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AN EMPIRICAL STUDY OF RISK SPILLOVER EFFECT OF CHINA'S SHADOW BANKING ON COMMERCIAL BANKS

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Abstract. *In this paper, a GARCH-VaR and CoVaR model based on the financial institutions of shadow banking system and the traditional commercial banks was established, in which the risk assessments of China's shadow and commercial banks were analyzed. The results showed that the value at risk in the shadow banking system was higher than that of the traditional commercial banks and the value at risk of large state-owned commercial banks was lower than those of the joint-stock and city commercial banks under the 99% confidence level. The shadow banking system was more fragile, and its inherent high leverage and instability was vulnerable to market shocks, which led to systemic risk. The conditional value at risk of commercial banks increased significantly after considering the spillover effect of the shadow banks. The risk spillover effects of China's shadow banks on the state-owned commercial banks were more than those on city commercial banks and joint-stock commercial banks.*

Keywords: Shadow bank, Commercial banks, GARCH-VaR model, CoVaR model, Risk spillover

1. **Introduction.** The shadow banking system can broadly be described as the system of credit intermediation and liquidity transformation that involves entities and activities fully or partially outside the regular banking system, according to the Financial Stability Board [1]. The definition of shadow banking differs from country to country as the different financial environment and market development. Market participants in China usually refer to nonbank financial institutions, such as trust companies, brokerage firms, small lenders and financial guarantors, as shadow banks [2,3]. With the change of China's macroeconomic policy environment and the gradual improvement of the financial market system, the impact of shadow banking on China's macro economy is more significant. Shadow banking has the potential not only to be a beneficial contributor to continued economic growth, but also to contribute to systematic instability if not properly monitored and regulated.

The non-bank financial intermediaries that comprise shadow banking provide services similar to traditional commercial banks, but are not regulated or supervised like a bank. More specifically, shadow banks are not subject to capital requirements, loan to deposit ratios or loan loss provisions. Not being regular banks, moreover, they do not have access to the central bank's lender of last resort facility. Of course, shadow banks by offering similar services to commercial banks provide more competition and more choices for consumers. They can even contribute to economic growth and development by expanding the availability of financial services. However, as shadow banks have complicated structures and inter-linkages with commercial banks and are far less heavily regulated than regular banks, they have the potential to cause systemic risks.

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The Value at Risk (VaR) model proposed by J. P. Morgan in the 1990s has been widely used in various financial institutions and regulators [4]. However, the biggest drawback of VaR model is that it can only predict potential risk of asset portfolio under normal market conditions, and cannot cover the extreme market conditions. The risk of individual financial institutions spread in the financial markets, which caused the systemic risk. Therefore, the VaR theory is very vulnerable in the event of a financial crisis. The Conditional Value at Risk (CoVaR) model was proposed by Adrian and Brunnermeier to measure the degree of risk overflows between financial institutions on the basis of VaR, that is the risk spillover effects on other financial institutions when a particular financial institution is in trouble [5]. The risk spillover effects of China's shadow banks on the state-owned commercial banks were more than those on city commercial banks and joint-stock commercial banks.

Many scholars have studied the risk spillover effect of commercial banks in China. The CoVaR method was used by Li et al. to measure the CoVaR and risk spillover effect between the China's stock-listed commercial banks [6,7]. The research results showed that there was no significant linear relationship between the contribution of systemic risk and the VaR. Yang et al. used the VaR and CoVaR method and quantile regression technology to calculate the systemic risk value and risk spillover value of 14 listed banks in China [8,9]. The study showed that the systematic risk spillovers of large banks were bigger.

The existing research literature mainly analyzed the static risk distribution of commercial banks from the empirical aspects, and discussed the systematic risk contribution of listed banks in China. However, there was little empirical research about the risk spillover effect of representatives of shadow banks, such as some listed securities companies, trust companies, and venture capital firms, on commercial banks in China. In this paper, a GARCH-VaR and CoVaR model was established using the listed securities companies, trust companies, venture capital firms as the research object. The inherent risk and the risk spillover effects of China's shadow banking system on the commercial banks were analyzed, and some countermeasures and suggestions according to the empirical analysis conclusion were proposed.

