An Empirical Study of Financial Risk Contagion Before and After the COVID-19

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Abstract. Since entering the 21st century, international exchanges have become more frequent, global financial markets have become increasingly complex, and the trend of instability and continuity of financial crisis has become more and more significant. The outbreak of a novel coronavirus pneumonia in early 2020 quickly swept the globe, whose impact on the global crisis has further strengthened the market's pessimistic expectations of the global economy. The market generally believes that the epidemic will cause a deep recession in the global economy, and its impact will far exceed the financial crisis. This paper uses VAR model and GARCH model to study whether there is financial risk contagion among the world's major economies during the period of covid-19. [1] The results show that the causality between the United States, Japan, Germany and Brazil in the epidemic period is deeper and more complex than that in the stationary period, which confirms that the exogenous impact of the epidemic has intensified the contagion effect of the financial crisis. Further impulse response analysis shows that after the epidemic, the epidemic has been a major factor in the financial crisis, but the causal relationship between China and other countries has not deepened. Further impulse response analysis shows that after the epidemic, the impact of various countries on the global stock index has deepened to varying degrees, which indicates that in the context of globalization, the relationship between the stock markets of various countries is increasingly close. Compared with the developed countries, the financial markets of developing countries are more fragile. Investors are less confident, and they are more likely to spread the crisis when there is a crisis. During the epidemic period, there is no contagion effect of financial risk between China and other countries, which is also the result of the success of China's strict capital control policy and epidemic prevention policy.

Keywords: Novel coronavirus pneumonia epidemic; financial crisis; financial risk contagion; VAR model; GARCH model

1 Introduction

In the present time of global economic integration and financial liberalization, the more active international capital has intensified the global financial instability, and various financial risks generated by exogenous or endogenous factors can be transmitted to other regions, countries

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and even every corner of the world in a complex way. We can know the domino effect of any problem in the fragile financial chain, which is the contagion of the financial crisis.

In early 2020, COVID-19 was first detected in Wuhan, and the World Health Organization declared the COVID-19 outbreak a global pandemic in March of the same year. Although the outbreak was effectively contained in China under a strong city closure policy by the Chinese government, the number of confirmed cases and deaths climbed across the country. The impact of the new crown epidemic on the global economy led to a general market perception that there was a risk of causing a deep global recession, the severity of which might even exceed that of the 2008 subprime mortgage crisis. To prevent a larger crash, the meltdown mechanism was triggered four times on March 9, 12, 16 and 18, 2020, when the closing price on the U.S. stock market fell by 7 percent, after having been triggered only once in 1997 since its implementation in 1988.[2] The Dow Jones Industrial Average and the S & P 500 Index fell 33% and 29%, respectively, from Dec. 31, 2019, to March 20, 2020, reported by the World Health Organization. [2] The FTSE100, the main UK index, fell by 24.80% [3]. Japan is down more than 20 percent from its peak in December 2019. [4]

In the final analysis, financial contagion is actually the information transmission of financial risk, in which the rate of return, volatility, skewness and kurtosis can be transmitted to a certain extent, but through the research of scholars, the effect of volatility is the most obvious [5] In theory, Masson systematically divides the transmission mechanism of crisis into "monsoon effect", "spillover effect" and "net contagion effect", which has been recognized by most academic researchers [6]

Nowadays, under the influence of the epidemic, the instability factors in financial markets in various countries have brought great risks. Especially for China, which is in the period of industrial transformation, the GDP growth rate is declining, which is a difficult challenge. This paper uses empirical analysis to study whether the financial risk transmission among countries in the world is aggravating under the epidemic situation, which is conducive to the understanding of the mechanism and influence of financial risk accumulation. At the same time, it can also explore and establish a mechanism for the early warning and treatment of financial risks applicable to China, which is of great significance to prevent the financial crisis in China.

