

The Impact of Sino-US Trade War on Volatility Spillover Effect Between Related Industries in Sino-US Stock Market

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ABSTRACT

This paper discusses the impact of the outbreak of the Sino-US trade war on the volatility spillover effects among steel, automobile manufacturing, electrical equipment, and semiconductor industries in the stock markets through establishing the MGARCH-BEKK model. The results show differences in the volatility spillover effects between different sectors in the Sino-US stock market before and after the Sino-US trade war.

Keywords- Sino-US trade war; Sino-US stock market; Volatility spillover effect

1. INTRODUCTION

As the largest developed and developing country globally, China-US relations are the most important bilateral relations in the 21st century. It is closely related to the complex and profound wave of globalization in the 21st century and is a complete reflection of the interests and contradictions of globalization. The Sino-US trade war is a dispute between China and the United States and goes beyond the boundaries of the two countries and represents the core contradiction between the two countries of different camps in the wave of globalization.

Taking this event as a starting point, this paper analyzes the impact of Sino-US trade friction on relevant industries in the Sino-US stock market from the perspective of stock index return volatility spillover effect of steel, automobile manufacturing, electrical equipment and semiconductor industries, and quantitatively studies the impact of Sino-US trade war on stock index return volatility spillover effect with the help of empirical analysis method. This has a certain reference significance for investors in the stock market and a certain guiding significance for maintaining the order of the stock market, stabilizing the volatility of the stock market and reducing the investment risk of the stock market. In addition, this study is related to the impact of Sino-US trade friction on the stock market. Therefore, it provides solutions and Countermeasures for the Chinese government and

enterprises in relevant industries to actively deal with the negative impact of trade friction.

2. RELATED LITERATURE REVIEW

There are many articles on the spillover effect between financial markets by scholars at home and abroad. They generally agree on the research conclusion: there is a spillover effect between financial markets, and it can be observed that information can be observed across markets.

Foreign scholars have long studied the spillover effects of stock markets in different countries. Booth, Martikainen, and Tse show an asymmetric volatility spillover effect between the stock markets of Denmark, Norway, Sweden and Finland [1]. Kanas studied the stock markets of France, Germany and Britain and found that the volatility spillover effect is asymmetric. For example, the German stock market has no volatility spillover effect on the British stock market, but there is a significant volatility spillover effect in other directions [2]. Golosnoy, Gribisch, and Liesenfeld found that affected by the financial crisis, both the German stock market and the Japanese stock market were affected by the apparent volatility spillover of the U.S. stock market, because the financial crisis originated from the U.S. stock market [3]. With the rapid development of China's economy, it also plays a more and more important role on the international stage. Many scholars began to study and discuss the volatility spillover effect between China's stock market and other countries' and regions' stock markets. Allen,

Amram, and McAleer studied the volatility spillover effect between Mainland China's stock market and the stock markets of neighboring countries and regions. They found that before the outbreak of the financial crisis, there was a significant volatility spillover effect between Mainland China's stock market and the stock markets of neighboring countries and regions. Still, within the duration of the financial crisis, the volatility spillover effect of Mainland China's stock market on the stock markets of other adjacent countries and regions can be almost ignored [4]. In addition, for the volatility spillover effect between stock markets in other countries, Tai studied the volatility spillover effect between Asian stock markets under the Asian financial crisis in 1997. The research shows that there are significant volatility spillover effects between stock markets and foreign exchange markets in Taiwan, South Korea, Malaysia, Philippines, Thailand and India. And the research method is the MGARCH model [5].

Domestic scholars mainly study the spillover effect between China's stock market and other countries' stock markets. Liu and Chen studied China's Shanghai and Shenzhen stock markets and other major countries' stock markets. They found that since 2006, China's stock market had had a significant volatility spillover effect on other major stock markets in the world. However, the volatility spillover effect of other global stock markets on China's stock market is not particularly obvious [6]. Li, Qin, and Dong studied the spillover effects of China's, U.S. stock market and foreign exchange market under the background of Sino-US trade friction. They found that for both markets, the United States had a one-way and significant spillover effect on China [7].

Based on the above literature, it is not difficult to see that domestic and foreign scholars generally agree on a spillover effect between stock markets. Still, few studies can select variables just before and after major financial events. Therefore, this paper wants to choose the period before and after the outbreak of the Sino-US trade war and study the impact of Sino-US trade friction on the volatility spillover effect between relevant industries in the stock markets of the two countries.