2. **The Risk Spillover Empirical Model.**

2.1. **Research object selection and data processing.** The shadow banking system in China mainly includes the non-bank financial institutions and some informal financial activities that leverage the functions of debt financing. The representative of the shadow banking includes the futures companies, leasing companies, trust companies, securities companies, investment companies, financial institutions and the folk financing, etc. In this paper, the relevant listed financial institutions of shadow banking were taken as the empirical analysis object in order to obtain the economic data which can accurately and effectively reflect the shadow banking system. Shaanxi International Trust Co., LTD. (SXIT) and Anxin Trust Co., LTD. (AXT) were selected as the representative of trust company. Haitong Securities Co., LTD. (HTS) and CITIC Securities Company Limited (CSCL) were selected as the representative of the securities class shadow banks. Bohai Capital Holding Co., LTD. (BHCH), Sunny Loan Top Co., LTD. (SLTC), Minsheng Holdings Co., LTD. (MSH) and Shanghai AJ Group Co., LTD. (SHAJ) were selected as the representative of the financing lease, guarantee, and pawnshop class shadow banks. Bank of China Limited (BOC), Industrial and Commercial Bank of China Limited (ICBC), China Construction Bank Corporation (CCB) and Bank of Communications Co., LTD. (BOCOM) were selected as the representatives of state-owned commercial banks. China CITIC Bank Co., LTD. (CITICB), Huaxia Bank Co., LTD. (HXB), China Minsheng

Banking Co., LTD. (CMBC), Pingan Bank Co., LTD. (PAB), Shanghai Pudong Development Bank Co., LTD. (SPDB), Industrial Bank Co., LTD. (CIB) and China Merchants Bank Co., LTD. (CMB) were selected as the representatives of joint-stock commercial banks. Bank of Beijing Co., LTD. (BOB), Bank of Nanjing Co., LTD. (BONJ), Bank of Ningbo Co., LTD. (BONB) were selected as the representatives of city commercial banks.

In order to reflect the strong integrity and consistency of economic data, the time span of the data is from January 1, 2008 to December 31, 2017. The data is derived from the daily closing price, and then the yield sequence, R_t, can be expressed as

$$R_t = \frac{P_t - P_{t-1}}{P_{t-1}} \times 100\% \tag{1}$$

The yield sequence was deducted by the corresponding mean of each financial institution, and then the new yield sequence obtained was used to establish GARCH-VaR and CoVaR model.

2.2. **GARCH-VaR and CoVaR model.** Value at Risk (VaR) is the maximum value of market risk and potential loss faced by the financial institution or product when they are in the extreme cases at certain confidence level and period of time. VaR model can effectively estimate the market risk of financial institutions and investment portfolios and express the risk value in the form of specific numbers, which is intuitive and quantitative. At present, the management mode and method based on the VaR metrology model are generally recognized and accepted by the more and more financial regulatory authorities and commercial banks, investment banks and institutional investors.

Financial time series usually show that the most recent data have a greater impact on predicting future volatility. Based on this, Engle and Bollerslev established Generalized AutoRegressive Conditional Heteroskedasticity (GARCH) model. The model assumes that the yield change is predictable by giving the greater weight for the new data. The predicted conditional mean and the variances also include new and previous information [10], and the equations are given by

$$R_t = \gamma + aR_{t-1} \tag{2}$$

$$\sigma_t^2 = \omega + \alpha\mu_{t-1}^2 + \beta\sigma_{t-1}^2 \tag{3}$$

where R_t is conditional mean, and γ is conditional variance. σ_t^2 is conditional variances, ω is constant, μ_{t-1}^2 and σ_{t-1}^2 are ARCH and GARCH terms respectively.

Empirical research shows that GARCH $(1, 1)$ model has better fitting characteristics for financial time series. Therefore, the GARCH $(1, 1)$ model is used to analyze the stock yield sequence of financial institutions and get the conditional variances sequence. Then the intrinsic value at risk of shadow banking system was calculated by the equation,

$$VaR_i = \mu_i - \alpha \times \sigma_i \tag{4}$$

where VaR is value at risk, μ, σ are respectively the expectation and standard deviation of yield, and α is the quantile of Gaussian distribution at a confidence level.

The conditional value at risk of commercial bank N in the case where the loss value of the shadow bank S is VaR and the confidence level is $1 - q$ can be expressed as

$$P_r\left(X^N \leq CoVaR_q^{N|S} \middle| X^S = VaR_q^S\right) = q \tag{5}$$

$$CoVaR_q^{N|S} = \hat{R}^N + Q(q)\hat{\sigma}^S \tag{6}$$

where the $CoVaR_q^{N|S}$ is the conditional value at risk, which covers the risk spillover effect of the shadow bank S on commercial bank N, including unconditional and spillover value at risk. The conditional value at risk reflects the total value at risk of commercial bank N. In order to reflect more clearly and specifically the incremental value at risk of commercial bank N during the occurrence of the largest possible loss of the shadow bank