2 Data pre-processing

2.1 Descriptive analysis

In order to study whether there is a contagion of financial risk among the world's major economies before and after the epidemic, this paper selects the major stock indices used by most scholars as the object of study, which can express the level of financial markets in their countries to some extent. Six indices of major economies were selected in terms of countries: Dow Jones in the United States, Shanghai Composite Index in China, Nikkei 225 in Tokyo, DAX in Germany, ibo in Brazil, and MSCI Global Index. Data from investing.com

The sample period in this paper covers the period from January 1, 2013 to May 1, 2021. Among them, the beginning of the date is chosen as January 1, 2013 in order not to overlap with the last financial crisis, i.e., the subprime mortgage crisis (2007-2009) and the subsequent

European debt crisis (2010-2012). Due to the different rules of trading markets in different regions, this paper chooses six sequences of trading days to facilitate the calculation, containing a total of 1,608 trading dates.

This research determines the name of the variable United States Dow Jones Index as USZ, China SSE Composite Index as CNZ, Japan Tokyo Nikkei 225 Index as JAZ, Germany DAX Index as GEZ, Brazil ibo Index as BRZ, MSCI Global Index as MSCI. Stock prices can reflect the volatility of the stock market, but the measure of the stock market is the return and risk, so the stock market index used by most scholars is chosen Yield, which is calculated as.

$$r_{i,t} = \ln p_{i,t} - \ln p_{i,t-1}$$

Where $r_{i,t}$ represents the logarithmic return of stock index i at date t, and $p_{i,t}$ represents the price of stock index i at date t. As shown in Table 1, the following are the descriptive statistics results and time series plots of the log returns of stock indices for each country. It can be seen that the skewness of the log return series for each country is less than 0 and the kurtosis is greater than 3, which is a characteristic of financial series that often exhibit a sharp peak followed by a tail. The JB statistic of each series rejects the original hypothesis and does not obey the normal distribution.

Table 1. Descriptive statistics of daily returns of each index

	RBRZ	RCNZ	RGEZ	RJAZ	RMSCI	RUSZ
Mean	0.041398	0.025825	0.042090	0.062767	0.044081	0.058050
Median	0.093725	0.065040	0.083241	0.087584	0.089340	0.106223
Maximum	13.02282	10.04528	10.41429	7.731370	8.058737	10.76433
Minimum	-15.99383	-10.62850	-13.05486	-8.252932	-9.996677	-13.84181
Std.Dev.	1.879504	1.561166	1.406225	1.494904	1.031058	1.231421
Skewness	-0.774041	-0.766973	-0.609537	-0.259684	-1.335140	-1.219271
Kurtosis	14.46570	10.40063	14.30122	7.004942	23.59750	28.10913
Jarque-Bera	8962.969	3824.813	8651.269	1092.044	28884.98	42613.28
Probability	0.00000	0.000000	0.000000	0.000000	0.000000	0.000000
Sum	66.52636	41.50134	67.63914	100.8671	70.83802	93.28645
SumS q.Dew	5673.251	3914.209	3175.814	3588.990	1707.307	2435.334

2.2 Elimination of conditional heteroskedasticity

Financial time series tend to have a volatility aggregation effect, meaning that when existing volatility is larger, subsequent volatility will be larger, and when existing volatility is smaller, subsequent volatility will be smaller. The GARCH model is of great value to scholars wishing

to study financial series, and is currently an effective way to eliminate conditional heteroskedasticity in financial series. the past information contained in this model is a good predictor of current period variance.

As shown in Table 2, after testing for smoothness, an ARMA model was established for the variables and the order of the model was determined using autocorrelation and bias correlation plots, where the model for rbrz was ARMA(1,1), the model for rcnz was ARMA(3,2), the model for rgez was ARMA(2,3), the model for rmsci was MA(3), the model for rjaz was MA(2), and the model for rusz model is ARMA(3,3). After modeling each variable separately, LM tests were performed on the residuals, and the results were as follows.

Table 2. ARMA model and LM test

Variables	ARMA model	ARCH-LM test			
		F value	Prob. F	Obs*R-squared	Prob. Chi-Square
rbrz	ARMA(1,1)	68.79435	0.0000	125.9792	0.0000
rcnz	ARMA(3,2)	908.9378	0.0000	878.6624	0.0000
rgez	ARMA(2,3)	4.414529	0.0122	8.809171	0.0122
rjaz	MA(2)	6848.584	0.0000	1511.904	0.0000
rmsci	MA(3)	13.24912	0.0000	26.15174	0.0000
rusz	ARMA(3,3)	25.58263	0.0000	49.80867	0.0000

As is shown in Table 3, it can be seen that the residuals of each series are passing the Lagrange multiplier test, and therefore have conditional heteroskedasticity, and the next step is to fit using the GARCH model. After using the most commonly used GARCH (1, 1), it is found that the fit is good, with all coefficients significant. The sum of ARCH and GARCH terms is less than 1, which is consistent with the model setting, and the sum of coefficients is close to 1, representing that the shocks at any time will be profound.