3. MODEL AND DATA

3.1. Model Selection

To study the volatility spillover effect, this paper adopts the MGARCH-BEKK (1,1) model proposed by Engle and Kroner in 1995 [7]. It is expressed as follows:

$$E_t = \alpha_0 + \sum_{j=1}^k \alpha_j E_{t-j} + \gamma_t, \quad \gamma_t | \Omega_{t-1} \sim N(0, H_t) \quad (1)$$

$$H_t = C^T C + A^T \gamma_{t-1}^T \gamma_{t-1} A + B^T H_{t-1} B \quad (2)$$

Equation (1) represents the mean equation, and γ Represents a two-dimensional residual column vector that

obeys a normal distribution with an expectation of 0 and a variance of H_t . Equation (2) represents the variance equation, where C is the constant term matrix, A is the ARCH term coefficient matrix, and G is the GARCH term coefficient matrix, representing the aggregation and persistence of volatility respectively. By expanding H_t into matrix form, equation (3) can be obtained:

$$H_t = \begin{bmatrix} c_{11} & c_{21} \\ 0 & c_{22} \end{bmatrix} \begin{bmatrix} c_{11} & 0 \\ c_{21} & c_{22} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{21} \\ a_{12} & a_{22} \end{bmatrix} \begin{bmatrix} \gamma_{1,t-1}^2 & \gamma_{1,t-1} \gamma_{2,t-1} \\ \gamma_{2,t-1} \gamma_{1,t-1} & \gamma_{2,t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} + \begin{bmatrix} g_{11} & g_{21} \\ g_{12} & g_{22} \end{bmatrix} \begin{bmatrix} h_{11,t-1} & h_{12,t-1} \\ h_{21,t-1} & h_{22,t-1} \end{bmatrix} \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix} \quad (3)$$

Among them, h_{11} and h_{22} represent the conditional variance of sequences, while the rest represent the conditional covariance between sequences. To study the volatility spillover effect between sequences, it is necessary to learn whether a_{ij} and g_{ij} are 0 simultaneously. If they are 0 simultaneously, it means that sequence i has no volatility spillover effect on sequence j. If a_{ij} , g_{ij} , a_{ji} and g_{ji} are 0 at the same time, it means that there is no volatility spillover effect in both directions between the two sequences.

3.2. Data Source, Processing and Description

3.2.1. Data Source

By referring to relevant literature and research and comparing relevant industrial data, this paper finally selects the Iron and Steel Index (Index Code: 882417), Automobile Manufacturing Index (Index Code: 882444), Electronic Component Index (Index Code: 882519), and Semiconductor Product Index (Index Code: 882524) in the Wind Fourth Industry Index to represent the iron and steel industry, automobile manufacturing industry, electrical equipment industry, semiconductor industry in China's stock market. Wind Fourth Industry Index data are from Wind Database. Correspondingly, in U.S. stock market, this paper selects the Steel Industry Index (Index Code: DJUST), Automobile Manufacturing Index (Index Code: DJUSAU), Electronic and Electrical Equipment Industry Index (Index Code: DJUSEE), and Semiconductor Industry Index (Index Code: DJUSSC) in the Dow Jones Industry Index to represent the steel industry, automobile manufacturing industry, electrical equipment industry, semiconductor industry. Dow Jones Industry Index are from the official website of Financial Times.

This paper selects the daily closing price of each industry index, and the sample range is from February 7, 2014 to April 16, 2021. Through screening, the number of samples finally selected in this paper is 1700. Taking February 23, 2018 as the watershed, the data are divided

into the data before the outbreak of the Sino-US trade war and the data after the outbreak of the Sino-US trade war, with 960 and 740 data respectively.

3.2.2. Data Processing

Because the selected data is the daily closing price and may contain a time trend, such a series may be non-stationary and non-normal. Therefore, the logarithmic rate of return of index prices of various industries in China and the United States stock market series is used for research. The calculation formula of yield is expressed by equation 4.

$$R_t = 100 \times \ln(P_t / P_{t-1}) \quad (4)$$

Where R_t represents the logarithmic rate of return of the industry index in period t, while P_t and P_{t-1} represent the prices of the industry index in period t and period t-1 respectively.

3.2.3. Variable Description

The variables used in this paper are the logarithmic rate of return of stock indexes of the Sino-US steel industry, automobile manufacturing industry, electrical equipment industry, and semiconductor industry before and after the outbreak of the Sino-US trade war. The specific corresponding relationship is shown in Table 1:

Table 1. Correspondence Description

	Industry	Before Trade War	After Trade War
CHINA	Steel	RCHSTB	RCHSTA
	Automobile Manufacturing	RCHAUB	RCHAUUA
	Electrical Equipment	RCHEQB	RCHEQA
	Semiconductor	RCHSCB	RCHSCA
UNITED STATES	Steel	RUSSTB	RUSSTA
	Automobile Manufacturing	RUSAUB	RUSAUA
	Electrical Equipment	RUSEQB	RUSEQA
	Semiconductor	RUSSCB	RUSSCA

3.3. Descriptive Statistical Analysis

In terms of the steel industry, it can be seen from table 2 that before the outbreak of the Sino-US trade war, from the mean value, the logarithmic return of the stock index of China's steel industry was greater than that of the United States. In contrast, from the standard deviation, the

volatility of the logarithmic return of the stock index of the U.S. steel industry was less than that of China. After the Sino-US trade war outbreak, from the mean value, the logarithmic return of China's steel industry stock index is less than that of the United States. From the standard deviation, the volatility of China's steel industry stock index logarithmic return is also less than that of the United States.

