A Study on the Linkage of Shanghai, Shenzhen, and Hong Kong Stock Markets in the Context of the COVID-19

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Abstract—In this paper, we use the representative stock indices of Shanghai, Shenzhen, and Hongkong as the research objects and the daily closing prices of stock indices from January 2, 2019, to January 20, 2021, as the sample data, and employ Granger causality tests, impulse response function analysis and the construction of DCC-GARCH models to empirically study the dynamics of the linkage between Shanghai, Shenzhen, and Hong Kong markets in the context of the occurrence of the COVID-19. The findings show that, first, the mainland stock market returns are affected by the historical returns of the Hong Kong market. Second, the occurrence of the COVID-19 strengthens the Mainland-Hong Kong stock market linkage effect and prolonged the shock. Third, the occurrence of the COVID-19 increases the volatility correlation between Shanghai and Hong Kong markets and decreases the volatility correlation between Shenzhen and Hong Kong markets.

Keywords- yield; Impulse Response; DCC-GARCH

1. INTRODUCTION

The COVID-19 outbreak in late 2019 so far has not only posed a serious threat to human lives and health but also caused significant losses to the global economy. To contain the outbreak, quarantine measures have been gradually adopted across the globe, some economies have experienced brief shutdowns, and financial markets have been in a state of persistent depression for a while. Numerous stock market indices experienced persistent sharp declines starting in February 2020, followed by a slow recovery accompanied by strong linkages with frequent shocks.

In terms of the linkage relationship of stock markets, there may be some linkage between stock markets in different regions. Gu Yao and Lu Lina[1](2006) found that there is a significant spillover effect of the Hong Kong market on the Shanghai and Shenzhen markets in terms of returns and volatility, with the Shanghai market leading the Shenzhen market in terms of return and volatility information. Lu, X. and Zhao, Y.[2](2012) conclude empirically that the three

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markets of Shanghai and Shenzhen have linkage effects; and the correlation of the three markets has time-varying dynamic characteristics. Xu Yingmei[3] (2013) and others analyzed that before 2000, there was only a lower-tail correlation between Shanghai and Hong Kong markets, and after 2001, the linkage between the two markets was increasing. Zhang Shiyang[4] (2015) analyzed the linkage between Shanghai and Shenzhen markets as well as the dynamic correlation of short-term fluctuations for analysis. The results show that there is no linkage between Shanghai and Shenzhen stock markets in the long run, while the short-term linkage is increasing, and the correlation between the three markets shows time-varying characteristics. Li Yuan[5](2016) finds that both A-share and H-share stock returns are influenced by the Shanghai and Hong Kong stock markets, but the difference between A-share prices influenced by the two stock markets is not significant, and H-share prices are influenced by the Hong Kong stock market much stronger than the Shanghai stock market. Xian Jingchen[6] (2018) et al. find that the opening of Shanghai-Hong Kong Stock Connect increases the linkage between Shanghai and Hong Kong stock markets in the short term, while also causing shocks to the volatility of the two markets in the short term. The above-mentioned articles mostly analyze the linkage in the context of the opening of Shanghai-Hong Kong Stock Connect and Shenzhen-Hong Kong Stock Connect.

There are relatively few studies on the linkage effects of stock markets in the context of the COVID-19. Using global representative stock markets as the research object, Xivi Zhong and Yingli Wu[7](2020) selected the Shanghai Stock Exchange Index, the Dow Jones Index, and the Hang Seng Index from October 8, 2019, to April 24, 2020, for empirical analysis and found that: there is a long-term stable equilibrium relationship among the three major indices; the dynamic impact of the COVID-19 on global stock markets is persistent.

Analyzing the existing literature, we can find that there have been a lot of results on the linkage between Shanghai, Shenzhen, and Hong Kong stock markets, but most of these studies focus on the background of the opening of Shanghai-Hong Kong Stock Connect and Shenzhen-Hong Kong Stock Connect. Moreover, among the existing studies, either the selected sample interval is short, which cannot reflect the linkage between stock markets more comprehensively, or the method used is single, which lacks convincing power.

Therefore, this paper selects the period from January 2, 2019, to January 20, 2021, as the sample interval, and uses the daily closing prices of the Shanghai Stock Exchange Index, the Shenzhen Stock Exchange Index, and the Hang Seng Index, and employs Granger causality tests, impulse response function analysis, and the construction of DCC-GARCH models, etc. This paper intends to investigate the linkage between the changes in stock market returns in Shanghai, Shenzhen, and Hong Kong in the context of the new crown pneumonia epidemic, and the dynamic response to dynamic shocks.