S, the spillover value at risk, $\Delta CoVaR_q^{N|S}$, and the spillover intensity, $\%CoVaR_q^{N|S}$, are respectively expressed as follows

$$\Delta CoVaR_q^{N|S} = CoVaR_q^{N|S} - VaR_q^S \tag{7}$$

$$\%CoVaR_q^{N|S} = \left(\Delta CoVaR_q^{N|S} \,/\, VaR_q^S\right) \times 100\% \tag{8}$$

3. **Results and Discussions.** The yield sequence was deducted by the corresponding mean of each financial institution, and then the new yield sequence obtained was used to establish GARCH-VaR and CoVaR model. The GARCH model is set according to Equations (2) and (3). By substituting yield sequence into Equations (2) and (3), the mean and variance regression equations are calculated and the coefficients of equations are as shown in Table 1 and Table 2.

TABLE 1. The coefficients of mean regression equation $R_t = \gamma + aR_{t-1}$

Institution	γ	a	Institution	γ	a
CCB	0.019	0.011	BOB	0.012	−0.050
BOCOM	0.007	0.025	BONJ	−0.005	−0.005
ICBC	0.024	−0.031	BONB	0.026	−0.036
BOC	0.005	−0.002	CSCL	0.027	0.017
CITICB	0.003	−0.002	HTS	−0.011	0.006
HXB	−0.012	−0.009	AXT	−0.003	−0.021
CMBC	−0.014	−0.004	SXIT	−0.030	−0.032
PAB	−0.018	−0.011	SHAJ	−0.012	0.020
SPDB	−0.011	0.003	MSH	0.005	0.041
CIB	0.011	0.010	SLTC	−0.004	0.016
CMB	0.016	−0.003	BHCH	−0.007	0.024

TABLE 2. The coefficients of variance regression equation $\sigma_t^2 = \omega + \alpha\mu_{t-1}^2 + \beta\sigma_{t-1}^2$

Institution	ω	α	β	Institution	ω	α	β
CCB	0.038	0.111	0.881	BOB	0.017	0.065	0.935
BOCOM	0.054	0.125	0.870	BONJ	0.033	0.065	0.930
ICBC	0.019	0.102	0.897	BONB	0.061	0.057	0.933
BOC	0.026	0.098	0.895	CSCL	0.024	0.054	0.945
CITICB	0.083	0.092	0.897	HTS	0.013	0.057	0.943
HXB	0.036	0.087	0.910	AXT	0.232	0.087	0.892
CMBC	0.029	0.105	0.897	SXIT	0.058	0.046	0.949
PAB	0.014	0.052	0.948	SHAJ	0.175	0.069	0.913
SPDB	0.016	0.079	0.922	MSH	0.224	0.060	0.916
CIB	0.009	0.062	0.939	SLTC	0.121	0.064	0.925
CMB	0.026	0.055	0.940	BHCH	0.088	0.063	0.930

The regression equations were estimated by one step forward on the basis of the GARCH model, and the prediction means and variances of financial institution were further calculated. The VaR can be obtained according to Equation (4). In order to compare and analyze the risk of commercial banks and representative institutions of shadow banks, their VaR was calculated under 99% confidence level, as shown in Table 3 and Table 4.

In Table 3 and Table 4, the VaR of shadow banking system is higher than that of commercial banks under the 99% confidence level. Shadow banking in addition to CITIC and Haitong Securities, their VaR levels are above 7, which shows that the shadow banking system has more potential risk than commercial banks, and is more fragile and vulnerable

Table 3. Mean, standard deviation and VaR of commercial banks

Institution		Mean	Standard deviation	VaR ($q = 1\%$)
State-owned commercial banks	CCB	0.019	1.596	−3.693
	BOCOM	0.007	1.862	−4.325
	ICBC	0.024	1.469	−3.394
	BOC	0.005	1.462	−3.396
Joint-stock commercial banks	CITICB	0.003	2.202	−5.120
	HXB	−0.012	2.229	−5.196
	CMBC	−0.014	2.015	−4.702
	PAB	−0.018	2.361	−5.511
	SPDB	−0.011	2.156	−5.027
	CIB	0.011	2.256	−5.238
	CMB	0.016	2.064	−4.785
City commercial banks	BOB	0.012	2.084	−4.835
	BONJ	−0.005	2.165	−5.040
	BONB	0.026	2.327	−5.387

Table 4. Mean, standard deviation and VaR of representative institution of shadow banks