Table 3. GARCH model coefficients

Variables	ARCH factor	P-value	GARCH coefficient	P-value
rbrz	0.086757	0.0000	0.866245	0.0000
rcnz	0.096377	0.0000	0.894132	0.0000
rgez	0.091650	0.0000	0.887263	0.0000
rjaz	0.093057	0.0000	0.881665	0.0000
rmsci	0.136852	0.0000	0.841295	0.0000
rusz	0.146236	0.0000	0.821841	0.0000

The GARCH model established for these six series was subjected to LM test and it was found that all accepted the original hypothesis, i.e., it represents a very good fit after the model, and after the fit each series no longer has ARCH effect. We use the variance series obtained after

GARCH modeling as the volatility of daily returns, i.e., second-order moments, to build a VAR model for further study.

To verify whether the epidemic poses a risk for financial crisis transmission, this paper defines January 1, 2013 to December 30, 2019 as the plateau period and December 31, 2019 to May 1, 2021 as the epidemic period, which is the date when China reports the first case of COVID-19 to the World Health Organization (WHO).[7] The focus of this chapter is not on the specific form of the utilized model, but rather on the Granger causality test and impulse response analysis.

3 Empirical analysis

3.1 Granger causality

As shown in Table 4, Granger causality test is performed for the smooth period, and out of 20 pairs of relationships between two pairs of five countries, of which the bolded part is significant at the level of 0.1, there are six pairs of causality. The results show that the U.S. is more closely related to all countries in the world and is more likely to spread financial risk when shocks occur due to the U.S. dollar as the world currency, where the U.S. has a two-way causal relationship with Germany, while there is only a one-way effect on Japan, and the two-way relationships for the BRICS countries all reject the original hypothesis. The association between developed economies continues to outweigh the relationship with emerging markets such as Brazil, a BRICS country. And as the world's two largest economies, there is still a close two-way causal relationship between China and the United States, indicating that the trade war initiated by the United States does not produce practical significance, and it is not wise to blindly seek to decouple China and the United States.

Table 4. Granger causality test in the steady state (Granger cause of behavior column)

	VCNZ	VBRZ	VGEZ	VJAZ	VUSZ
VCNZ		0.9382	0.1819	0.1739	**0.0000**
VBRZ	0.2136		0.8435	0.9887	0.3312
VGEZ	**0.0009**	0.9495		0.7633	**0.0000**
VJAZ	0.8861	0.1510	0.2467		**0.0000**
VUSZ	**0.0001**	0.2529	**0.0079**	0.2802	

As shown in Table 5, Granger causality test is conducted for the epidemic period, and there are 9 causal pairs out of 20 pairs of relationships between two pairs of five countries, of which the bolded part is significant at the level of 0.1. It is easy to see that the shock of the epidemic intensified the effect of financial crisis risk contagion among countries, especially the shock of developed countries on emerging markets is more closely affected according to the smooth period. As the first country to find the epidemic in China, Hubei province suffered huge economic losses in the early stage of the epidemic. However, with the strict control of the government and the active cooperation of the people, the epidemic situation has been well controlled. Compared with the stationary period, the causal relationship with all countries,

whether developed or developing, accepts the original hypothesis that there is no contagion effect of financial crisis.