2. STUDY DESIGN

2.1 Sample Selection and Data Sources

In this paper, the daily closing price data of the Shanghai Stock Exchange Index (SH), Shenzhen Stock Exchange Index (SZ), and Hang Seng Index (HK) are selected to represent the price movements of the three stock markets in Shanghai, Shenzhen and Hong Kong. Based on the

timing of the epidemic, the sample selected for the study is the daily closing price data from January 2, 2019, to January 20, 2021, and the final sample size is 487 after excluding the mismatched data between the Mainland and Hong Kong stock markets.

The epidemic did not attract much attention in the early stage, and from January 20, 2020, the news indicated that there was "human-to-human" transmission of Newcastle pneumonia, and a nationwide isolation policy was gradually started, which affected the stock market to a certain extent. To compare the linkage between Shanghai, Shenzhen, and Hong Kong stock markets in different periods, the sample data are divided into two phases: the first phase from January 2, 2019, to January 20, 2020; the second phase from January 21, 2020, to January 20, 2021.

2.2 Empirical Design

This paper first uses Granger causality to test the linkage between stock market returns, then uses impulse response function to study the impact of dynamic shocks on returns, and finally uses the DCC-GARCH model to portray the dynamic relationship between stock market volatilities in the three places.

2.3 Descriptive Statistics

The daily return series of stock indices are shown in Figure 1. As can be seen from the figure, the daily return series of each stock index shows a strong volatility clustering. The volatility trends of the daily return series of these three indexes are similar, and the volatility starts to strengthen after the outbreak of the COVID-19, among which the volatility of Hang Seng Index returns is stronger. Based on the overall analysis of the index return series trend, Shanghai, Shenzhen, and Hong Kong stock markets should have a certain degree of linkage during the sample period.

The descriptive statistics of the Shanghai(SH), Shenzhen(SZ), and Hong Kong(HK) stock market return series or the two stages are shown in Table I. The mean values of the returns of the three stock markets in the first stage are positive, with the Shenzhen returns significantly larger than the Hong Kong returns, and the Mainland stock market returns are more volatile. In the second stage, the mean values of returns of all three stock markets decreased to different degrees and the standard deviation of returns increased slightly, indicating that the occurrence of the new crown pneumonia made the stock market more volatile.

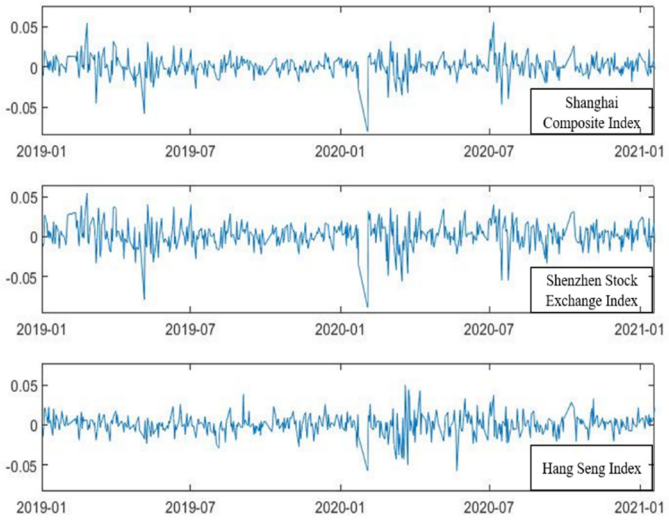

Figure 1. Time-series chart of daily returns of Shanghai, Shenzhen, and Hong Kong stock market indices.

TABLE I DESCRIPTIVE STATISTICS

	Stage I			Stage II		
	SH	**SZ**	**HK**	**SH**	**SZ**	**HK**
Mean	0.00086	0.00171	0.00048	0.00062	0.00133	0.00017
Median	0.00050	0.00057	0.00083	0.00111	0.00190	0.00102
Max	0.05449	0.05437	0.03825	0.05554	0.04008	0.04925
Min	-0.0575	-0.0786	-0.0289	-0.0804	-0.0883	-0.0572
Standard deviation	0.01134	0.01464	0.00978	0.01348	0.01726	0.01542
P-value	0.00000	0.00000	0.00306	0.00000	0.00000	0.00000

3. EMPIRICAL STUDIES

3.1 Granger causality test

Firstly, the smoothness tests are conducted on the returns of stock markets in both phases, and the original hypothesis is significantly rejected, i.e., the series of Shanghai, Shenzhen, and Hong Kong stock market returns in both phases are smooth series.

Granger tests are performed on the returns of the Shanghai Composite Index (SH), Shenzhen Stock Exchange Index (SZ), and Hang Seng Index (HK) during the sample period. The results are shown in Table II.

