Risk spillover effect of real estate industry and banking industry

Yuwei He *

School of Nanjing University of Science And Technology, Nanjing, China

* Corresponding Author Email: 1678249545@qq.com

Abstract. The relationship between the real estate market and the banking industry has always been concerned, and its fluctuation may have a significant impact on the banking industry. In order to deeply understand this influence mechanism, this study uses DCC-GARCH model to analyze the sample data from 2012 to 2022, and reveals the volatility linkage between the real estate market and the banking industry, so as to more accurately analyze the risk transmission effect, with a view to providing support for risk management and policy formulation and helping to establish a more stable and sustainable financial system.

Keywords: Real estate; banking; risk spillover effect.

1. Introduction

The relationship between the real estate market and the financial market, as an important component of a country's economy, has attracted much attention. In the past few decades, the volatility of the real estate market has not only had a profound impact on the real estate industry itself, but also posed a challenge to the stability of the financial system. Especially the relationship between the real estate industry and the banking industry, due to the important financing and lending role of the banking industry in the real estate market, its risk spillover effect has a significant impact on the stability of the financial system. However, the extent and mechanism of this risk spillover effect still require in-depth research and understanding. With the increasing complexity of financial markets, traditional methods have limitations in explaining the risk transmission mechanisms between different markets. Therefore, introducing more advanced methods to study the risk spillover effects of the real estate industry on the banking industry has become increasingly important. In this context, this study adopted the DCC-GARCH model to more accurately quantify the degree of risk transmission in the banking industry in the real estate market by calculating the CoVaR value.

In recent years, scholars' research on risk spillovers has mostly focused on individual studies, only focusing on the potential impact of the real estate industry on the banking industry, without paying attention to the potential impact of bank risks on the real estate industry. Mei et [1]found that the time variation of bank risk premiums is partially determined by interest rates and real estate market conditions. This article focuses on the study of bidirectional risk spillovers between the real estate industry and the banking industry, which can better study the relationship between the two.

There have been many explorations both domestically and internationally regarding the measurement of risk spillovers. Early scholars used vector autoregressive models (VARs) to construct risk spillover networks by decomposing the total prediction error into variances. Diebold and YilmaZ [2] tracked the daily time-varying correlations of major financial institutions in the United States based on the establishment of variance decomposition, measuring the degree of risk spillover in the financial market. Adrian and Maximilian Brauneis [3]proposed the concept of conditional at risk CoVaR based on value at risk (VaR). CoVaR considers the interdependence between financial institutions and measures the systemic risk contribution of a financial institution by calculating its probability distribution of transmitting risk to the entire financial system. On this basis, many experts and scholars have explored different methods and models to calculate CoVaR to measure the contagion effect and contribution to systemic risk when a risk event occurs. In 2016, Tobias and Brunnermeier [4] [4] further optimized the measurement of systemic risk based on the CoVaR method and proposed Δ CoVaR. The research foundation of this article is also based on the calculation of

CoVaR and related concepts. For the calculation method of CoVaR, the quantile method and copula method were commonly used by predecessors. Congwen et [5]used the copula method to measure the risk spillover effects of various shadow banks on commercial banks based on the characteristics of Chinese shadow banks. The DCC-GARCH model, quantile method, and Copula method can all be used to calculate CoVaR. In comparison, the DCC-GARCH model allows for correlation coefficients of time changes and considers volatility linkage, which can effectively capture volatility linkage between different markets. Therefore, this article uses this model for research.

2. Real estate and banking risk spillover mechanism

2.1. The Impact of Real Estate Risks on Bank

When the house price rises, the borrower's collateral value increases, and banks are more willing to lend, thus improving the credit supply. On the contrary, when house prices fall, the value of borrowers' collateral decreases, and banks may tighten credit conditions. Secondly, higher housing prices can provide greater mortgage value, making it easier for borrowers to obtain credit with lower interest rates, and at the same time reducing the risk of non-performing loans for banks. If the house price fluctuates greatly, it may lead to the decline of the borrower's repayment ability, thus increasing the risk of non-performing loans of banks. This poses a challenge to the stability of banks. Therefore, banks usually pay attention to the stability of the real estate market to reduce risks. Finally, the fluctuation of house prices will also affect the stability of the entire financial system. When the house price falls sharply, it may trigger a series of chain reactions, lead to the instability of the bank's balance sheet, and may even trigger a financial crisis. This requires regulators to pay close attention to the relationship between the real estate market and bank credit in order to maintain the stability of the financial system.