Table 2. Statistical Characteristics of Steel Industry

	RCHSTB	RUSSTB	RCHSTA	RUSSTA
Mean	0.096249	0.036438	-0.00525	-0.004475
Median	0.217366	0.032962	0.023488	-0.003955
Maximum	9.4724	11.05357	7.125259	12.42967
Minimum	-10.4646	-6.362968	-10.22267	-15.44313
Std. Dev.	2.30355	1.777156	1.6149	2.368014
Skewness	-0.846943	0.23308	-0.308021	-0.628491
Kurtosis	7.308399	4.995834	6.939115	9.914464
Jarque-Bera	857.2623	168.0263	490.1309	1522.853
Probability	0.000000	0.000000	0.000000	0.000000

In terms of the automobile manufacturing industry, it can be seen from table 3 that before the outbreak of the Sino-US trade war, from the mean value, the logarithmic return of the stock index of China's automobile manufacturing industry was greater than that of the United States. From the standard deviation, the volatility of the logarithmic return of the stock index of China's automobile manufacturing industry was also more

significant than that of the United States. After the Sino-US trade war outbreak, from the mean value, the logarithmic return of the stock index of China's automobile manufacturing industry is less than that of the United States. In contrast, from the standard deviation, the volatility of the logarithmic return of the stock index of the American automobile manufacturing industry is greater than that of China.

Table 3. Statistical Characteristics of Automobile Manufacturing Industry

	RCHAUB	RUSAUB	RCHAUA	RUSAUA
Mean	0.073077	0.001863	0.004134	0.190753
Median	0.088216	0.047915	-0.016714	0.102932
Maximum	9.390042	4.564618	7.248029	16.90612
Minimum	-10.26543	-5.318296	-10.14347	-17.87803
Std. Dev.	1.920406	1.275066	1.906873	3.083825
Skewness	-0.677988	-0.433327	-0.289708	-
Kurtosis	8.605069	4.434221	5.534138	10.14481
Jarque-Bera	1330.219	112.3231	208.3586	1591.572
Probability	0.000000	0.000000	0.000000	0.000000

In terms of the electrical equipment industry, it can be seen from table 4 that before the outbreak of the Sino-US trade war, from the mean value, the logarithmic return of the stock index of China's electrical equipment industry was greater than that of the United States. In contrast, from the standard deviation, the volatility of the logarithmic return of the stock index of the U.S. electrical equipment industry was less than that of China. After the Sino-US

trade war outbreak, from the mean value, the logarithmic return of the stock index of China's electrical equipment industry is less than that of the United States. In contrast, from the standard deviation, the volatility of the logarithmic return of the stock index of China's electrical equipment industry is greater than that of the United States.

Table 4. Statistical Characteristics of Electrical Equipment Industry

	RCHEQB	RUSEQB	RCHEQA	RUSEQA
Mean	0.078027	0.048293	0.02929	0.051861
Median	0.187793	0.082417	0.054122	0.090595
Maximum	9.542663	3.194083	6.4653	10.57007
Minimum	-10.4681	-5.056478	-10.35647	-12.66669
Std. Dev.	2.395746	0.97689	2.092246	1.811584
Skewness	-0.870682	-0.564359	-0.498107	-1.01509
Kurtosis	7.498065	5.246889	5.088757	12.49038
Jarque-Bera	930.5977	252.9005	165.1232	2904.162
Probability	0.000000	0.000000	0.000000	0.000000

In terms of the semiconductor industry, it can be seen from table 5 that before the outbreak of the Sino-US trade war, the logarithmic rate of return of the stock index of China's semiconductor industry was lower than that of the United States from the average. In contrast, the volatility of the logarithmic rate of return of the stock index of the U.S. semiconductor industry was lower than that of China

from the standard deviation. After the Sino-US trade war outbreak, from the mean value, the logarithmic return of China's semiconductor industry stock index is less than that of the United States. From the standard deviation, the volatility of China's semiconductor industry stock index logarithmic return is also less than that of the United States.

Table 5. Statistical Characteristics of Semiconductor Industry

	RCHSCB	RUSSCB	RCHSCA	RUSSCA
Mean	0.064757	0.086955	0.06462	0.093643
Median	0.18735	0.159788	0.023044	0.172899
Maximum	8.822675	4.972174	7.32914	11.66034
Minimum	-10.22417	-6.87649	-9.922209	-18.21528
Std. Dev.	2.531626	1.306919	2.202471	2.25655
Skewness	-0.935246	-0.514759	-0.373179	-0.856659
Kurtosis	6.8033	5.574968	4.675374	11.82825
Jarque-Bera	718.5532	307.6148	103.7211	2493.598
Probability	0.000000	0.000000	0.000000	0.000000

Across the board, from the kurtosis coefficient, the kurtosis coefficient of logarithmic return of stock indexes in all industries is greater than 3 before and after the outbreak of the Sino-US trade war, which indicates that all sequences have the characteristics of "peak and thick tail". From Jarque-Bera statistics, the log return series of stock indexes in all industries rejected the null hypothesis at the significant level of 1% before and after the outbreak of the Sino-US trade war, indicating that all series obey the normal distribution.

3.4. Unit Root Inspection

Before establishing the MGARCH-BEKK model, the unit root test should be carried out to ensure the stability of the time series. After testing, all stock index log return series are stationary series, and the MGARCH-BEKK model can be established for further research.

4. EMPIRICAL TEST OF VOLATILITY SPILLOVER EFFECT

4.1. Steel Industry

By observing the operation results of GARCH-BEKK in Table 6, it can be found that a11 and a22 reject the null

Table 6. GARCH-BEKK Results of RCHSTB and RUSSTB

	Variable	Coefficient	Std Error	T-Statistics	Significant
1	e1	0.128140	0.049433	2.592210	0.009536
2	e2	0.045356	0.055079	0.823470	0.410242
3	c11	0.158939	0.047102	3.374350	0.000740
4	c21	0.023510	0.042994	0.546820	0.584506
5	c22	0.129547	0.048529	2.669480	0.007597
6	a11	0.289575	0.020707	13.984190	0.000000
7	a12	0.081342	0.011616	7.002500	0.000000
8	a21	-0.074360	0.021889	-3.397160	0.000681

hypothesis when the significance level is 1%, indicating that both RCHSTB and RUSSTB have a significant ARCH effect. g11 and g22 reject the null hypothesis when the significance level is 1%, meaning that both RCHSTB and RUSSTB have a significant GARCH effect.

By observing the Wald test results in Table 7, it can be found that under the condition that the significance level is 1%, both "no volatility spillover of RCHSTB to RUSSTB" and "no volatility spillover of RUSSTB to RCHSTB" reject the null hypothesis, indicating that before the outbreak of the Sino-US trade war, the volatility spillover effect between RCHSTB and RUSSTB has the characteristics of significance and bidirectionality. This shows that before the outbreak of the Sino-US trade war, the volatility of the steel industry in China's stock market will significantly affect the volatility of the steel industry in the U.S. stock market. The volatility of the steel industry in the U.S. stock market will also considerably affect the volatility of the steel industry in China's stock market.

9	a22	-0.124173	0.021456	-5.787320	0.000000
10	g11	0.944781	0.005899	160.159520	0.000000
11	g12	0.207017	0.028196	7.342100	0.000000
12	g21	0.085932	0.039265	2.188520	0.028632
13	g22	-0.980240	0.005618	-	0.000000
				174.467070	

Table 7. Wald Test Results of RCHSTB and RUSSTB

Null Hypothesis	Statistics	Probability
1. No volatility spillover between RCHSTB and RUSSTB	120.38661	0.000000
2. No volatility spillover of RCHSTB to RUSSTB	86.091676	0.000000
3. No volatility spillover of RUSSTB to RCHSTB	13.271734	0.001312

By observing the operation results of GARCH-BEKK in Table 8, it can be found that a11 and a22 reject the null hypothesis when the significance level is 1%, indicating that both RCHSTA and RUSSTA have a significant ARCH effect. g11 and g22 reject the null hypothesis when the significance level is 1%, meaning that both RCHSTA and RUSSTA have a significant GARCH effect.

By observing the Wald test results in table 9, it can be found that under the condition of 5% significance level,

Table 8. GARCH-BEKK Results of RCHSTA and RUSSTA

	Variable	Coefficient	Std Error	T-Statistics	Significant
1	e1	-0.009206	0.055845	-0.164840	0.869069
2	e2	-0.023784	0.068106	-0.349220	0.726921
3	c11	0.457049	0.084555	5.405360	0.000000
4	c21	-0.141235	0.138773	-1.017740	0.308802
5	c22	-0.400321	0.128594	-3.113060	0.001852
6	a11	0.289021	0.048085	6.010610	0.000000
7	a12	-0.095841	0.063129	-1.518180	0.128969
8	a21	0.007486	0.021979	0.340580	0.733416
9	a22	0.325213	0.048767	6.668710	0.000000
10	g11	0.916984	0.025864	35.454040	0.000000
11	g12	0.071819	0.043183	1.663120	0.096289
12	g21	-0.002676	0.008716	-0.307050	0.758802
13	g22	0.917932	0.026797	34.255480	0.000000

"no volatility spillover of RCHSTA to RUSSTA" and "no volatility spillover of RUSSTA to RCHSTA" do not reject the null hypothesis, indicating that there is no volatility spillover effect between RCHSTA and RUSSTA after the outbreak of Sino-US trade war, which suggests that after the outbreak of Sino-US trade war. The volatility of the steel industry in China's stock market has no impact on the volatility of the steel industry in the U.S. stock market, and the volatility of the steel industry in the U.S. stock market does not affect the volatility of the steel industry in China's stock market.