Institution	Mean	Standard deviation	VaR ($q = 1\%$)
CSCL	0.027	2.695	−6.243
HTS	−0.011	2.788	−6.497
AXT	−0.003	3.170	−7.377
SXIT	−0.030	3.218	−7.515
SHAJ	−0.012	3.109	−7.244
MSH	0.005	3.012	−7.003
SLTC	−0.004	3.170	−7.378
BHCH	−0.007	3.028	−7.052

because of its inherent high level and the instability. The VaR of commercial banks is about 5 or lower, and so their market risk is small. The VaR level of commercial Banks is about 5 or lower, and the market risk is small. The VaR of state-owned commercial banks is lower than that of joint-stock and city commercial banks. For example, the VaR of Industrial and Commercial Bank of China is 3.394 and the VaR of Pingan Bank is more than 5.5. This is because that the state-owned commercial banks have the strong capital, strong anti-risk ability, strong technical and management advantages, and a clear development strategy. In addition, the state-owned commercial banks were supervised and restricted strictly by CBRC, and their risk coefficient is low. While the city commercial banks and joint-stock commercial banks had more overlapping business with shadow banking, so the risk coefficient was higher.

Therefore, financial regulators should give full attention to the risk prevention of shadow banking, strengthen effective supervision of the shadow banking institutions, which promote the healthy and stable development of China's financial system.

According to the VaR of commercial and shadow banks, the conditional value at risk of the commercial banks come from shadow banking is calculated by Equation (6) at 99% confidence level. Meanwhile, the spillover VaR and strength can be calculated by Equations (7) and (8), and the calculated results are shown in Table 5, Table 6, and Table 7, respectively.

Table 5. Conditional value at risk of commercial banks come from shadow banking

Institution	CSCL	HTS	AXT	SXIT	SHAJ	MSH	SLTC	BHCH
CCB	−6.251	−6.468	−7.356	−7.466	−7.214	−6.989	−7.356	−7.026
BOCOM	−6.263	−6.479	−7.367	−7.478	−7.225	−7.001	−7.367	−7.038
ICBC	−6.246	−6.462	−7.350	−7.461	−7.208	−6.984	−7.350	−7.021
BOC	−6.265	−6.482	−7.369	−7.480	−7.228	−7.003	−7.370	−7.040
CITICB	−6.267	−6.483	−7.371	−7.482	−7.229	−7.004	−7.371	−7.042
HXB	−6.282	−6.498	−7.386	−7.497	−7.244	−7.019	−7.386	−7.057
CMBC	−6.284	−6.501	−7.389	−7.499	−7.247	−7.022	−7.389	−7.059
PAB	−6.288	−6.504	−7.392	−7.503	−7.250	−7.025	−7.392	−7.062
SPDB	−6.281	−6.498	−7.386	−7.496	−7.244	−7.019	−7.386	−7.056
CIB	−6.259	−6.476	−7.363	−7.474	−7.221	−6.997	−7.364	−7.034
CMB	−6.254	−6.470	−7.358	−7.469	−7.216	−6.992	−7.358	−7.029
BOB	−6.258	−6.474	−7.362	−7.473	−7.220	−6.995	−7.362	−7.032
BONJ	−6.275	−6.491	−7.379	−7.490	−7.237	−7.012	−7.379	−7.049
BONB	−6.244	−6.460	−7.348	−7.459	−7.206	−6.981	−7.348	−7.018

Table 6. Spillover value at risk of commercial banks come from shadow banking

Institution	CSCL	HTS	AXT	SXIT	SHAJ	MSH	SLTC	BHCH
CCB	−2.558	−2.775	−3.662	−3.773	−3.520	−3.296	−3.663	−3.333
BOCOM	−1.938	−2.154	−3.042	−3.153	−2.900	−2.676	−3.042	−2.713
ICBC	−2.852	−3.068	−3.956	−4.067	−3.814	−3.590	−3.956	−3.627
BOC	−2.869	−3.086	−3.974	−4.084	−3.832	−3.607	−3.974	−3.644
CITICB	−1.147	−1.363	−2.251	−2.362	−2.109	−1.885	−2.251	−1.922
HXB	−1.085	−1.302	−2.189	−2.300	−2.048	−1.823	−2.190	−1.860
CMBC	−1.582	−1.798	−2.686	−2.797	−2.544	−2.320	−2.686	−2.357
PAB	−0.777	−0.993	−1.881	−1.992	−1.739	−1.515	−1.881	−1.552
SPDB	−1.254	−1.471	−2.358	−2.469	−2.217	−1.992	−2.359	−2.029
CIB	−1.021	−1.237	−2.125	−2.236	−1.983	−1.758	−2.125	−1.796
CMB	−1.468	−1.685	−2.572	−2.683	−2.431	−2.206	−2.573	−2.243
BOB	−1.422	−1.639	−2.526	−2.637	−2.384	−2.160	−2.527	−2.197
BONJ	−1.235	−1.451	−2.339	−2.450	−2.197	−1.972	−2.339	−2.010
BONB	−0.856	−1.073	−1.960	−2.071	−1.818	−1.594	−1.961	−1.631