The high proportion of real estate credit in the banking industry forms a high real estate risk exposure, which makes the real estate risk easily transformed into the banking system risk. In the bank-led structure, almost all the real estate financing comes from commercial banks, which makes the banking sector produce a high proportion of real estate credit, and then makes the real estate risk highly concentrated in the banking system. This potential financial risk still exists until recently. The high proportion of real estate credit in the banking industry, on the one hand, makes the development of the real estate industry inseparable from the stability of the banking industry [6], on the other hand, the higher real estate risk exposure makes the banking industry more sensitive to the risks of the real estate industry [7]. The two form a community of interests and a symbiotic relationship of risks. Real estate risks can easily affect the systemic risks of the banking sector through credit channels [8]. Historical evidence shows that in the past few decades, systemic risks in the banking industry have become more frequent, and real estate development is often the main factor behind these risks [9], and real estate prosperity is closely related to the emergence of systemic risks.

2.2. The Impact of Bank Risk on Real Estate

Banks are one of the most important sources of financing in the real estate market [10]. Banks support real estate transactions and development projects by providing loans to buyers and developers. The change of credit supply directly affects the financing ability of buyers and developers. When banks provide more loans, it is easier for buyers to obtain financing, thus promoting the activity of the real estate market. The liquidity of banks will also affect the real estate market. The bank's ability to supply funds affects the ability of buyers to pay and the credit cost of buyers. When the bank has sufficient funds, buyers can get low-cost loans more easily, thus supporting real estate transactions.

The role of banks in the real estate market also involves the stability of the market. The bank's credit policy and risk management directly affect the volatility of the real estate market. If banks are too aggressive in credit expansion, it may lead to an excessively lively real estate market, which in turn will trigger a market bubble. On the contrary, if banks are too cautious, it may lead to a downturn in the market. In addition, the government's regulation and control policies on the real estate market will affect the market by affecting the bank's credit policy. Policies such as restricting purchases and loans implemented by the government will affect the financing ability of buyers, thus affecting market demand. Banks will adjust their credit policies according to the policy requirements to meet the government's regulatory objectives. In addition, the bank's credit activities in the real estate market may also bring risks. If banks lend too much, the risk of non-performing loans may rise. The increase of non-performing loans may affect the health of banks' balance sheets, thus affecting their credit policies and market influence.

When risks occur in the banking industry, banks will shrink the credit supply and reduce the loan amount of real estate developers and buyer[s] [11], thus affecting the financing environment of the real estate market [12]. It leads to the delay or interruption of real estate development projects, reduces the purchasing power of buyers, and then affects the transaction volume and price of the real estate market. At the same time, the rising risk of banks is usually accompanied by the increase of capital cost, which leads banks to raise loan interest rates or tighten loan conditions, which will increase the financing costs of buyers and developers and inhibit the activity of the real estate market, thus further leading to a decline in the confidence of investors and consumers. Buyers delay the decision to buy a house, and developers delay the start of the project, which affects the supply-demand relationship and price trend of the real estate market, affects the operation and return of real estate funds, and causes risk losses.

3. Model introduction

3.1. 3.1 DCC-GARCH Model

GARCH model introduces the lag term of conditional variance on the basis of ARCH model to consider the influence of past variance on current variance. Compared with ARCH model, GARCH model has the following advantages: (1) GARCH model introduces the lag term of conditional variance, which can consider the influence of past variance on current variance. This enables the model to better capture the long-term dependence and persistence of volatility in time series data. In contrast, ARCH model only considers the influence of past error terms on current variance. (2) The parameters of 2) GARCH model are more flexible and can adapt to different data characteristics and model requirements. The fitting ability and prediction accuracy of the model can be improved by adjusting the weight of lag order and conditional variance. (3) Because GARCH model considers the time variation of variance, it can better capture the phenomenon of peak and thick tail in financial market data, that is, the occurrence of extreme fluctuations. To sum up, GARCH model overcomes some limitations of ARCH model in terms of long-term dependence, peak-tail phenomenon and flexibility by introducing the lag term of conditional variance, which makes the model more adaptable to the characteristics of actual financial market data and provides more accurate risk measurement and volatility prediction. The standard GARCH model has the following structure:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \, \mu_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2 \tag{1}$$

