A Research on Volatility Spillover Effect between Real Estate Industry Index and other Related Industries Based on MGARCH-BEKK/DCC Model

Jie Xiao*, Zhongxin Ni*
School of Economics, Shanghai University, Shanghai 200444, China

*Corresponding author e-mail: zhongxinmi@i.shu.edu.cn, *18717865113@163.com

Abstract. We use the MGARCH-BEKK / DCC model to study the volatility spillover effects and dynamic correlations between industry indexes. We selected indexes for four industries: real estate, raw materials, manufacturing, and banking. The research results show that the real estate industry will be greatly affected by the manufacturing industry, raw materials industry, and banks, and there are two-way fluctuation spillover effects between them. The raw material industry is mainly affected by the manufacturing industry, and it is also affected by real estate and banks, but the impact is relatively small. Banks have influence on the other three industries, especially on the real estate and manufacturing industries. Manufacturing mainly affects the real estate and raw materials industries, but it has less impact on banks. In addition, the DCC coefficient between stock indexes is positive for most of the time period. The dynamic correlation between the real estate index and ICBC stocks, and the dynamic correlation between the raw material index and ICBC stocks have significant asymmetry, and to some extent, their fluctuation characteristics are similar.

1. Introduction
The real estate industry is one of the most important industries in China. In recent years, China's housing price problem has been the focus of attention. In addition, the development of real estate has an important impact on the quantity of housing supply, thus affecting the fluctuation of house prices. The general equilibrium theory in economics tells us: different markets often affect each other. Therefore, in order to help real estate development more effectively and stabilize housing prices, it is necessary to conduct research on other industries that affect the industry, such as raw materials, industry, and banks. There is a lot of research on the real estate industry in academia, and most of them focus on the factors affecting housing prices, but there is a lack of research on market linkages. This article mainly examines the transmission mechanism of return volatility in four different industries: real estate, raw materials, industry and banking. We select representative stock indexes or stocks from various industries to study the volatility spillover relationship between them, in order to grasp the dynamic relationship of earnings between different industries, which has important guiding significance for asset allocation and pricing and the securities market.

In recent years, scholars have done some research on the earnings relationship between industry stocks. Apergis [1] used the GARCH model to study the relationship and volatility between the average return on stocks in the Greek banking system and real estate investment trusts. Studies have
shown that the return on real estate investment trusts affects bank stock returns. The impact was even stronger after the crisis. Burdekin and Tao [2] used Chinese 1999-2011 data to study the relationship between loan activity, real estate prices, stock prices, and inflation, and the results showed that there was a correlation between them. Gerlach and Peng [3] conducted an empirical study on the relationship between bank loans and real estate prices in Hong Kong from 1982 to 2001. The results show that changes in real estate prices will have an important impact on bank credit expansion. However, there is little literature linking real estate with industries such as manufacturing and raw materials. Different from those literatures, we use the BEKK / DCC-MGARCH model to study the volatility spillover relationship between different industries and consider the time-varying dynamic correlation.

2. Empirical analysis

2.1. Data description

We obtain the daily closing price data of the assets as a representative of their industry conditions in recent years. We selected are CSI 300 real estate stock index, CSI 300 raw material stock index, CSI 300 manufacturing stock indexes, and choose ICBC stocks as the representative of Banking industry. The time period we selected is from January 1, 2007 to December 31, 2016. Taking January 1, 2007 as the base period, using their daily closing price data to calculate their respective daily rate of return series, then we analyze the characteristics of the time series. The sample contains data for 2589 trading days. The source of stock indexes or stock data for various industries is the Wind database.

| Table 1. Descriptive statistics of returns. |
|-------------------------------------------|
| Real estate index | Raw material index | Manufacturing index | Banking |
| Min | -0.1057 | -0.4248 | -0.1057 | -0.1058 |
| Max | 0.0960 | 0.0963 | 0.0959 | 0.0958 |
| Median | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Mean | 0.0007 | 0.0005 | 0.0004 | -0.0001 |
| Std. | 0.0342 | 0.0374 | 0.0300 | 0.0178 |
| Skewness | -0.1162 | -0.7641 | -0.2708 | -0.1166 |
| Kurtosis | 1.6550 | 7.5708 | 2.5653 | 7.3808 |
| normtest.W | 0.9534 | 0.9300 | 0.9427 | 0.8836 |
| norm test.p | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