Table 5. Granger causality test for the epidemic period (Granger cause of behavior column)

	VCNZ	VBRZ	VGEZ	VJAZ	VUSZ
VCNZ		0.5341	0.9095	0.9785	0.5280
VBRZ	0.5116		**0.0979**	**0.0025**	**0.0000**
VGEZ	0.4880	**0.0000**		**0.0832**	0.1040
VJAZ	0.5869	0.1916	**0.0003**		0.1269
VUSZ	0.8309	**0.0000**	**0.0000**	**0.0147**	

3.2 Impulse Response Analysis

As shown in Figure 1, Looking at the shocks to the global stock index for each country, the left side shows the plateau period and the right side shows the epidemic period. In the smooth period, shocks are below 0.12 for both developed and developing countries, with mainly positive responses, and basically level off after period 4. The shocks to global stock indices are more complex across countries during the epidemic period, while the shocks are also longer, basically leveling off after period 10, and the positive and negative effects interact, suggesting that the epidemic strengthens the impact of stock markets across countries and increases the risk of financial crisis propagation. Although the shocks were strengthened to varying degrees across countries, the increase in shocks was greater in the stock markets of the BRICS countries, exemplified by Brazil, compared to developed markets. Emerging markets, which are both high-risk and high-return in nature, were also more affected in the face of the crisis due to their immature development, and investors' relative lack of confidence in the market made them more prone to herding effects.

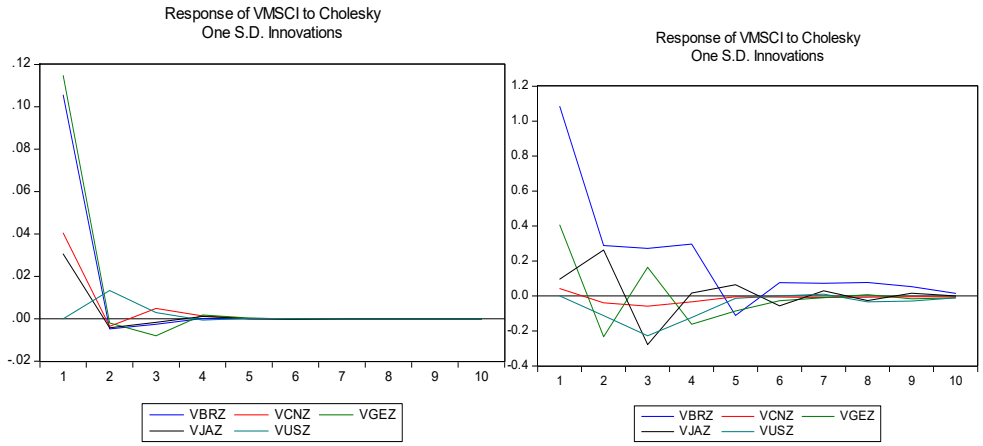

Fig 1. Impulse response analysis of countries to global indices before and after the outbreak

In the previous step of studying the shocks to the global index, it can be found from Figure 1 that there is no increase in China to the global stock index before and after the epidemic, and to confirm this, the shocks to China by country are further analyzed. As shown in Figure 2, In the stable period, the shocks are mainly positive, with the largest one from the U.S. to China, reaching 0.103202 in period 2, and all countries converge to 0 around period 5. The negative shocks increase relatively in the epidemic period, with the largest one from Brazil to China, reaching 0.070782 in period 1, while the shocks from the U.S. decrease significantly, with all countries converging to 0 after period 10. Overall, the absolute value of shocks did not change significantly, but the speed of restoring stability was slower, indicating that there were unstable factors in the global stock market during the epidemic, among which China was relatively independent and did not experience financial crisis contagion effects, but the shocks from Brazil did not decrease compared to the stable period, so the possibility of contagion from developing countries should be strictly prevented and controlled.