Table 9. Wald Test Results of RCHSTA and RUSSTA

Null Hypothesis	St atistics	Probabilit y
1. No volatility spillover between RCHSTA and RUSSTA	3.08959 6	0.542945
2. No volatility spillover of RCHSTA to RUSSTA	2.88952 6	0.235802
3. No volatility spillover of RUSSTA to RCHSTA	0.12088 4	0.941349

4.2. Automobile Manufacturing Industry

By observing the operation results of GARCH-BEKK in Table 10, it can be found that a11 and a22 reject the null hypothesis when the significance level is 1%, indicating that both RCHAUB and RUSAUB have a significant ARCH effect. g11 and g22 reject the null hypothesis when the significance level is 1%, meaning that both RCHAUB and RUSAUB have a significant GARCH effect.

By observing the Wald test results in Table 11, it can be found that under the condition of 5% significance level,

"no volatility spillover from RCHAUB to RUSAUB" and "no volatility spillover from RUSAUB to RCHAUB" do not reject the null hypothesis, indicating that there is no volatility spillover effect between RCHAUB and RUSAUB before the outbreak of Sino-US trade war. This suggests that before the outbreak of Sino-US trade war, the volatility of the automobile manufacturing industry in China's stock market has no impact on the volatility of the automobile manufacturing sector in the U.S. stock market, and the volatility of the automobile manufacturing industry in the U.S. stock market does not affect the volatility of the automobile manufacturing industry in China's stock market.

Table 10. GARCH-BEKK Results of RCHAUB and RUSAUB

	Variable	Coefficient	Std Error	T-Statistics	Significant
1	e1	0.057825	0.039580	1.460960	0.144027
2	e2	0.015132	0.040232	0.376110	0.706831
3	c11	0.121570	0.032034	3.795050	0.000148
4	c21	0.215783	0.350215	0.616140	0.537800
5	c22	0.612193	0.153328	3.992690	0.000065
6	a11	0.250368	0.025124	9.965220	0.000000
7	a12	0.055744	0.030710	1.815150	0.069501
8	a21	0.031203	0.046049	0.677610	0.498022
9	a22	0.341518	0.046488	7.346430	0.000000
10	g11	0.966327	0.006005	160.923720	0.000000
11	g12	-0.008663	0.010476	-0.826990	0.408244
12	g21	-0.027443	0.043399	-0.632350	0.527158
13	g22	0.781504	0.053489	14.610460	0.000000

Table 11. Wald Test Results of RCHAUB and RUSAUB

Null Hypothesis	Statistics	Probability
1. No volatility spillover between RCHAUB and RUSAUB	20.101767	0.413448
2. No volatility spillover of RCHAUB to RUSAUB	12.470860	0.175907
3. No volatility spillover of RUSAUB to RCHAUB	14.509708	0.786995

By observing the operation results of GARCH-BEKK in table 12, it can be found that a11 and a22 reject the null hypothesis when the significance level is 1%, indicating that there is a significant ARCH effect in both RCHAUA and RUSAUA. g11 and g22 reject the null hypothesis when the significance level is 1%, meaning that there is a considerable GARCH effect in RCHAUA and RUSAUA.

By observing the Wald test results in table 13, it can be found that under the condition that the significance level is 1%, both "no volatility spillover from RCHAUA to RUSAUA" and "no volatility spillover from RUSAUA

to RCHAUA" reject the null hypothesis, indicating that the volatility spillover effect between RCHAUA and RUSAUA is a significant and bidirectional after the outbreak of the Sino-US trade war. This shows that after the outbreak of the Sino-US trade war, the volatility of the automobile manufacturing industry in China's stock market will significantly affect the volatility of the automobile manufacturing sector in the U.S. stock market. At the same time, the volatility of the automobile manufacturing industry in the U.S. stock market will also significantly affect the volatility of the automobile manufacturing industry in China's stock market.

Table 12. GARCH-BEKK Results of RCHAUA and RUSAUA

	Variable	Coefficient	Std Error	T-Statistics	Significant
1	e1	-0.007126	0.072188	-0.098710	0.921370
2	e2	0.161879	0.082285	1.967290	0.049150
3	c11	0.887292	0.218662	4.057830	0.000050
4	c21	0.097325	0.135386	0.718870	0.472221
5	c22	0.229192	0.232750	0.984710	0.324765
6	a11	-0.445538	0.072006	-6.187480	0.000000
7	a12	0.032427	0.083007	0.390650	0.696054
8	a21	-0.058022	0.047549	-1.220250	0.222370
9	a22	0.350755	0.043581	8.048350	0.000000
10	g11	0.737185	0.112508	6.552290	0.000000
11	g12	-0.132900	0.057181	-2.324200	0.020115
12	g21	0.093402	0.028840	3.238580	0.001201
13	g22	0.942554	0.019526	48.270680	0.000000