From Table 1, we can see: (1) From the perspective of the distribution of the returns, none of the return series are not subject to the normal distribution (the normality test P-values are far less than 0.05), and their kurtosis is significantly greater than 3, with spike characteristics. Judging from the skewness, their return distributions all show a left-skewing phenomenon; (2) From the mean value: the maximum return sequence mean of the real estate index is 0.0007, followed by the raw material index and the manufacturing index, and the average return of bank stocks is close (3) From the standard deviation statistics the standard deviation of the return of the real estate stock index, the raw material stock index, and the manufacturing index are all about 0.0300, and the standard deviation of the return series of the Industrial and Commercial Bank of China is 0.0178, compared to the other three stock indexes the standard deviation of the return series is smaller, which indicates that it is more stable than the other three stock index returns.
Figure 1. Return sequences of assets in different industries.

Figure 2. Cumulative Return sequences of assets in different industries.

From Figure 1, we can see that the return volatility of the real estate index and the manufacturing index are relatively large, and the volatility of the raw material index and the Industrial and Commercial Bank stock return are relatively small. And the volatilities were large in 2008. At the same time, as shown in Figure 2, the cumulative return of the real estate index and raw material index is smaller than that of the manufacturing index and ICBC. In addition, in 2008, the stock index or the cumulative return of stocks showed a sharp decline. It can be seen that the financial crisis in 2008 had a huge impact on these industries.

2.2. Statistical test

We first perform a unit root test to check whether the return series are stable, so as to ensure the accuracy of the model. Table 2 show that both the ADF test and the PP test reject the original hypothesis of instability, which indicates that there is no unit root for each stock return series, that is, they are stable at a significance level of 0.05, and suitable for GARCH models.
Table 2. Results of the stationarity test.

|                | ADF test          | PP test          |
|----------------|-------------------|------------------|
|                | No intercept      | With intercept   | Intercept + trend |
| Real estate    | -34.121 (-2.58)   | -34.133 (-3.43)  | -34.135 (-3.96)   |
| Raw material   | -32.982 (-2.58)   | -32.985 (-3.43)  | -32.980 (-3.96)   |
| Manufacturing  | -35.538 (-2.58)   | -35.539 (-3.43)  | -35.543 (-3.96)   |
| Banking        | -38.457 (-2.58)   | -38.452 (-3.43)  | -38.453 (-3.96)   |

Note: Values in parentheses are critical values at a significant level of 1%

Before establishing the GARCH model, we also need to perform a correlation test on the data. We draw ACF for all return series. The results are shown in Figure 3 below, which shows that each return series has autocorrelation.

Figure 3. ACF of assets in different industries.

By making the maximum likelihood estimation for each stock return sequence, we obtain the residual sequence, and then perform an ARCH effect test on the residual sequence, and select a lag order of 1. In order to ensure the reliability of the test results, we performed LB test and LM test on the square of the residual sequence and the residual sequence respectively. The results are shown in Table 2-3 below. The results show that the values of the chi-square statistic are relatively large, and the accompanying probability is far less than 0.01. Therefore, at the significance level α of 0.01, the null hypothesis that there is no ARCH effect is significantly rejected.

Table 3. ARCH Effect Test for Residual Sequences.

|                | LB Test ($\hat{\chi}^2$) | LM Test ($\hat{\epsilon}^2$) |
|----------------|--------------------------|-------------------------------|
|                | Chi-square value | P-value | Chi-square value | P-value |
| Real estate    | 131.95          | 0.000   | 131.77          | Yes     | 0.000   |
| ARCH effect    | Yes            |         | Yes             |         |
| Raw material   | 21.7           | 0.000   | 21.668          | Yes     | 0.000   |
| ARCH effect    | Yes            |         | Yes             |         |
| Manufacturing  | 156.53          | 0.000   | 156.31          | Yes     | 0.000   |
| ARCH effect    | Yes            |         | Yes             |         |
| Banking        | 92.172          | 0.000   | 92.035          | Yes     | 0.000   |
| ARCH effect    | Yes            |         | Yes             |         |
2.3. Empirical test

According to the results of the above ARCH test, the sequences have significant ARCH effects. Therefore, we set up the GARCH (1, 1) model to re-estimate. The GARCH (1,1) model can be expressed as:

\[
\begin{align*}
    r_t &= X^T b + \varepsilon_t, \quad \varepsilon_t = \sigma_t \eta_t \\
    \sigma_t^2 &= \omega + \alpha_1 \varepsilon_{t-1}^2 + \gamma_1 \sigma_{t-1}^2
\end{align*}
\] (1)

