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Research on Co-movement Between China and USA Stock Market under the Impact of COVID-19

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Abstract: The worldwide economic market has fluctuated wildly due to COVID-19, therefore revealing the co-movement of international stock markets should reduce its destructive force and shock. Based on the "Economic Basic Hypothesis" and "Market Contagion Hypothesis," this work uses VECM and GARCH models to examine international market volatility using the Shanghai Composite Index (SSEC), Shenzhen Composite Index (SZSE), and S&P 500 index. The total trading data of three indexes are divided into 2 periods, with September 01, 2019 as the cut-off point. The period 1 is from January 5, 2015 to August 30, 2019 and the period 2 is from September 3, 2019 to December 30, 2022. The study shows that: 1) During the COVID-19, the short-term return of both stock markets has declined and volatility has increased; 2) there is no reliable co-integration relationship between S&P 500, SSEC and SZSE which also declaims no long-run equilibrium between two markets; 3) before and during the COVID-19, the close to close return rate of America stock market guided the return rate of China stock market; 4) both S&P 500, SSEC shows an asymmetric effect and the leverage effect is distinct; 5) the co-movement was stronger when the rate of return was relatively high; 6) volatility spillover effect of China to USA stock market was significant.

Keywords: stock market, co-movement, volatility spillover effect, dynamic correlation

1. Introduction

With the gradual integration of economic activities, the interdependence of global financial markets has been increasing, and international financial activities have penetrated and interacted with each other. Regional financial market fluctuations have also spread rapidly, increasing the resonance risk of the market. China and the US trade often, affecting the global economy and finance. Researching China-U.S. stock market links can help developing and developed nations connection.

In September 2019, COVID-19 ravaged worldwide stock markets. The Shanghai Index plummeted 7.72% and the Shenzhen Composite Index 8.45% on February 3, 2020. The S&P 500 overall index of the US hit the largest decline since the financial crisis in 2008, triggering two circuit breakers in March 2020.

The purpose of this article is to conduct an empirical research on the fluctuation trend of the China and USA stock markets during the COVID-19 period. The value of the study is that, first, the impact of the epidemic on the financial market linkage of developed and developing countries can be explored in the long or short term; second, if large-scale public health events occur again, studying

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the transmission process of the impact of the U.S. stock market on China stock market will provide reliable evidence to formulate and promulgate relevant regulations more reasonably; third, the study has important implications for strengthening global policy coordination, jointly stepping out of the financial crisis and avoiding systemic financial risks.

This paper innovates by using VECM model and GARCH model to carry out long-term equilibrium and short-term volatility spillover effects and establish the long-term and short-term linkage relationship between the China and USA stock markets. It also analyses the impact of COVID-19 on the China and USA stock markets by taking the dynamic change characteristics of the stock market guidance relationship as a whole. We distinguish the stock market return according to the trading time, and decompose it in detail in the information transmission process. Moreover, we introduce the quantile regression into the stock market linkage analysis, and observe its correlation under different market fluctuations.

We briefly review related literatures in Section 2 and introduce the analysis method in Section 3, followed by the statistical analysis and estimation results in Section 4. Section 5 summarizes the study.

2. Literature Review

Scholars have made various researches on the co-movement of financial markets. Volatility spillover effect refers to the possible interaction between the volatility of different financial markets. In view of international market fluctuations, scholars have summarized two types of hypotheses: " Economic Fundamental Hypothesis " and " Market Contagion Hypothesis ".

The " Economic Fundamental Hypothesis " is based on the complete rational hypothesis, which believes that the relationship of asset prices originates from the fundamental aspects of assets. Mcqueen & Roley found that the economic fundamentals of many countries affect each other, so the linkage of macroeconomic variables is the factor of the linkage of stock market returns [1]. Contessi et al. observed that the euro and European economic convergence had increased the stock market linking effect of European countries [2]. On the contrary, the " Market Contagion Hypothesis " pays more attention to the behavioral characteristics of investors, and believes that the decisive reason for the linkage is the unstable investor factor.

Using the US, Japan, Hong Kong, and Shanghai stock markets as examples, Xiuliang Dong & Fengqi Cao stated that Shanghai stock market will be affected by US and Japan stock markets through Hong Kong stocks [3]. Bing Zhang et al analyzed the transmission mechanism of stock market co-movement from theories and tested the linkage characteristics of the Chinese and American stock markets in stages [4]. Rao Jianping et al found that after the trade war, the co-movement of the markets of China and America has decreased [5]. There is an obvious nonlinear causal linkages in BRIC economics in which the contagious effects of the US crisis exists, according to the research of Stelios D. Bekiros [6]. Kübra Akca suggests that volatility spillovers in the US, UK, Germany, Spain, Turkey, and Greece stock markets during the crisis era reduce diversification benefits for investors [7]. Yudong Wang et al. found high volatility spillover from the US to five major stock markets during US business cycle recession s[8].

The existing literature has already analyzed the volatility of the financial market in different ways and obtained many useful conclusions. The impact of the COVID-19 epidemic has had a significant impact on the global market, but there is little literature analysis on this. In view of this, this paper will use GARCH model and other methods to study the fluctuation trend of the stock markets in China and the United States under the COVID-19 epidemic.

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3. Analysis Methods

3.1. Analysis Hypothesis

Based on the "Economic Fundamental Hypothesis" and "Market Contagion Hypothesis", the author proposed two hypothesizes.

Hypothesis 1: After the shock of COVID-19, due to the limitation of global trading, the short-term correlation of China and USA stock market has declined but the long-term co-movement remained no change. Since both USA and China government enacted a series of policies to prevent the epidemic, which restricted the economic intercourses, externally bringing a slump in short-term correlation. As the stock market shows a great similarity with the macro-economic path, there will also be long-term equilibrium in the stock market, bringing the result that the long-term co-movement of two markets would not be affected by COVID-19.

Hypothesis 2: The market contagion was strengthened during COVID-19, bringing a stronger correlation between two stock markets, especially under extreme conditions. Because market participants are not completely rational, under the global impact of the COVID-19 epidemic, it is more likely to have behavioral characteristics such as convergence psychology and herding effect. The sensitivity of the market and the psychological factors of investors will also enhance the linkage of the stock market. Meanwhile, as the COVID-19 has led investors to panic, both negative and positive impacts will be amplified by the market, which will make the stock market extremely impacted.

3.2. Analysis Methods

Johansen test and Error Correction model are used to assess the two countries' stock markets' long-term association. Granger test and DCC-GARCH model examine mean and volatility spillover effects in short-term relationships. Finally, quantile regression method is used to analyze market linkage under extreme conditions.

3.2.1. Co-integration test of Johansen multivariate system.

Johansen test is a method to test multiple cointegration relationships. Canonical correlation analysis estimates matrix and test matrix ranks, and tests multiple cointegration relationships based on the unit root test.

For a VAR (p) model with a p-order lag term:

$$Y_t = \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \cdots + \Pi_p Y_{t-p} + \mu_t \quad (1)$$

The author selected transitory VECM to convert here and use both Trace Test and Maximum Eigenvalue Test in this paper.

According to different specification of trends in VECM, five cases are yielded:

Table 1: VECM.

	The cointegrating equation	The levels of the data
Model 1	No constant, no trends	No constant, no trends
Model 2	a constant mean, no trends	No constant, no trends
Model 3	a constant mean, no trends	Linear but not quadratic trends
Model 4	a constant mean, linear trends	Linear but not quadratic trends
Model 5	a constant mean, linear trends	have quadratic trends, linear time trend

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On the advice of Nieh & Lee, the author selected models through the rule of Pantula: the model 1 is abandoned due to its restrictions and model 5 is abandoned for the rarity of quadratic trends. In empirical research, the first model which confirms no co-integration will be selected to be the appropriate one. In this paper, when the results of these models' conflict, the author will choose the most reliable result combining with the characteristics of the sample data under this rule.

3.2.2. DCC-GARCH.

On the basis of GARCH, in order to verify the leverage effect, Glosten et al extended the asymmetric GARCH model, GJR model (TGARCH). Then Engle and Sheppard put forward the dynamic conditional correlation coefficient DCC-GARCH model to analyze the volatility and dynamic correlation between multiple financial market variables after considering the correlation between assets, so as to analyze the volatility spillover effect, which can be used to analyze the degree of nonlinear correlation between variables.

The conditional return time series of k-yuan assets in DCC model can be expressed as:

$$r_t|F_{t-1} \sim N(0, H_t)$$

$$H_t = D_t R_t D_t, R_t = Q_t^{*-1} Q_t Q_t^{*-1}$$

$$Q_t = (1 - \sum_{m=1}^{M} \alpha_m - \sum_{n=1}^{N} \beta_n)\bar{Q} + \sum_{m=1}^{M} \alpha_m \varepsilon_{t-m} \varepsilon_{t-m}' - \sum_{n=1}^{N} \beta_n Q_{t-n} \quad (2)$$

where F_{t-1} is the information set up to the t-1 period, R_t is the dynamic conditional correlation matrix, D_t is the k * k diagonal matrix formed by the diagonal term of the conditional standard deviation calculated by the single variable GARCH model.

Granger Test. Granger non-causality is that if the conditional distribution of $y_t$determined by the lag value of y_t and x_t is the same as that determined by the lag value of y_t, then x_{t-1} has Granger non-causality to y_t.

In VAR:

$$y_t = \sum_{i=1}^{k} \alpha_i y_{t-i} + \sum_{j=1}^{k} \beta_j x_{t-j} + u_{1t} \quad (3)$$

The null hypothesis of Granger's non-causality is $\beta_1 = \beta_2 = \cdots = \beta_k = 0$.

The above test is completed by F statistics. If the F value falls within the critical value, the original assumption is accepted, that is, x_t is not the Granger cause of y_t.

4. Data and Results

4.1. Data

According to the background of COVID-19 public health emergencies, this paper selects two periods' data, January 5, 2015 to August 30, 2019 as period 1 and September 3, 2019 to December 30, 2022 as period 2. China's stock market was represented by the Shanghai and Shenzhen Composite Indices. S&P 500 represented US stocks. CSMAR provided all data.

Due to the different stock market holidays in the two countries, there are certain differences in trading days. Before the analysis, the date data of the two markets that do not coincide were deleted, and a total of 1885 sets of data were obtained. The stock market trend of the two countries is shown in Figure 1.

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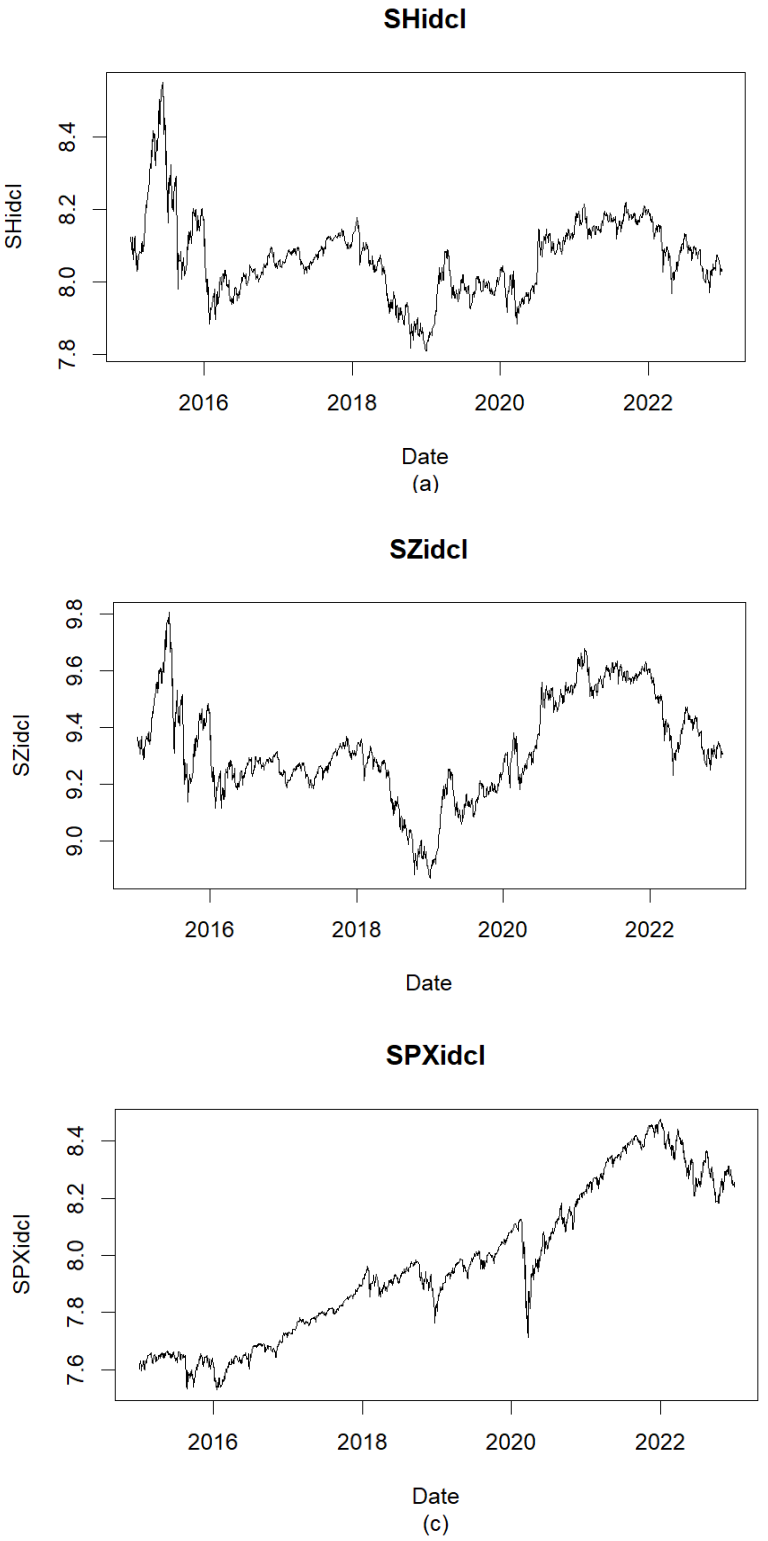

Figure 1: Charts of Close-to-close of SSEC, SZSE, S&P 500.

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The China stock market opens from 9:30 a.m. to 11:30 a.m. and from 1:00 p.m. to 3:00 p.m. in each trading day. The USA stock market opens at 9:30 a.m. EDT, remains open at noon and close at 4:00 p.m. This study divides the rate of return into two components, the Close-to-close return and the Open-to-close return, using Hamao's decomposition to examine how overseas market movements affect local market opening and closing prices. Calculation formula:

$$R\_OP_t = \ln(OP_t) - \ln(CL_{t-1}) \quad (4)$$

$$R\_CL_t = \ln(CL_t) - \ln(CL_{t-1}) \quad (5)$$

where R_OP_t represents the Open-to-close return and R_CL_t represents Close-to-close return on day t, OP_t is the opening index price on day t, CL_t represents the pre-closing index price on the t day. SHIOP, SHICL, and SPXOP and SPXCL are the Shanghai Composite Index, Shenzhen Composite Index, and S&P 500 stock index's open-to-close and close-to-close returns.

4.2. Descriptive Analysis

Table 2: The Open-to-close and Close-to-close return of SSEC, SZSE and S&P 500.

Stock Return	Before COVID-19				During COVID-19			
	Means	Standard deviation	Skewness	Kurtosis	Means	Standard deviation	Skewness	Kurtosis
SHIOP	-0.1152%	0.0213	0.7644	6.3377	-0.0701%	0.0147	0.6293	4.6140
SHICL	0.0122%	0.0156	1.0650	6.1576	-0.0068%	0.0111	0.7713	5.6357
SZIOP	-0.0577%	0.0255	0.9077	4.6388	-0.0595%	0.0195	0.5332	2.1381
SZICL	0.0162%	0.0185	0.8923	3.8687	-0.0172%	0.0146	0.6435	2.7089
SPXOP	-0.0373%	0.0115	0.6323	5.4291	-0.0284%	0.0174	0.9509	6.2279
SPXCL	-0.0330%	0.0089	0.3956	4.0898	-0.0356%	0.0156	0.7946	12.2255

From Table 2, it can be seen that, except for the weak peak characteristics of Shenzhen adult index in the epidemic situation, the six groups of data show obvious right deviation and peak in two stages, with obvious "peak and thick tail" distribution characteristics, which is non-normal distribution.

The Shanghai Composite Index and the Shenzhen Composite Index had lower standard deviations, volatility, and returns after the epidemic, while the S&P 500 had higher standard deviations, volatility, and yields.

4.3. Cointegration Test

4.3.1. Unit root test.

The ADF unit root test results show that at a significant level of 1%, the three original index series (SHI, SZI and SPX) are not stationary, while their first-order differences (SHICL, SZICL and SPXCL) and the opening returns (SHIOP, SZIOP and SPXOP) are stationary.The unit root test suggests that China and the US stock market index series are in long-term equilibrium.

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4.3.2. Johansen test.

The Close-to-close return is used here for analysis. In the test of the first and second stages, the original hypothesis cannot be rejected, and the three stock indexes have time trends, so model 3 and 4 are better than model 2. Therefore, in the two stages, the S&P 500 index, Shanghai Composite Index, and Shenzhen Composite Index do not cointegrate, and the Chinese and US stock markets do not have a long-term equilibrium relationship.

4.4. Return Spillover

This research tests the short-term price-leading relationship between the China and USA stock markets using Granger causality and the AIC and SC criteria to choose the appropriate lag order. All lag orders from 1 to 5 were examined for Granger causality because lag order considerably affects it. In the analysis, the asynchrony of the practice of the China and USA stock markets was also taken into account, and Granger causality test was carried out based on the Open-to-close return and Close-to-close return respectively. According to the SC criteria, the lag order 1 was selected as the main result, as shown in Table 3.

The Granger result of the Chinese stock market's close-to-close and open-to-close returns guides the US stock market's return before and during the pandemic. Before the epidemic, the China stock market's close-to-close return was the Major cause for the S&P 500's open-to-close return, which had a modest impact on the US stock market's opening price. The China stock market's close-to-close performance affects the S&P 500's open-to-close return after the pandemic.

Table 3: Granger test.

Null hypothesis	lags	Before COVID-19	In COVID-19
		P value	P value
SHICL is not the Granger cause of SPXOP	1	0.05765 .	0.002874 **
SHICL is not the Granger cause of SPXCL	1	0.6929	0.9093
SZICL is not the Granger cause of SPXOP	1	0.02958 *	0.01162 *
SZICL is not the Granger cause of SPXCL	1	0.4898	0.7893
SPXCL is not the Granger cause of SHIOP	1	2.363e-14 ***	1.732e-08 ***
SPXCL is not the Granger cause of SHICL	1	5.555e-11 ***	0.0002378 ***
SPXCL is not the Granger cause of SZIOP	1	4.373e-14 ***	6.115e-07 ***
SPXCL is not the Granger cause of SZICL	1	3.761e-10 ***	0.001259 **

4.5. Leverage Effect

In order to construct the GARCH family models, we first test the ARCH effect on several sets of data. According to the method of McLeod & Li (1983), we set the null hypothesis that the sequence is not suitable for the ARCH model. The test results show that the P values of the 12 groups of data are all less than 0.05, and there is ARCH effect. GARCH model can be established.

The TGARCH model uses the absolute value of the residual rather than the square term of the residual to capture the leverage effect, representing the leverage effect. If the leverage effect exists, γ should be negative. Therefore, the leverage effect test is same to verify the value and significance of TGARCH model.

There are 12 sets of data in the two stages before and after the COVID-19. TGARCH model is constructed for each set of data, and the results are tested γ as shown in Table 4.

The estimated γ of the two groups of returns of the Shanghai Composite Index and Shenzhen Composite Index are mostly significant negative, which indicates that there are significant leverage

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effects and asymmetric effects, and both have passed the autocorrelation McLeod & Li test and the normal Jarque-Bera test of residuals, and the TGARCH model has a good fitting effect.

Table 4: Gamma in TGARCH.

	Before COVID-19		In COVID-19	
	Gamma1	**P value**	**Gamma1**	**P value**
SHIOP	-2.77E-02	0.851879	-9.95E-02	1.03E-01
SHICL	-2.34E-02	7.39E-01	-1.28E-01	0.037984
SZIOP	-8.70E-02	0.26723	-8.15E-02	5.26E-01
SZICL	-3.41E-02	0.940294	-7.83E-02	9.46E-02
SPXOP	-2.71E-01	7.21E-07	-3.81E-01	1.21E-04
SPXCL	-3.44E-01	3.18E-14	-2.40E-01	8.39E-02

4.6. Volatility Spillover

This research analyses China-US stock market volatility spillover using the DCC-GARCH model. Considering the time difference between China and the US and the asynchronous opening and closing times, the conditional variance time-varying correlation coefficient of the Close-to-close return (SHICL, SZICL) of SSEC and SZSE and the Open-to-close return (SPXOP) of S&P 500 are used to investigate the volatility spillover effect of two stock markets. The conditional variance time-varying correlation coefficient of the Open-to-close return (SHIOP, SZIOP) of SSEC and SZSE and the Close-to-close return (SPXCL) of S&P 500 are employed for the volatility spillover effect of the US stock market. The empirical results are shown in Figure 2.

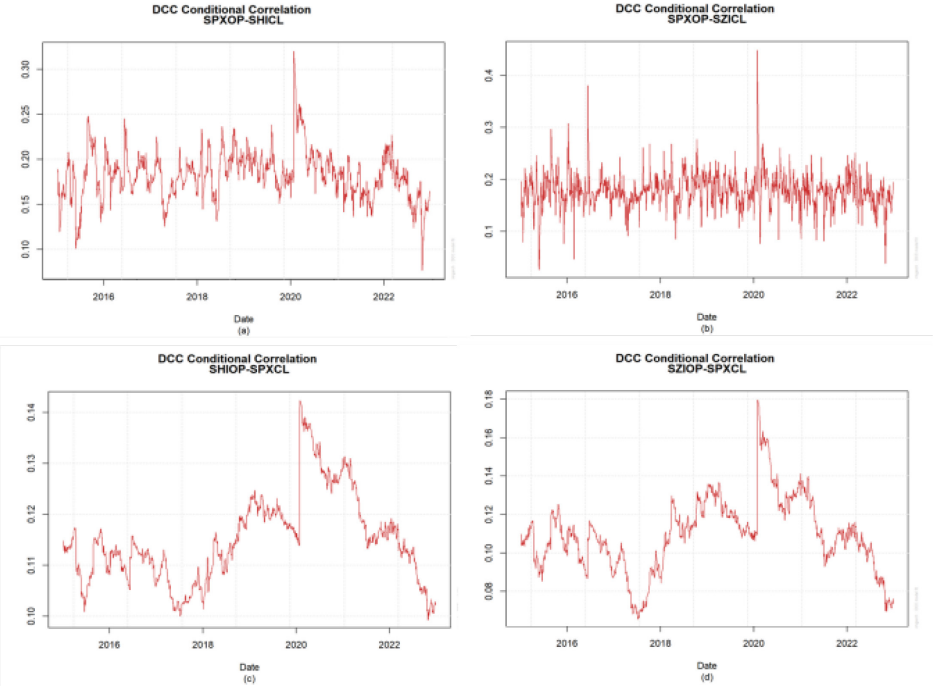

Figure 2: Conditional variance time-varying correlation coefficient.

4.7. Quantile Regression

In previous study, it is found that the USA stock market and the China stock market have a certain impact. In order to study the difference between the rise and fall of different stocks, this paper conducted a quantile regression on the Open-to-close return of the SSEC and Open-to-close return of

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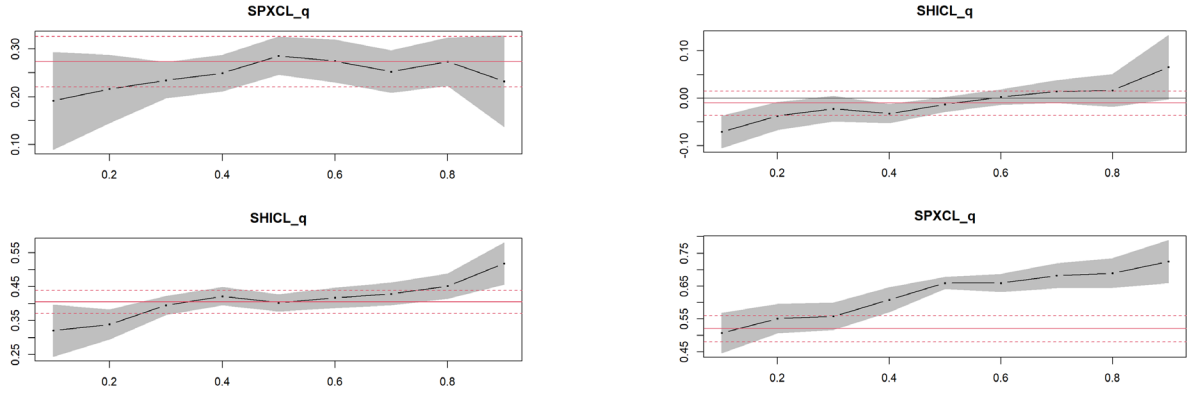
the S&P 500 Index, which can show the relationship between at different levels. This paper sets 9 specific quantiles, ranging from 0.1 to 0.9, to analyze the degree of difference affected:

$$SHIOP_t = \beta_0 + \beta_1 SPXCL_{t-1} + \beta_2 SHICL_{t-1} + \varepsilon_t \quad (6)$$

$$SPXOP_t = \beta_0 + \beta_1 SHICL_{t-1} + \beta_2 SPXCL_{t-1} + \varepsilon_t \quad (7)$$



(a) (b)

Figure 3: Quantile regression of SHIOP (left) and SPXOP.

Figures 3 shows the values of quantile regression coefficients. The gray shaded area represents the 95% confidence interval. According to the regression results, all regression coefficients are significant and have an overall upward trend. The Shanghai Composite Index is affected by the S&P 500 Index and its own return, and the higher the return, the greater the impact. The Open-to-close return of the S&P 500 index in the United States is the same. Higher own return is, greater the impact on the return from the Shanghai Composite Index. But in general, the Close-to-close return has a greater impact on the Open-to-close return of the index itself than other countries' stock markets.

5. Conclusion

This article selects daily market data from the Shanghai Composite Index, Shenzhen Composite Index, and S&P 500 Index in two stages and reaches numerous conclusions: First, the COVID-19 pandemic lowered China and US stock market returns and increased volatility. That barely affected stock market volatility. Second, China and US stock markets do not cointegrate or have a long-term equilibrium relationship. Finally, before COVID-19, the Granger result of the China stock market yield guides the USA stock market return. Fourth, two markets' returns are asymmetric and leveraged. Sixth, bigger returns increase China-US stock market influence. Sixth, the volatility spillover effect of the Chinese stock market on the US stock market is rather strong, but the US-China volatility spillover effect is more stable.