Table 13. Wald Test Results of RCHAUA and RUSAUA

Null Hypothesis	Statistics	Probability
1. No volatility spillover between RCHAUA and RUSAUA	3.945382	0.000477
2. No volatility spillover of RCHAUA to RUSAUA	3.475604	0.001959

3. No volatility spillover of RUSAUA to RCHAUA	0.479068	0.000707
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4.3. Electrical Equipment Industry

By observing the operation results of GARCH-BEKK in table 14, it can be found that a11 and a22 reject the null hypothesis when the significance level is 1%, indicating that RCHEQB and RUSEQB have a significant ARCH effect. g11 and g22 reject the null hypothesis when the significance level is 1%, meaning that RCHEQB and RUSEQB have a significant GARCH effect.

By observing the Wald test results in table 15, it can be found that under the condition that the significance level is 1%, the null hypothesis is not rejected by "no

volatility spillover from RCHEQB to RUSEQB", while the null hypothesis is rejected by "no volatility spillover from RUSEQB to RCHEQB", indicating that there was a unidirectional and significant volatility spillover effect in the direction of RUSEQB to RCHEQB before the outbreak of the Sino-US trade war. This shows that before the outbreak of the Sino-US trade war, the volatility of the electrical equipment industry in China's stock market has no impact on the volatility of the electrical equipment industry in the U.S. stock market, while the volatility of the electrical equipment industry in the U.S. stock market will significantly affect the volatility of the electrical equipment industry in China's stock market.

Table 14. GARCH-BEKK Results of RCHEQB and RUSEQB

	Variable	Coefficient	Std Error	T-Statistics	Significant
1	e1	0.043989	0.052728	0.834260	0.404134
2	e2	0.061260	0.030544	2.005630	0.044896
3	c11	0.158951	0.054673	2.907300	0.003646
4	c21	-0.127345	0.124186	-1.025440	0.305154
5	c22	0.339589	0.067321	5.044360	0.000000
6	a11	0.224625	0.029056	7.730630	0.000000
7	a12	-0.072309	0.020247	-3.571380	0.000355
8	a21	-0.015941	0.076834	-0.207470	0.835644
9	a22	0.310961	0.049952	6.225190	0.000000
10	g11	0.971778	0.009660	100.603260	0.000000
11	g12	0.026566	0.006557	4.051490	0.000051
12	g21	0.001020	0.051926	0.019640	0.984330
13	g22	0.854881	0.042732	20.005620	0.000000

Table 15. Wald Test Results of RCHEQB and RUSEQB

Null Hypothesis	Statistics	Probability
1. No volatility spillover between RCHEQB and RUSEQB	18.274320	0.000209
2. No volatility spillover of RCHEQB to RUSEQB	16.949381	0.951460
3. No volatility spillover of RUSEQB to RCHEQB	0.099515	0.000707

By observing the operation results of GARCH-BEKK in Table 16, it can be found that a11 and a22 reject the null hypothesis when the significance level is 1%, indicating that RCHEQA and RUSEQA have a significant ARCH effect. g11 and g22 reject the null hypothesis when the

significance level is 1%, meaning that RCHEQA and RUSEQA have a significant GARCH effect.

By observing the Wald test results in table 17, it can be found that under the condition that the significance level is 1%, the null hypothesis is not rejected by "no

volatility spillover from RCHEQA to RUSEQA", while the null hypothesis is rejected by "no volatility spillover from RUSEQA to RCHEQA", indicating that after the outbreak of the Sino-US trade war, there is still a one-way and significant volatility spillover effect from RUSEQA to RCHEQA. This shows that after the outbreak of the Sino-US trade war, the volatility of the electrical

equipment industry in China's stock market still has no impact on the volatility of the electrical equipment industry in the U.S. stock market, while the volatility of the electrical equipment industry in the U.S. stock market will still significantly affect the volatility of the electrical equipment industry in China's stock market.

Table 16. GARCH-BEKK Results of RCHEQA and RUSEQA

	Variable	Coefficient	Std Error	T-Statistics	Significant
1	e1	0.040928	0.078814	0.519300	0.603550
2	e2	0.103919	0.049193	2.112480	0.034645
3	c11	1.646041	0.258530	6.366930	0.000000
4	c21	0.243280	0.068207	3.566780	0.000361
5	c22	-0.000006	0.911438	-0.000007	0.999995
6	a11	0.253529	0.080024	3.168140	0.001534
7	a12	-0.016780	0.043769	-0.383380	0.701438
8	a21	-0.139629	0.080579	-1.732820	0.083127
9	a22	0.435403	0.045727	9.521700	0.000000
10	g11	-0.539605	0.192953	-2.796570	0.005165
11	g12	0.061851	0.053128	1.164180	0.244352
12	g21	0.305531	0.081528	3.747550	0.000179
13	g22	0.877867	0.025189	34.850760	0.000000