$$\mu_t = \nu_t \sqrt{\alpha_0 + \sum_{i=1}^{q} \alpha_i \, \mu_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2} \tag{2}$$

Among them, $\alpha_0$represents the average volatility level in the previous period without considering the past conditional variance and residual square; $\mu_t$is a random disturbance term; σ_t^2represents the conditional variance of T period, and q represents the influence of the residual squares of the past q periods on the current period, which is called ARCH order. The higher the ARCH order means that the residual squares of more past periods have an influence on the current period, and the parameter

α represents the weight of the residual squares of the past to the conditional variance of the current period. P represents the influence of the conditional variance in the past p periods on the current period, which is called GARCH order. The higher GARCH order means that the conditional variance in more periods in the past has an influence on the current period. The parameter β represents the weight of the past conditional variance to the current period, which is a white noise sequence. In order to ensure the stability of the model, GARCH model requires that the sum of ARCH term (α) and GARCH term (β) should not exceed 1, that is, $\alpha+\beta<1$, so as to avoid the infinite variance or standard deviation of the model.

Assuming that there is a time-varying nonlinear relationship between the returns of assets I and J, which is the return of assets I at time T, the structure of DCC-GARCH model at time T is as follows:

$$\mathrm{X_t} = \mu_\mathrm{t} + \mathrm{e_t} \tag{3}$$

$$\mathrm{e_t} = \varepsilon_\mathrm{t}\sqrt{\mathrm{H_t}} \tag{4}$$

$$\mathrm{H_t} = \mathrm{D_t R_t D_t} \tag{5}$$

$$\mathrm{R_t} = (\mathrm{Q_t^*})^{-1}\mathrm{Q_t}(\mathrm{Q_t^*})^{-1} \tag{6}$$

$$\mathrm{Q_t} = (1-\alpha-\beta)\overline{\mathrm{Q}} + \alpha(\varepsilon_{\mathrm{t}-1}^{\mathrm{i}}\varepsilon_{\mathrm{t}-1}^{\mathrm{j}'}) + \beta\mathrm{Q_{t-1}} \tag{7}$$

Where $\mathrm{X_t} = (\mathrm{x_j^i}, \mathrm{x_j^i})'$, $\mu_\mathrm{i} = (\mu_i, \mu_i)'$, $e_t$are random disturbance term with a specific distribution, e_t is an error term,$H_t$is a conditional covariance matrix of random disturbance term,D_t is a diagonal matrix of dynamic standard deviation, and its diagonal element is the standard deviation estimated by univariate GARCH. R_t Is a dynamic correlation coefficient matrix and Q_t is a covariance matrix; Q_t^* is the conditional standard deviation matrix, which is obtained by square root of diagonal elements ofQ_t. $\bar{Q}$ Is the unconditional covariance matrix after residual standardization; $\alpha$is the influence degree of the square of the past standardized residual on the conditional correlation coefficient, and β is the influence degree of the past dynamic conditional correlation coefficient on the current dynamic conditional correlation coefficient, which represents the attenuation coefficient of the model.

3.2. CoVaR Model

CoVaR indicates that the losses that a portfolio or asset may face under the given conditions of a systemic risk event, can be used to measure the risk spillover in the financial market. ΔCoVaR Considers the correlation between different assets in the system and can capture the systemic risk. It is an extension and improvement of CoVaR. ΔCoVaR Can measure the contribution of specific financial institutions to the systemic risk of the whole financial system. By calculatingΔCoVaR, we can determine which financial institutions in the financial system have higher risk spillover potential to other institutions when the systemic risk increases. The high value of ΔCoVaR means that a financial institution makes greater risk contribution to other institutions when the systemic risk increases, which implies the potential risk contagion effect.