In stage I, at the 5% significance level, the SSE Composite Index return and the Hang Seng Index return are Granger causal to each other; the SZ Index return and the Hang Seng Index return are Granger causal to each other. In the stage II, at 10% significance, SZ Index returns are Granger causes of SH Index returns, and Hang Seng Index returns are Granger causes of SSE Composite Index and SZ Composite Index returns.

TABLE II GRANGER CAUSALITY TEST RESULTS

Stage	Original hypothesis	F-statistic	P
I	SH is not the reason for SZ's Granger	0.41828	0.5184
	SZ is not the reason for SH's Granger	0.31316	0.4183
	SH is not the reason for HK's Granger	4.77004	0.0299
	HK is not the reason for SH's Granger	4.95882	0.0269
	SZ is not the reason for HK's Granger	3.03584	0.0827
	HK is not the reason for SZ's Granger	3.91912	0.0488
II	SH is not the reason for SZ's Granger	1.22994	0.2990
	SZ is not the reason for SH's Granger	2.06259	0.0867
	SH is not the reason for HK's Granger	1.03237	0.3913
	HK is not the reason for SH's Granger	2.06081	0.0869
	SZ is not the reason for HK's Granger	0.78388	0.5367
	HK is not the reason for SZ's Granger	2.38426	0.0523

Figure 2. represents the transmission paths between indices before and after the COVID-19, respectively. In the context of the COVID-19, fluctuations in the SZ index and HS index cause fluctuations in the SH Index; fluctuations in the HS index also cause fluctuations in the SZ index. This COVID-19 outbreak first broke out in Mainland, and the SSE Composite and SZ index was the first to be hit, and it took some time before the outbreak broke out outside the Mainland, at which point the Hang Seng Index was affected.

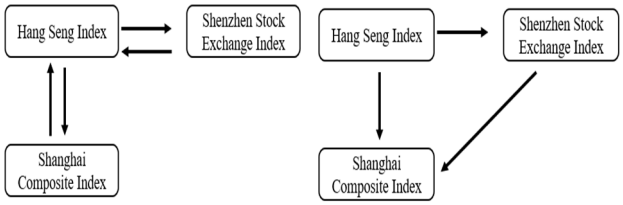

Figure 2. Risk transmission path.

3.2 Impulse Response Function Analysis

3.2.1 Impulse response function analysis of Shanghai and Shenzhen markets.

Analyzing Figure 3, we can find that there is a certain lag effect of the change in the SSE Composite Index return on the SZSI return before and after the COVID-19; the difference is that this lag effect will be stronger in the second stage.

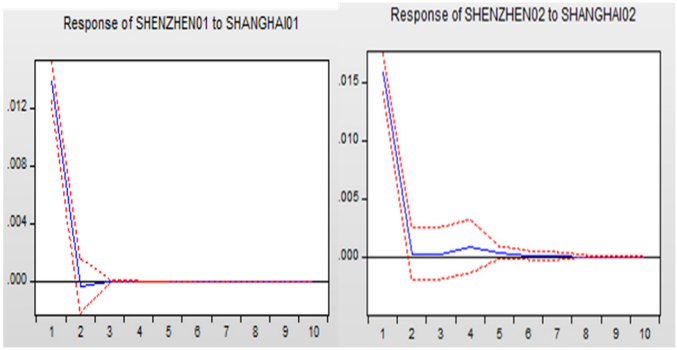

Figure 3. Plot of Shanghai market impulse response function to Shenzhen market.

From Figure 4, it can be seen that in the short term, the impact of the shock of SZSI return on the SSE Composite Index return is small, basically fluctuating around 0 up and down in a small range before tending to a stable state. After the occurrence of the new crown pneumonia epidemic, the impact of the change of SZSI return on the SSE Composite Index return is prolonged, there is a certain lag effect and the degree of impact has increased.

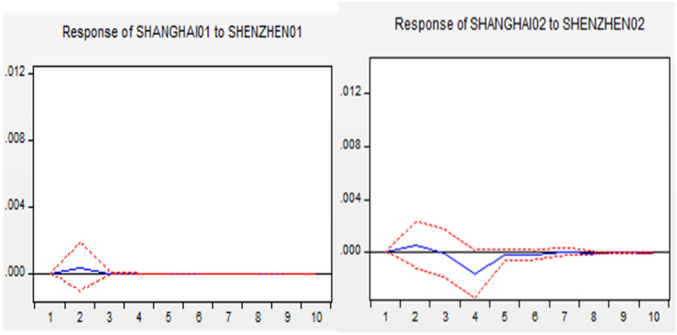

Figure 4. Plot of the impulse response function of Shenzhen market to Shanghai market.