Table 17. Wald Test Results of RCHEQA and RUSEQA

Null Hypothesis	Statistics	Probability
1. No volatility spillover between RCHEQA and RUSEQA	26.5503 11	0.000025
2. No volatility spillover of RCHEQA to RUSEQA	1.44846 4	0.484697
3. No volatility spillover of RUSEQA to RCHEQA	26.4300 51	0.000002

4.4. Semiconductor Industry

By observing the operation results of GARCH-BEKK in Table 18, it can be found that a11 and a22 reject the null hypothesis when the significance level is 1%, indicating that both RCHSCB and RUSSCB have a significant ARCH effect. g11 and g22 reject the null hypothesis when the significance level is 1%, meaning that both RCHSCB and RUSSCB have a significant GARCH effect.

By observing the Wald test results in table 19, it can be found that under the condition that the significance

level is 1%, both "no volatility spillover of RCHSCB to RUSSCB" and "no volatility spillover of RUSSCB to RCHSCB" reject the null hypothesis, indicating that the volatility spillover effect between RCHSCB and RUSSCB was significant and bidirectional before the outbreak of the Sino-US trade war. This shows that before the outbreak of the Sino-US trade war, the volatility of the semiconductor industry in China's stock market will significantly affect the volatility of the semiconductor industry in the U.S. stock market. At the same time, the volatility of the semiconductor industry in the U.S. stock market will also significantly affect the volatility of the semiconductor industry in China's stock market.

Table 18. GARCH-BEKK Results of RCHSCB and RUSSCB

	Variable	Coefficient	Std Error	T-Statistics	Significant
1	e1	0.042295	0.048565	0.870900	0.383810
2	e2	0.084618	0.039691	2.131890	0.033016
3	c11	-0.032262	0.045338	-0.711580	0.476723
4	c21	-0.497928	0.027268	-18.260590	0.000000
5	c22	0.613914	0.022735	27.003100	0.000000
6	a11	0.252373	0.029052	8.687070	0.000000
7	a12	0.144080	0.042288	3.407110	0.000657
8	a21	0.164603	0.037161	4.429410	0.000009
9	a22	-0.325917	0.052414	-6.218160	0.000000
10	g11	0.960250	0.007492	128.164320	0.000000
11	g12	-0.015306	0.024192	-0.632710	0.526921
12	g21	0.040121	0.018701	2.145390	0.031921
13	g22	0.684170	0.015177	45.079280	0.000000

Table 19. Wald Test Results of RCHSCB and RUSSCB

Null Hypothesis	Statistics	Probability
1. No volatility spillover between RCHSCB and RUSSCB	363.53675 9	0.000000
2. No volatility spillover of RCHSCB to RUSSCB	45.577051	0.000000
3. No volatility spillover of RUSSCB to RCHSCB	47.935495	0.000000

By observing the operation results of GARCH-BEKK in table 20, it can be found that a11 does not reject the null hypothesis when the significance level is 5%, indicating that the arch effect of RCHSCA is not significant. In comparison, a22 rejects the null hypothesis when the significance level is 1%, indicating that RUSSCA has a significant ARCH effect. g11 and g22 reject the null hypothesis when the significance level is 5%, meaning that both RCHSCA and RUSSCA have a significant GARCH effect.

By observing the Wald test results in table 21, it can be found that under the condition that the significance

level is 5%, the null hypothesis is rejected by "no volatility spillover of RCHSCA to RUSSCA", while "no volatility spillover of RUSSCA to RCHSCA" does not reject the null hypothesis, indicating that there is a one-way and significant volatility spillover effect in the direction of RCHSCA to RUSSCA after the outbreak of the Sino-US trade war. This shows that after the outbreak of the Sino-US trade war, the volatility of the semiconductor industry in China's stock market will significantly affect the volatility of the semiconductor industry in the U.S. stock market, while the volatility of the semiconductor industry in the U.S. stock market has no impact on the volatility of the semiconductor industry in China's stock market.

Table 20. GARCH-BEKK Results of RCHSCA and RUSSCA

	Variable	Coefficient	Std Error	T-Statistics	Significant
1	e1	0.092430	0.083114	1.112090	0.266098
2	e2	0.143219	0.063155	2.267730	0.023346
3	c11	1.682099	0.403327	4.170560	0.000030
4	c21	-0.160920	0.161441	-0.996770	0.318875