Where \( \eta_t \) is an independent identically distributed random perturbed sequence with a mean of zero and a variance of 1, \( \omega \) is the constant term of the volatility equation, \( \alpha_1 \) and \( \gamma_1 \) are ARCH and GARCH coefficients, respectively, which must satisfy \( \alpha_1 > 0 \) and \( \gamma_1 > 0 \), to ensure the positive definiteness of the conditional variance. And \( \alpha_1 + \gamma_1 < 1 \) to ensure the stability of the model. The larger \( \alpha_1 + \gamma_1 \), the more obvious the persistence of volatility, and the GARCH model can better characterize the "volatility aggregation" and "thick tail" of financial markets.

For comparison, we use an equation structure with only constant terms for each sequence, and calculate the ARCH and GARCH parameter estimation results as shown in Table 4.

**Table 4.** Parameter estimation results of GARCH (1,1) model.

|               | \( \alpha \) | P-value | \( \gamma \) | P-value | \( \alpha + \gamma \) |
|---------------|--------------|---------|--------------|---------|------------------------|
| Real estate   | 0.0744       | 0.0049  | 0.9199       | 0.0000  | 0.9943                 |
| Raw material  | 0.1031       | 0.0013  | 0.8367       | 0.0000  | 0.9398                 |
| Manufacturing | 0.0481       | 0.0050  | 0.9447       | 0.0000  | 0.9928                 |
| Banking       | 0.0880       | 0.0032  | 0.9081       | 0.0000  | 0.9961                 |

From the results in table 4, it can be seen that at a significance level of 1%, the parameter estimation results of ARCH and GARCH terms are very significant, and the constraint condition \( \alpha + \gamma < 1 \) is satisfied, which indicates that the GARCH (1,1) model perform well for this situation. The value of \( \alpha + \gamma \) is as high as 0.90 or more, which indicates that the fluctuations of each asset have significant continuity, but the continuity of the fluctuation of the Raw material industry index is weaker than others.

On this basis, we re-tested the equation for heteroscedastic ARCH effects, and the results are shown in Table 5. The results clarify that the null hypothesis is not rejected (H0: there is no ARCH effect), which indicates that the residuals of the GARCH model have no Conditional heteroscedasticity, that is, the model well fits the fluctuations of each return series.
Table 5. Test of Heteroscedasticity ARCH Effect for model Fitting.

|                       | ARCH LM Test | Statistic | P-Value |
|-----------------------|--------------|-----------|---------|
| Real estate           |              |           |         |
| ARCH Lag [3]          |              | 0.2246    | 0.6356  |
| ARCH Lag [5]          |              | 0.5724    | 0.8621  |
| ARCH Lag [7]          |              | 1.2611    | 0.8678  |
| Raw material          |              |           |         |
| ARCH Lag [3]          |              | 0.1097    | 0.7405  |
| ARCH Lag [5]          |              | 0.2101    | 0.9631  |
| ARCH Lag [7]          |              | 0.3425    | 0.9903  |
| Manufacturing         |              |           |         |
| ARCH Lag [3]          |              | 2.453     | 0.1173  |
| ARCH Lag [5]          |              | 3.148     | 0.2690  |
| ARCH Lag [7]          |              | 4.459     | 0.2852  |
| Banking               |              |           |         |
| ARCH Lag [3]          |              | 0.1725    | 0.6779  |
| ARCH Lag [5]          |              | 0.9416    | 0.7503  |
| ARCH Lag [7]          |              | 1.6968    | 0.7811  |

Figure 4. Volatility of assets in different industries.

The results in Figure 4 show that the returns on the real estate index and the raw material index in the two periods from 2007 to 2009 and 2015 to 2016 were relatively volatile, while the fluctuations in the return from 2010 to 2014 were relatively small. The return on ICBC stocks fluctuated greatly from the beginning of 2007 to the beginning of 2010, and the fluctuation rate was relatively small and stable from 2011 to 2014, and the volatility increased significantly from 2015 to 2016. The volatility of the above-mentioned return on assets from 2007 to 2009 and 2015 to 2016 was relatively large compared to other years, and its volatility was relatively small from 2011 to 2014.

Next, in order to measure the impact of volatility across industries, we use the BEKK-MGARCH model to obtain the estimated parameters and significance of the model conditional variance covariance matrix, as shown in Table 6.
Table 6. Estimated parameter results of BEKK-GARCH model.

| Matrix element | Real estate--Raw material—Manufacturing--Banking |
|----------------|-----------------------------------------------|
|                | C                                      | A                                       | B                                      |
| (1,1)          | 0.0174**                               | -0.1690**                               | 0.7197**                               |
|                | (41.296)                               | (-3.611)                                | (29.898)                               |
| (1,2)          | ---                                    | -0.1157**                               | 0.7381**                               |
|                |                                        | (-3.438)                                | (37.336)                               |
| (1,3)          | ---                                    | 0.1056**                                | -0.0748**                              |
|                |                                        | (3.236)                                 | (-9.115)                               |
| (1,4)          | ---                                    | -0.1203**                               | 0.2347**                               |
|                |                                        | (-7.875)                                | (12.800)                               |
| (2,1)          | -0.0294**                              | 0.0205                                  | -0.0890**                              |
|                | (-53.951)                              | (1.089)                                 | (-13.579)                              |
| (2,2)          | -0.0015                                | -0.3861**                               | -0.0092                                |
|                | (-1.574)                               | (-12.471)                               | (-0.573)                               |
| (2,3)          | ---                                    | -0.3905**                               | 0.6063**                               |
|                |                                        | (-11.255)                               | (29.217)                               |
| (2,4)          | ---                                    | -0.0341**                               | -0.0308*                               |
|                |                                        | (-2.948)                                | (-1.708)                               |
| (3,1)          | 0.0002                                 | -0.2287**                               | 0.3290**                               |
|                | (0.2039)                               | (-4.814)                                | (11.366)                               |
| (3,2)          | -0.0058**                              | -0.1956**                               | -0.0083                                |
|                | (-4.667)                               | (-3.781)                                | (-0.247)                               |
| (3,3)          | -0.0010                                | 0.0712                                  | 0.1781**                               |
|                | (-0.370)                               | (1.140)                                 | (3.454)                                |
| (3,4)          | ---                                    | -0.0977**                               | 0.1629**                               |
|                |                                        | (-7.566)                                | (3.895)                                |
| (4,1)          | 0.0028**                               | -0.2900**                               | 0.0063                                 |
|                | (5.814)                                | (-9.219)                                | (0.184)                                |
| (4,2)          | -0.0027**                              | 0.0380                                  | -0.0651                                |
|                | (-2.747)                               | (0.517)                                 | (-1.197)                               |
| (4,3)          | 0.0040**                               | -0.6258**                               | 0.0656                                 |
|                | (9.580)                                | (-6.824)                                | (0.864)                                |
| (4,4)          | 0.0001                                 | 0.0905**                                | -0.8851**                              |
|                | (0.144)                                | (2.208)                                 | (-72.157)                              |

Note: * means significant at the 10% level and ** means significant at the 5% level. Values in parentheses are Wald statistic values.

The following conclusions can be drawn from Table 6: (1) The diagonal elements of the ARCH coefficient matrix A are significantly different from 0 at a significance level of 5%, which indicates that the fluctuations in the return of the real estate stock index, raw material stock index, and ICBC stock are significantly affected by their own information. The diagonal elements of the GARCH coefficient matrix B have a non-zero effect at a significance level of 5%, which indicates that the real estate stock index, manufacturing stock index, and Industrial and Commercial Bank stock returns. The fluctuations of the rate are relatively affected by the variance of the previous period, while the fluctuation of the return of the raw material stock index is less affected by the variance of the previous period. (2) The elements a_{12}, b_{11}, a_{13}, b_{33}, and a_{44} are significantly non-zero at a significance level of 5%, which indicates that fluctuations in raw material stock indexes, manufacturing stock indexes, and Industrial and Commercial Bank stocks have caused a fluctuation spillover effect on real estate stock index.
fluctuations. (3) At the 5% significance level, $b_{21}$ is significantly different from zero, but $a_{21}$ is not significantly different from zero at a higher significance level, which indicates that real estate stock index volatility has a volatile spillover effect on raw material stock indexes, but it is relatively weak. (4) In the same way, we find that fluctuations in the returns of real estate stock indexes and ICBC stocks have produced a spillover effect on manufacturing stock indexes. The fluctuation of the real estate stock index has a volatility spillover effect on the fluctuations of ICBC stocks, but it is relatively weak. The volatility spillover effect of the fluctuation of manufacturing stock index on the fluctuation of ICBC stock is also relatively weak. The raw material stock index has no volatility spillover effect on ICBC stocks.