When the conditional variance and dynamic conditional correlation coefficient are obtained by DCC-GARCH, let the value at risk of financial time series be$\mathrm{VaR_{q,t}^{\gamma}} = \Phi^{-1}(\mathrm{q\%})$, $\gamma$is the conditional variance of financial time series,$\sigma_\mathrm{t}^{\delta}$ is the conditional variance of financial time seriesδ. And$\rho_\mathrm{t}^{\gamma\delta}$is the dynamic conditional correlation coefficient between them .The conditional value at risk of financial time series δ when risk occurs to γ is:

$$\mathrm{CoVaR}_{q,t}^{\delta|\gamma} = \Phi^{-1}(\mathrm{q\%})\sigma_\mathrm{t}^{\gamma}\sqrt{1-(\rho_\mathrm{t}^{\gamma\delta})^2} + \Phi^{-1}(\mathrm{q\%})\rho_\mathrm{t}^{\gamma\delta}\sigma_\mathrm{t}^{\gamma} \tag{8}$$

The degree of risk spillover from γ to δ is:

$$\Delta\mathrm{CoVaR}_{q,t}^{\delta|\gamma} = \Phi^{-1}(\mathrm{q\%})\rho_\mathrm{t}^{\gamma\delta}\sigma_\mathrm{t}^{\gamma} \tag{9}$$

4. Empirical research

4.1. Description of variables

In this paper, according to the international industry classification standard of Shen Yin, the real estate industry index and the banking industry index are selected through the wind database, and the time interval is from January 1, 2012 to December 30, 2022, and the non-trading day data are excluded. In order to make the data more stable and comparable, the original closing data is logarithmized to obtain logarithmic rate of return, which can smooth the change of data and reduce the influence of extreme values. The variable R1 represents the real estate industry and R2 represents the banking industry.

Table. 1 statistical description.

	Mean	Median	Max	Min	Std.Dev	Skewness	Kurtosis
R1	0.0233	0.0041	9.4073	-9.9537	1.8564	-0.4926	7.2270
R2	0.0301	-0.0475	8.6481	-10.5038	1.4484	0.0787	10.0923

The average represents the average performance of the index return. As can be seen from the above table, the average returns are all positive, and the median represents the typical performance of the data to a certain extent. From the median point of view, the median yield of real estate industry is positive, and the median yield of banks is negative. The maximum and minimum values can help us determine the range and possible extreme conditions of the rate of return. Combined with the standard deviation, the banking industry is more stable than the real estate industry. The real estate industry is skewed to the left, and the banking industry is skewed to the right, both of which have high kurtosis, and the yield data have the characteristics of peak and thick tail. Combined with the following yield histogram, it can be further verified that the yield data of both of them are non-normal distribution.

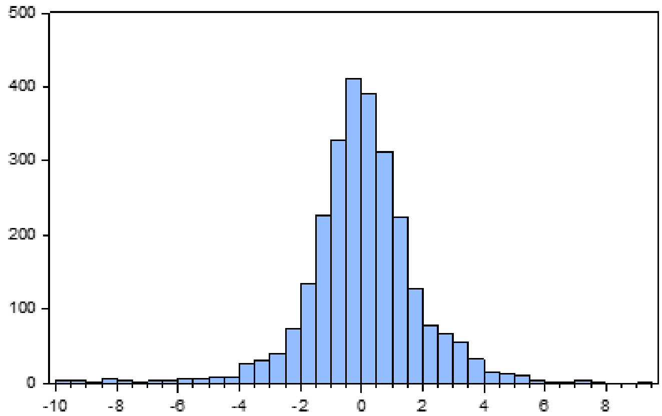

Fig 1. Real estate yield histogram.