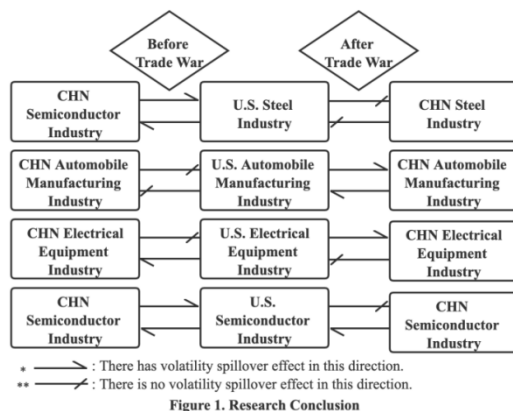
5	c22	-0.000010	1.009037	-0.000010	0.999992
6	a11	0.114991	0.078830	1.458730	0.144640
7	a12	0.021559	0.040286	0.535150	0.592548
8	a21	0.151733	0.066904	2.267920	0.023334
9	a22	0.392044	0.043183	9.078690	0.000000
10	g11	0.612864	0.242332	2.529030	0.011438
11	g12	0.159078	0.038679	4.112780	0.000039
12	g21	-0.053888	0.042343	-1.272660	0.203139
13	g22	0.881209	0.022691	38.835820	0.000000

Table 21. Wald Test Results of RCHSCA and RUSSCA

Null Hypothesis	Statistics	Probability
1. No volatility spillover between RCHSCA and RUSSCA	22.044224	0.000196
2. No volatility spillover of RCHSCA to RUSSCA	19.556563	0.000057
3. No volatility spillover of RUSSCA to RCHSCA	5.207707	0.073988

5. RESEARCH CONCLUSION

By selecting 1700 daily closing price data of steel industry index, automobile manufacturing industry index, electrical equipment industry index and semiconductor industry index in China and the United States from February 7, 2014 to April 16, 2021, and taking the outbreak of China US trade war as the node, this paper constructs a MGARCH-BEKK model to compare the data before and after the outbreak of Sino-US trade war. This paper analyzes the impact of the Sino-US trade war on the volatility spillover effect between relevant industries in the China’s and U.S. stock markets, and draws the following conclusions (as shown in Figure 1):



5.1. Steel Industry

In terms of the steel industry, before the outbreak of the Sino-US trade war, there was a significant and two-way volatility spillover effect between the steel industry in China's stock market and the steel industry in the U.S. stock market. After the Sino-US trade war outbreak, there was no volatility spillover effect between the steel industry in China's stock market and the steel industry in the U.S. stock market. The reason is that China is the country with the highest output of steel products globally, and the proportion of China's import and export trade of steel products is relatively small. After the outbreak of the Sino-US trade war, the trade volume of steel products between China and the United States has decreased due to the impact of tariffs imposed by China and the United States, which makes the relationship between the volatility of steel industries in the Sino-US stock market no longer close.

5.2. Automobile Manufacturing Industry

In terms of the automobile manufacturing industry, before the outbreak of the Sino-US trade war, there was no volatility spillover effect between the automobile manufacturing industry in China's stock market and the automobile manufacturing industry in the U.S. stock market. After the Sino-US trade war outbreak, there was a significant and two-way volatility spillover effect between

the automobile manufacturing industry in China's stock market and the automobile manufacturing industry in the U.S. stock market. The reason is that after the outbreak of the Sino-US trade war, China imposed high tariffs on American imported vehicles and the United States imposed high tariffs on Chinese imported vehicles, which greatly limited the exchanges of automobile trade between China and the United States. Therefore, Chinese and American automobile enterprises were significantly impacted, and showed a more obvious volatility correlation in the stock market.

5.3. Electrical Equipment Industry

In terms of the electrical equipment industry, before the outbreak of the Sino-US trade war, the electrical equipment industry in the US stock market had a significant and one-way volatility spillover effect on the electrical equipment industry in the Chinese stock market. After the Sino-US trade war outbreak, the electrical equipment industry in the U.S. stock market still had a significant and one-way volatility spillover effect on the electrical equipment industry in the Chinese stock market. The reason is that the United States has always exported a large number of electrical equipment products to China. After the outbreak of the Sino-US trade war, the United States has dramatically reduced the share of electrical equipment products imported from China, which makes it difficult for the volatility of the electrical equipment industry in China's stock market to be transmitted to the electrical equipment industry in the U.S. stock market. The change of the electrical equipment industry in American stock market can significantly affect the electrical equipment industry in Chinese stock market.

5.4. Semiconductor Industry

In the semiconductor industry, before the outbreak of the Sino-US trade war, there was a significant and two-way volatility spillover effect between the semiconductor industry in China's stock market and the semiconductor industry in the U.S. stock market. After the Sino-US trade war outbreak, the semiconductor industry in China's stock market had a significant and one-way volatility spillover

effect on the semiconductor industry in the U.S. stock market. The reason is that the United States is a substantial exporter of semiconductor products, and most of China's semiconductor products contain American technology. After the outbreak of the Sino-US trade war, the U.S. government restricted the export of American semiconductor enterprises to China, resulting in the volatility of the semiconductor industry in the U.S. stock market that cannot be effectively transmitted to China's stock market.

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