In summary, the volatility spillover effect of the above industries can be summarized as Figure 5. The direction of the arrow in the figure is the direction of volatility transmission. The solid arrow indicates that the volatility overflow is large, and the dashed arrow indicates that the volatility overflow is small.

![Figure 5. Volatility Spillover Conduction Pattern.](image)

From the results in Figure 5, it can be concluded that the real estate industry will be greatly affected by manufacturing, raw materials industries, and banks, and there are two-way fluctuation spillover effects between them. It can be seen that the development of real estate cannot be separated from manufacturing and raw materials in terms of construction, and the development of real estate cannot be separated from banks. The raw material industry is mainly affected by the manufacturing industry. Real estate and banks also affect it, but the impact is relatively small. Banks have an impact on the other three industries, and have a more obvious impact on real estate and manufacturing. The manufacturing industry mainly affects the real estate and raw materials industries, and has less impact on banks.

In order to clearly characterize the dynamic correlation between the real estate index and other industries, we use the DCC-GARCH model (dynamic condition correlation coefficient) to analyze the long-term changes in the correlation between pairs of stock indexes. The results show that each coefficient estimate is significant at a significance level of 0.05, and the model better fits the dynamic process of the correlation between them. We can draw the dynamic condition correlation coefficient graphics between them, which shown in figures 6 to 8.
From the DCC coefficient (dynamic condition correlation coefficient) trend chart between the indexes, we can draw conclusions: (1) On the whole, from 2007 to 2016, the dynamic correlation between the real estate index and other industries was relatively stable, with an average value between 0.3 and 0.4; and the dynamic correlation between the real estate index and other industries was significantly asymmetric. Their volatility characteristics are very similar: the correlation between 2008 and 2013 was significantly higher than the correlation between 2014 and 2016, which indicates that
their correlation has decreased in recent years. (2) From the perspective of the stability of the DCC coefficient, the DCC coefficient is positive for most of the time period, which indicates that the industries are mutually reinforcing at that time; while the DCC coefficient becomes negative in some time periods. This shows that there is a mutual restraint effect between industries at this time, which may be caused by the impact of extreme events in certain time periods. We can also see that the correlations between the indexes have changed significantly in 2008, and some even changed from the original positive correlation to the negative correlation. For example, in 2008 and early 2013, the DCC coefficient between the real estate index and the raw material index suddenly became negative.

3. Conclusion
In summary, there is a two-way fluctuation spillover effect between the real estate industry market and the three related industries, and its effect with the manufacturing market is the most obvious. That is, if the real estate industry market and the manufacturing market are subject to shocks and volatile, it will have a great impact on the other party. On the one hand, the real estate industry, especially real estate development and construction, cannot be separated from raw materials, manufacturing, especially steel manufacturing, and financial support from banks. On the other hand, the development of the real estate industry will also expand the demand for manufactured goods in the manufacturing market, various raw materials (such as wood) in the raw materials market, and financing from the banking industry, which will help maintain and develop these related industries.

We can also draw conclusions that the real estate industry market and the raw material industry market are more sensitive than other industry markets. They are affected by several other markets. Banks are more affected by the real estate and manufacturing industries than the raw material industry. The manufacturing market has a major impact on the raw material industry market and the real estate industry market.

Therefore, we can make some suggestions for the development of the industries. Firstly, since the real estate industry market and the raw material industry market are more sensitive than the other two markets, we must pay more attention to the volatility of their related indicators. Secondly, the banking industry has volatility spillovers in several other markets, so it is important to improve the bank's funding system. Thirdly, the manufacturing industry has a strong influence on other industries, so the development of the manufacturing industry cannot be ignored, it is crucial to the development of other industries.

References
[1] Apergis N. Financial Crisis and the Real Estate Market in Greece: The Impact on Bank Stock Prices[J]. International Journal of Economics and Business Research, 2012, 4(5):534-539.
[2] Burdekin R. C. K. Tao R. Chinese Real Estate Market Performance: Stock Market Linkages, Liquidity Pressures, and Inflationary Effects. The Chinese Economy, 2014, 47(2):8-22.
[3] Gerlach S., Peng W. Bank Lending and Property Prices in Hong Kong [J]. Journal of Banking & Finance, 2005, 29(2):471-480.
[4] Engle R. Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroscedasticity models[J]. Journal of Business & Economic Statistics, 2002, 20(3):340-351.