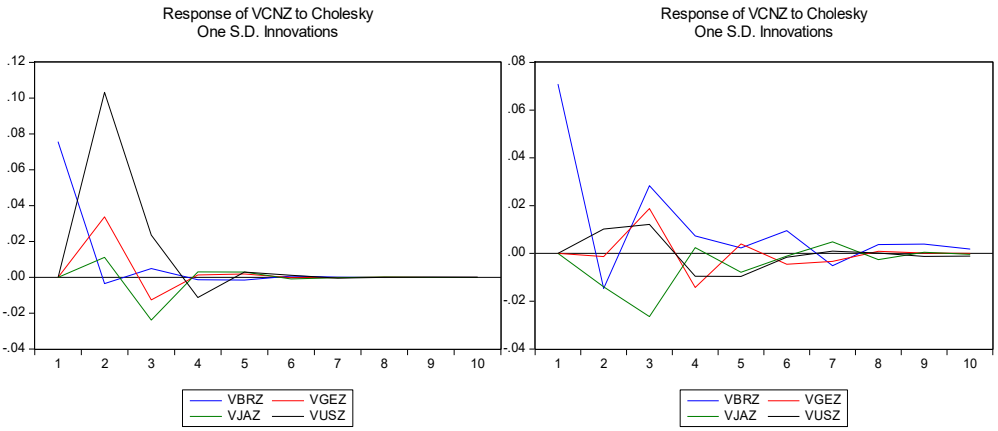

Figure 2. Impulse response analysis of countries to China before and after the outbreak

4 Conclusions and Recommendations

In this paper, under the premise that there is conditional heteroskedasticity in the stock market return series, a GARCH(1, 1) model is constructed to eliminate this feature, and the variance obtained from this model is used as the return volatility and then tested empirically. In order to demonstrate the contagion effect of financial crisis in each country, the following conclusions were obtained by constructing a VAR model and using Granger causality test and impulse response analysis. First, Granger causality test shows that the causal relationship between the US, Japan, Germany, and Brazil deepens during the epidemic period compared with the stable period, and the degree of impact is more complex, which confirms that the exogenous shock of the epidemic exacerbates the contagion effect of financial crisis, but the causal relationship between China. Second, further impulse response analysis reveals that the shocks to global stock indices deepened to different degrees in all countries after the epidemic, suggesting that financial crisis contagion is more likely to occur in today's globalized world where stock markets are more closely linked among countries. Developing countries are more vulnerable than developed countries in terms of financial markets and lack of investor confidence, which

makes it easier to transmit the crisis outward in case of a crisis.Third,the absence of financial risk contagion effects between China and other countries during this epidemic is also the result of the dual effect of the success of China's strict capital control policy and epidemic prevention policy under its institutional advantages.

Based on the conclusions, this paper makes the following recommendations: First, continue to give full play to our institutional advantages. On the one hand, to promote the development of the real economy and avoid excessive development of the virtual economy. On the other hand, continue to adopt strict controls on overseas speculative capital so as to fundamentally improve the resilience and avoid the contagion of financial risks. Secondly, we should pay attention to the regions with a high possibility of direct financial risk contagion to China, such as Brazil and other developing countries. In addition, we should be alert to the indirect contagion from developed countries to China through developing countries. Third, establish a systematic financial risk early warning mechanism to prepare for possible crises in advance and not to fight unprepared battles. For example, the international crude oil thunderstorm during this epidemic led to huge economic losses for our investors and damaged the credit of state-owned banks to some extent, generating a huge public opinion impact. Therefore, although our domestic market has been relatively stable, in the context of global economic instability, there is still the possibility of various events occurring overseas that could affect the stability of our financial sector.

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References

[1] Zhang Zhibo, Qi Zhongying. Test method and empirical analysis of contagion effect of financial crisis based on VAR model [J]. Journal of management engineering, 2005 (03): 115-120

[2] World Economic Forum. (2020). Mad March: how the stock market is being hit by COVID-19.https://www.weforum.org/agenda/2020/03/stock-market-volatility-coronavirus/.

[3] The Guardian. (2020). FTSE 100 suffers worst quarter since 1987 as Covid-19 recession looms - as it happened.

[4] Bloomberg. (2020). Perfect storm plunges Asia stocks into bear markets one by one.https://www.bloomberg.com/news/articles/2020-03-09/perfect-storm-is-plunging-asia-stocks-to-bear-markets-one-by-one.

[5] Wei Yanhua, Qi Shutian. Research on the contagion of financial crisis in Asian emerging markets: a test method based on Copula theory [J]. International financial research, 2008 (9): 39-43

[6] Masson P R. Contagion: Monsoonal Effects, Spillovers, and Jumps Between Multiple Equilibria [J]. Imf Working Papers, 2006.

[7] WHO. (2020b). Novel Coronavirus (2019-nCOV) Situation Report -1. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports.