of banks is significant in the regression analysis of state-owned banks. Non-state-owned banks can better regulate their own situation, the mismatch phenomenon is not obvious, so the regression coefficient is not significant.

For state-owned banks, the regression coefficient of the market-to-book value ratio of banks is positive, and significant at 1% confidence level; for whole sample and non-state-owned banks, the regression coefficient of the market-to-book value ration of banks is not significant. The company with large market-to-book value ratio is a value company. with the increase of market-to-book value ratio, the risk of banks gets smaller and the spillovers effect weakens, therefore the regression coefficient is negative.

For whole sample, the regression coefficient of volatility of bank's yield rate is negative and significant at the confidence level of 10%; for state-owned banks and non-state-owned banks, the regression coefficient is also negative, but not significant. Yield volatility is the volatility of bank's yield, which is a measure of the uncertainty of bank's yield, and reflects risk level o bank's assets. The higher the volatility, the higher the risk of bank's assets, and the stronger the spillovers effect. Considering the risk of bank's assets is small and great fluctuation is unlikely, so the volatility of bank's yield rate has no significant impact on the systemic risk of commercial banks.

For whole sample, state-owned banks and non-state-owned banks, the regression coefficient of Beta is negative and not significant. Beta is an index to measure the extent to which an investment responds to changes in market portfolio, and it is a risk index. Assets of commercial banks have smaller risks, therefore have smaller beta value, so beta has no significant impact on the systemic risk of commercial banks.

7. Conclusion

From the view of risk spillovers and contagion, this paper measures the systemic risk of commercial banks in China, and focuses on exploring the influencing factors of systemic risk of commercial banks in China. By constructing the ΔCoVaR model, this paper gets the average ΔCoVaR of commercial banking system from 2007 to 2018, and therefore draws the risk spillovers effect of China's banking system. Through analysis, it is found that the risk spillovers effect is the strongest during the 2008 financial crisis and 2015 stock market crash in China, which is related to the real world economy, and therefore has a better warning significance.

In order to further explore the influencing factors of systemic risk in China's commercial banking system, this paper constructs panel data and carries out regression analysis on the whole sample, state-owned banks and non-state-owned banks. The results of regression show that the bank leverage ratio and the logarithmic value of bank market value have significant effects on the systemic risk of commercial banks in all three groups. The bank's maturity mismatch and bank's market-to-book value ratio have significant effects on the systemic risk of state-owned commercial banks. Some indicators of commercial banks are significantly related to risk spillovers effect, but at the same time these indicators are also very important for the development and operation of commercial banks. How to balance the risk spillovers and the development and operation of commercial banks needs further research.

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