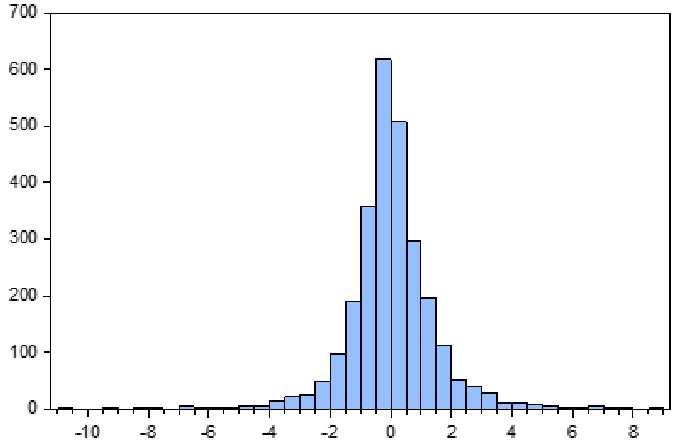

Fig. 2 Histogram of banking yield.

4.2. Empirical results

4.2.1. Stability test

If the data does not have stationarity, using models based on stationarity assumptions may produce misleading results. Therefore, in order to ensure the reliability and effectiveness of the model, this article uses ADF test to perform stationarity analysis on the data. From the results in the table below, it can be seen that the ADF values of each return rate series are all below the critical value at a 1% confidence level, indicating that the return rates are all stationary sequences.

Table. 2 Stability test results.

variable	ADF	10%critical value	5%critical value	1%critical value	P value
R1	-49.02612	-3.127604	-3.41149	-3.961479	0.0000
R2	-52.44109	-3.127604	-3.41149	-3.961479	0.0000

4.2.2. ARCH effect test

When establishing the DCC-GARCH model, we assume that the conditional variance changes over time and there is an ARCH effect. Therefore, before applying the DCC-GARCH model, it is necessary to conduct an ARCH effect test to verify the existence of conditional heteroscedasticity in the data and ensure that the conditional variance has been appropriately modeled before establishing a conditional dependent model.

Table. 3 ARCH effect test results.

	R1	R2
F value	135.932	69.574
P value	0.000	0.000
Obs*R^2 value	129.442	67.858
P value	0.000	0.000

From the above table, it can be seen that the P-values of the F statistic and Obs*R2 statistic are both 0.000, indicating the ARCH effect. Further DCC-GARCH fitting can be performed.

4.2.3. DCC-GARCH simulation

Andersen ET. [13] Found that GARCH (1, 1) can effectively fit financial time series in their research on the stock market. Later, scholars verified that GARCH (1,1), due to its short lag period, can help avoid excessive noise impact, and can usually provide more accurate volatility modeling when processing financial market data [14]. Therefore, this article will use this method. The use of this model for risk overflow calculation mainly involves three steps. Firstly, estimate the conditional variance model of the asset. By estimating the parameters of the GARCH (1, 1) model for each asset's historical return series, the estimated values of the parameters are obtained, and the conditional variance series for each asset is calculated; Then, estimate the dynamic conditional correlation coefficient matrix; Finally, based on the estimated conditional variance and dynamic conditional correlation coefficient matrix, all parameters such as CoVaR can be calculated as a measure of risk spillover.

From the table below, it can be seen that compared to the real estate industry, the banking industry is larger, indicating that past volatility has a greater impact on the current conditional variance, yield is more sensitive, and can respond more quickly to new information in the market; The impact of volatility decays faster over time, indicating that the return rate of the banking industry is relatively stable, and its volatility will relatively quickly return to the average level and will not be continuously affected by past volatility for a long time. This phenomenon is mainly due to the relatively stable profit model of the banking industry, relatively reliable sources of income, and strict regulation and supervision. Market participants' expectations for the banking industry are also relatively stable.

Table. 4 GARCH (1, 1) fitting result.

industry	R1	R2
α_1	0.078545	0.105891
P value	0.0000	0.0000
β_1	0.908859	0.883809
P value	0.0000	0.0000
$\alpha_1+\beta_1$	0.987404	0.9897
$\alpha_1+\beta_1<1$	yes	yes

The dynamic correlation coefficient can capture the change of correlation between asset returns with time, allow the correlation coefficient to change in different time periods, and more accurately reflect the dynamic characteristics of the market. From the following figure, we can see the change of dynamic conditional correlation coefficient between the real estate industry and the banking industry, and the dynamic conditional correlation coefficients between them are all greater than zero in the sample period, indicating that the real estate industry has a positive dynamic correlation with the banking industry. From this, it can be inferred that the real estate industry and the banking industry have a positive systemic risk spillover to each other. From 2012 to 2016, the dynamic correlation coefficient between real estate and banks remained at a high level, peaked in 2016, fluctuated and declined around 2017, began to climb around 2018, continued to fluctuate after 2019, and showed a significant decline after strengthening regulation in 2021. The risk spillover will be calculated by CoVaR model to further study the risk situation.

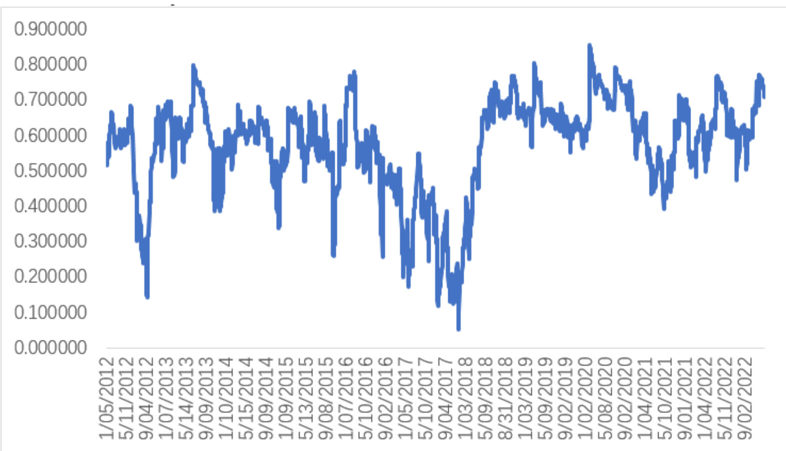

Fig. 3 Dynamic correlation coefficient.

4.2.4. Risk Spillover Effect Analysis

$\mathrm{CoVaR}_{q,t}^{A|B}$ is the conditional value at risk, which measures the total risk value of market A, including the unconditional value at risk of market A and the risk spillover of extreme risk events of market B. Then,the CoVaR andΔCoVaR values of real estate and financial industries are calculated with the data of conditional covariance and dynamic correlation coefficient obtained above at 95% confidence level to further analyze the conditional value at risk and risk spillover.

On the whole, the value at risk of real estate industry and banking industry fluctuated slightly from 2012 to the first half of 2013, and began to fall back from the second half of 2013 to the first half of 2014, and then began to rise sharply, maintaining a high level of shock, reaching a peak around mid-2015, then slowly returning to normal, reaching the bottom value in recent years around October 2017, then showing a fluctuating trend and reaching a small peak in 2020. Comparing the at-risk value of the banking industry with the at-risk value of the real estate industry, we can find that the at-risk value of the real estate industry is relatively small, and the risks of the banking industry may not be easily introduced into the real estate industry. The reason is that banks provide real estate loans, but they usually control the risks related to real estate through risk management measures such as loan review and collateral evaluation. In addition, banks will also take measures to diversify their loan portfolios to make them less exposed to the real estate industry. In addition, the real estate industry is a huge fund demander, which needs a lot of financing to support the development and sales of real estate projects. It will be affected by many factors, including macroeconomic situation, policy regulation, supply-demand relationship, etc. The systemic risks of the banking industry may be interfered and neutralized by other factors when transmitted to the real estate market, thus reducing the direct impact on the real estate industry. Moreover, due to the cyclical characteristics and long development cycle of real estate projects, the bank's actions may not immediately affect the supply-demand relationship and price level of the real estate market.

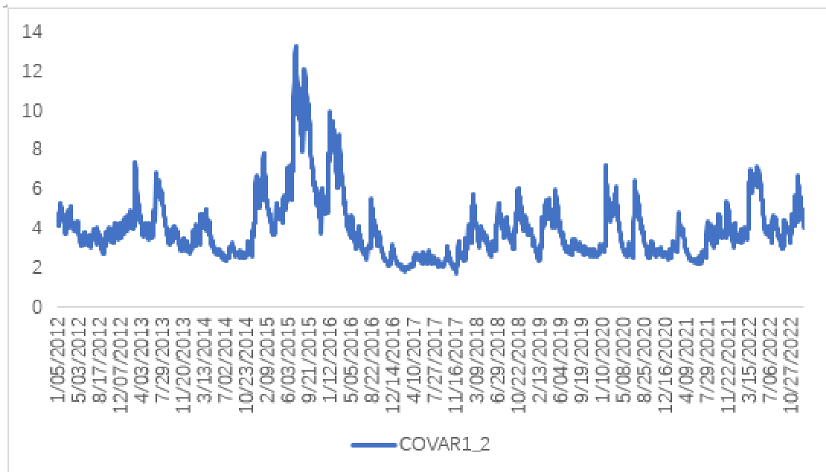

Fig. 4 CoVaR value of real estate industry

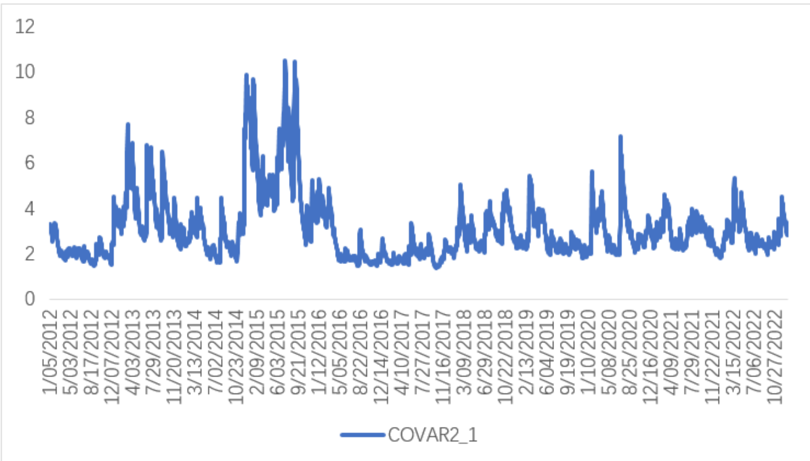

Fig. 5 CoVaR value of banking industry

The previous part measures the total risk of one market between the real estate industry and the financial industry when the risk occurs in the other market, and the following part will use ΔCoVaR to further study the degree of risk spillover. Different from CoVaR, ΔCoVaR pays more attention to the loss change of asset A when the risk of asset B changes, which can be used to measure the absolute value of the systematic risk contribution of asset B to asset A, that is, the degree of risk spillover.

Figure 6 below shows the risk spillover from real estate to banking at different times, and Figure 7 shows the risk spillover from banking to real estate at different times. ΔCoVaR values are all positive and not zero, which further verifies the previous conclusion that there is mutual risk spillover effect between the real estate industry and the banking industry, but the spillover intensity is asymmetric, and the risk spillover intensity of the real estate industry is greater than that of the banking industry. The reasons are as follows: (1) Difference of dependency. The real estate industry usually relies on the bank's funds to support development projects and purchase demand. However, the customer base of the banking industry may be more diversified, covering not only the real estate industry, but also other industries and individuals. Therefore, when the real estate market fluctuates, banks will bear the risk contagion from many industries, and the real estate industry's dependence on banks is more concentrated, which may lead to a more significant risk contagion effect.(2) Different types of assets. The banking industry has a variety of assets in its portfolio, including loans, investments and other financial products in different industries. This decentralized asset structure enables banks to have a certain buffer capacity against fluctuations in the real estate market. However, the main asset of the real estate industry is real estate, so its risk is more directly related to the fluctuation of the market, which may be more obvious when the risk is transmitted. (3) Affected by market sentiment. The real estate market sentiment is easily influenced by investors' confidence, which may lead to violent market fluctuations. The decline in investor sentiment may lead to the withdrawal of investors from the real estate market and aggravate the downward trend of the market. As a financial intermediary, banks are not sensitive to the fluctuation of market sentiment, so their risk spillover to the real estate market may be relatively small. (4) The infectivity of debt default is different. When the real estate market fluctuates, real estate developers and buyers face an increased risk of debt default. This may cause the banking industry to face the risk spillover from non-performing loans. In contrast, banks, as financial institutions, are less likely to pass on their debt and loan risks to other departments.