3.2.2 Impulse response function analysis of Shanghai and Hong Kong markets.

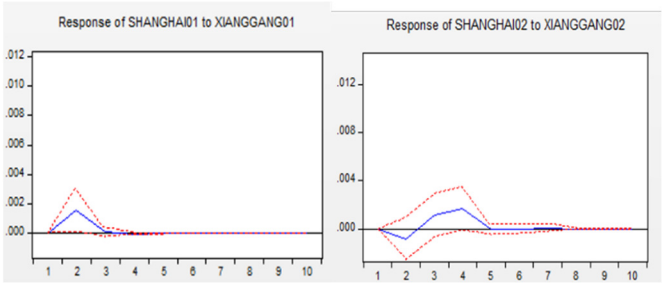

Figure 5. Plot of the impulse response function of Hong Kong market to Shanghai market.

The impulse response function plot of Shanghai vs. Hong Kong is similar in trend to the impulse response function plot of Shanghai vs. Shenzhen and is not repeatedly described here.

As can be seen in Figure 5, the impact of the shock to the Hang Seng Index return on the SSE Composite Index return is positive before the new crown pneumonia outbreak, which has a shorter and smaller impact. The outbreak of the COVID-19 outbreak prolongs the impact of the change in the Hang Seng Index return on the SSE Composite Index return, with a negative impact in the short term and a positive impact in the long term.

3.2.3 Impulse response function analysis of Shenzhen and Hong Kong markets.

The plot of the impulse response function of Shenzhen market to Hong Kong market is similar to the trend of impulse response function plot of Shanghai market to Shenzhen market, and the plot of the impulse response function of Hong Kong market to Shenzhen market is similar to the trend of impulse response function plot of Hong Kong market to Shanghai market, so we will not repeat the description here.

3.3 DCC-GARCH model

Next, the parameters of the DCC-GARCH model are estimated separately for the Shanghai and Shenzhen stock index returns, and the estimated results are shown in Table III .

In the first stage, the sum of α + β between the SSE Composite Index return series and the SZSI return series is extremely close to 1, which indicates that the correlation between Shanghai and Shenzhen market volatilities is high. The sum of α+β between the SZSI return series and the HSI return series is greater than the sum of α+β between the SSE Composite Index return series and the HSI return series, which indicates that the volatility correlation between the stock market of Shenzhen and Hong Kong is stronger than the volatility correlation between Shanghai and Hong Kong.

TABLE III PARAMETER ESTIMATION RESULTS OF THE DCC-GARCH MODEL

		α	β	α+β
	SH and SZ	0.0414***	0.9524***	0.9938
I	**SH and HK**	0.1375**	0.3189**	0.4564
	SZ and HK	0.0572*	0.8850***	0.9422
	SH and SZ	0.1438***	0.7720***	0.9158
II	**SH and HK**	0.1542**	0.6517**	0.8059
	SZ and HK	0.1982**	0.2154**	0.4136

In the second stage, the sum of α + β of the SSE Composite Index and SZSI return series decreases compared to the first stage, indicating that the outbreak of the new crown epidemic reduces the correlation between the volatilities of Shanghai and Shenzhen. There is a strange result here, the sum of α+β of the SSE Composite Index return series and the Hang Seng Index return series increases from 0.4564 in the first period to 0.8059 in the second period, while the

sum of α+β of the SZSI return series and the Hang Seng Index return series decreases from 0.9422 to 0.4136 in the second period. This means that the occurrence of the COVID-19 strengthens the correlation of volatility between Shanghai and Hong Kong and reduces the correlation of volatility between Shenzhen and Hong Kong.

4. CONCLUSION

The daily closing price data of the Shanghai Composite Index, Shenzhen Stock Exchange Index, and Hang Seng Index from January 2, 2019 to January 20, 2021 are divided into two phases with the impact of the COVID-19 as the general background.

First, impulse response function and variance decomposition analysis of the return series between Shanghai, Shenzhen and Hong Kong stock markets conclude: (1) the mainland stock market returns are affected by the historical returns of the Hong Kong market, (2) the occurrence of the new COVID-19 strengthens the linkage effect between the mainland and Hong Kong stock markets and prolongs the duration of the shock. Then, the DCC-GARCH model is further constructed to analyze the volatility correlation between the stock indices of Shanghai and Shenzhen markets, and it is found that the occurrence of the COVID-19 increases the volatility correlation between Shanghai and Hong Kong markets and decreases the volatility correlation between Shenzhen and Hong Kong markets.

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