It can be found from Table 5 that the conditional value at risk of BONB come from CITIC Securities is 6.244, and the conditional value at risk of PAB come from SXIT is 7.503. It indicated that the conditional value at risk of commercial banks come from the securities shadow banking was less than that from trust companies shadow banking. Moreover, the conditional value at risk of commercial banks increased significantly after considering the spillover effect of the shadow banks. In other words, when the shadow banks were in trouble, the traditional commercial banks would also face the greater risk. It can be found in Table 6 and Table 7, the spillover effects of China's shadow banks on the state-owned commercial banks were more than those on city commercial banks and joint-stock commercial banks. Among them, the risk spillover intensity of SXIT to BOC was as high as 120.2%, while the risk spillover intensity of CSCL to PAB was just 14.1%. This may be because that the mixed business model of Pingan Insurance (Group) Company of China, Ltd. was good for the risk diversification of commercial banks. In general, the spillover intensity of shadow banks to the joint-stock banks and city banks was small. On the one hand, it showed that the own risk of joint-stock banks and city banks was bigger, and their risk supervision should be strengthened. On the other hand,

Table 7. Spillover intensity of shadow banking to commercial banks (%)

Institution	CSCL	HTS	AXT	SXIT	SHAJ	MSH	SLTC	BHCH
CCB	69.26	75.12	99.16	102.1	95.32	89.24	99.17	90.24
BOCOM	44.81	49.81	70.33	72.90	67.05	61.86	70.34	62.72
ICBC	84.03	90.41	116.57	119.83	112.38	105.7	116.58	106.8
BOC	84.49	90.87	117.01	120.2	112.83	106.2	117.02	107.3
CITICB	22.40	26.63	43.97	46.13	41.19	36.81	43.97	37.53
HXB	20.89	25.05	42.13	44.27	39.40	35.08	42.14	35.80
CMBC	33.64	38.25	57.12	59.48	54.10	49.33	57.13	50.12
PAB	14.10	18.03	34.13	36.15	31.56	27.48	34.14	28.16
SPDB	24.95	29.26	46.92	49.12	44.09	39.63	46.92	40.37
CIB	19.49	23.62	40.56	42.68	37.85	33.57	40.57	34.28
CMB	30.68	35.21	53.76	56.07	50.79	46.10	53.76	46.87
BOB	29.41	33.89	52.24	54.54	49.31	44.67	52.25	45.43
BONJ	24.50	28.79	46.41	48.61	43.59	39.14	46.41	39.87
BONB	15.89	19.91	36.39	38.45	33.75	29.59	36.40	30.28

it showed that the shadow banking business had spread the most risk of joint-stock banks and city banks, which was beneficial to their risk management.

4. **Conclusion and Recommendation.** In this paper, the daily yield of the 14 listed commercial banks and 8 financial institutions as the representatives of shadow banking system from 2008 to 2017 was used in the GARCH-VaR and CoVaR model, the value at risk of shadow banking and commercial banks and the spillover effects of shadow banking on commercial banks in China were empirically analyzed.

The VaR of shadow banking system is higher than that of commercial banks under the 99% confidence level, and the VaR of state-owned commercial banks is lower than that of joint-stock and city commercial banks. The shadow banking system has more potential risk developing the systemic risk than commercial banks and is more fragile and vulnerable because of its inherent high level and the instability, which was easy to develop a systemic risk. The systemic risk tended to expand to commercial banks due to the natural connection between the commercial banks and shadow banking, and then through the credit channels of bank to formal financial institutions, which formed the bidirectional conduction mechanism of risk.

The conditional value at risk of commercial banks increased significantly after considering the spillover effect of the shadow banks. The risk spillover effects of China's shadow banks on the state-owned commercial banks were more than those on city commercial banks and joint-stock commercial banks. On the one hand, it showed that the own risk of joint-stock banks and city banks was bigger, and their risk supervision should be strengthened. On the other hand, it showed that the shadow banking business had spread the most risk of joint-stock banks and city banks, which was beneficial to their risk management.

In general, the shadow banking system has a strong risk spillover effect on commercial banks. Therefore, it is necessary to establish a risk firewall between the shadow banking system and traditional commercial banks to effectively prevent the risk spillover effect of shadow banks and avoid the spread and diffusion of risks in the financial system.

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