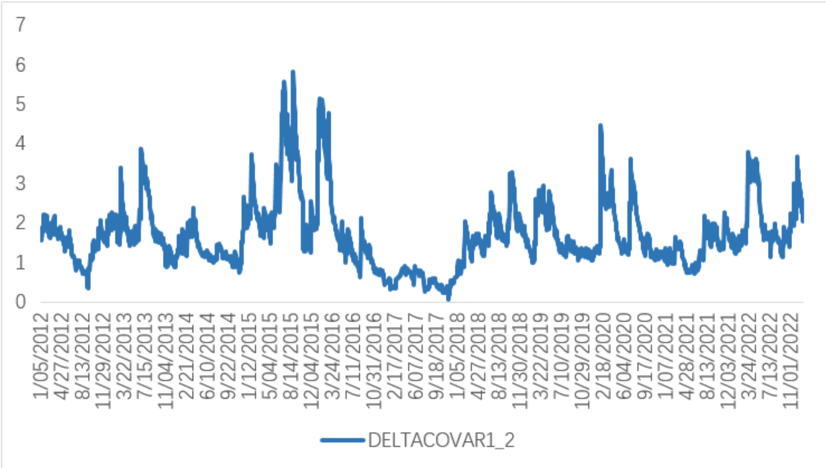

Fig. 6 Risk Spillover of Real Estate to Banking Industry.

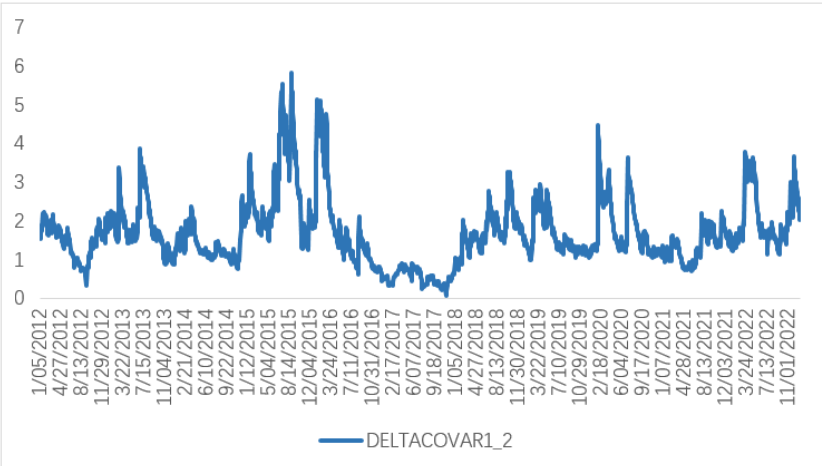

Fig. 7 Risk Spillover of Banking to Real Estate Industry.

5. Summary and suggestions

From the above analysis, we can see that there is mutual risk spillover effect between the real estate industry and the banking industry, which will affect each other and have time-varying characteristics, and the level of risk spillover between them is not the same in different periods. In addition, the degree of risk spillover between them is not consistent, and the risk spillover effect of real estate on banking is greater than that of banking on real estate.

Based on the conclusion of the paper, there is a mutual risk spillover effect between the real estate industry and the banking industry, which means that their risks will conduct and influence each other to a certain extent. Therefore, the following suggestions are put forward: (1) Strengthen supervision and risk management: In view of the large risk spillover effect of the real estate industry on the banking industry, banks should strengthen the monitoring and risk management of the real estate market. Banks need to carefully assess the loan risk of real estate projects, ensure that loans are reasonable and guard against the risk of non-performing loans. At the same time, regulators should strengthen the supervision of banks and real estate markets to ensure the stability of the financial system. (2) Banks can set up a certain risk buffer during the high risk period to resist the risk spillover effect from the real estate market. This can include measures such as increasing capital reserves and raising non-performing loan reserves to cope with possible adverse effects. (3) Relevant departments should pay attention to the linkage between different markets when specifying policies and regulating markets, so as to achieve better policy effects.

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