The empirical results above allow us to evaluate the research hypothesis. Hypothesis 1 predicts no long-term co-movement between Chinese and American stock markets. Before and after the COVID-19 pandemic, the China and US financial markets had a strong link, which has increased. Despite the current trend of economic globalisation, the capital markets of China and the United States are still quite different, and the Chinese stock market is not fully representative of Chinese economic development, so hypothesis 1 is invalid. However, the short-term information transmission of the China and USA stock markets still brought linkage to the stock market fluctuations during the COVID-19 epidemic.

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For Hypothesis 2, during COVID-19, there was an obvious short-term interaction. After the epidemic, it was further strengthened. The impact of the COVID-19 epidemic had a direct impact on China investors, USA investors and world investors. The impact of psychological expectations and herding effects further amplified this influence which was reflected by fluctuation and strengthened the correlation between the China and USA stock markets. Although Sino-US trade is limited after the outbreak of the epidemic, its short-term relevance still exists.

Since the current world monetary system is still dominated by the US dollar, United States has a certain degree of dominance over the world currency, but US dollar may damage the interests of other countries without sufficient constraints. The consequences are global inflation, excess liquidity, and risk spread from the United States to the world, in which China's financial market will inevitably be affected by the American financial market, and this trend will become more and more obvious.

The conclusions of this study have the following policy implications:

First, China's financial market information disclosure system, market supervision system and laws and regulations are not complete. Compared with western developed countries, the information disclosure of listed companies in China is not perfect. In addition, China's stock market has not yet formed a systematic and complete regulatory system, which may lead to speculators evading market regulation. In the process of formulating market rules, the financial supervision department should also pay attention to the linkage the characteristics of information transmission to improve the supervision efficiency and reduce systemic risks.

International capital market risk communication needs improvement. The preceding causal test indicates a clear two-way causal relationship between the USA stock market and the China stock market. China's capital market is increasingly linked to the global economy due to globalisation and internationalisation. As a result, China should focus on the internal linkage between the domestic and the international capital market, and cooperate with prudent supervision to maintain the stability of the capital market.

References

[1] *McQueen,G.,V.VRoley.”Stock Price ,News ,and Business Condition”, Review of Financial Studies[J], 1993, 6,683-707*

[2] *Silvio Contessia1, Pierangelo De Pace, Johanna L.Francisc.” The cyclical properties of disaggregated capital flows”,Journal of International Money and Finance[J],2010, 32, 528-555*

[3] *Dong Xiuliang, Cao Fengqi. The Spillover effect of Domestic and foreign stock market volatility: An Empirical Study based on Multivariate GARCH Model [J]. Mathematical Statistics and Management, 2009,28 (06) : 1091-1099*

[4] *Zhang Bing, Fan Zhi-zhen, Li Xin-dan. Research on the co-movement of Chinese and American stock markets [J]. Economic Research, 2010, 11:141-151*

[5] *Rao Jianping, Wang bo, Tang Minghui. (2019). Research on the linkage between China and the US stock market before and after the trade war. Journal of Quantitative Economics, 36(04), 8-13.*

[6] *Stelios D. Bekiros. (2014). Contagion, decoupling and the spillover effects of the US financial crisis: Evidence from the BRIC markets. International Review of Financial Analysis, 33, 58-69.*

[7] *Kübra Akca, Serda Selin Ozturk. (2015). The Effect of 2008 Crisis on the Volatility Spillovers among Six Major Markets. International Review of Finance, 16(1), 169-178.*

[8] *Yudong Wang, Zhiyuan Pan, Chongfeng Wu. (2018). Volatility spillover from the US to international stock markets: A heterogeneous volatility spillover GARCH model. Journal of Forecasting, 37(3), 385-400.*