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A Research on the Impact of Global Stock Market Co-movement during Covid-19 Epidemic

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Abstract

Covid-19 has brought huge fluctuations to world economy and such volatilityis evidently indicated by global stock market. In light of econometric hypotheses, this paper explained the comovement mechanism of global stock markets, made descriptive statistical analysis to the market returns of sample countries with VAR and DCC-GARCH models, and examined the comovement of market returns. The result shows that stock market in Brazil was the most volatile among all sample countries. Meanwhile, after the outbreak, VIX and WTI's influence on dynamic correlation coefficients increased, showing a positive and significant impact and thereby strengthening the comovement of global stock markets.

Keywords: Covid-19 epidemic, global stock market, co-movement, DCC-GARCH model, return, descriptive statistics

1. Introduction

Covid-19 swept the entire globe in 2020, being highly contagious and difficult to contain. Epidemic prevention and control faces enormous challenge. Necessary isolation measures were taken in many countries to prevent a wide-scale outbreak. Such measures, however, has caused economic activities to grind to a halt. The stagnation that followed has caused immeasurable impact on financial markets (Xu & Pu, 2021, pp. 70-80). Greater risks in various markets, as well as the huge pressure on global financial system, have brought much fluctuation to the entire financial market (Ma, Guo & Shen, 2021, pp.22-40). China's GDP fell by 6.8% year-on-year in the 1st quarter of 2020. While the country's full-scale epidemic prevention measures have, to a certain extent, contributed to the recovery of its economy. World economy resurgence, however, still faces much uncertainty (Hong & Zhong, 2020, pp.4-13). As an indicator of the economy, stock markets in all countries experienced fluctuations of varying degrees at the outbreak of the epidemic while the fluctuation in one country has coupling effects on that of others (Wu, Zhu & Bai, 2020,pp.176-184). This paper studies the comovement of global stock market during the Covid-19 epidemic, and analyzes the changes of comovement before and after the outbreak, and do some research on the impact of global public health emergencies on the comovement of stock markets, aiming to provide crucial reference for taking scientific and rational economic measures by all governments.

1.1 Literature Review

It is well-known that any sudden event will have a lasting impact on the financial market. Some scholars analyzed the impact of "September 11" on the stock market of the United States and France, and showed that "September 11" had a greater impact on the stock market than previous emergencies (Maillet and Michel 2005,pp.597-610). And another scholaors estimated the equilibrium price of the financial market by using DDM model, and confirmed through VAR model and VECM model that the shock of unexpected events has a far-reaching impact on the market price and equilibrium price, and there is a long-term co-integration relationship between the two prices (Yang & Huang, 2011,pp.5-10). Some ecomomists introduced dummy variables to distinguish different types of emergencies, and studied the dynamic impact effect of emergencies on our financial market through VAR model, showing that different types of emergencies have different dynamic impact effects on the financial market, and their duration is different (Li, 2013,pp.137-148). Granger causality test shows that the risks caused by emergencies can be transmitted to the national debt market through the stock market and corporate bond market, and the stock market and corporate bond market can be transmitted to each other.

Some of the BRICS scholars studied the comovement between the stock markets of the countries, major developed countries and the US. On the basis of decomposition of stock market index series into different time scales by wavelet method, DCC model is adopted to analyze stock market comovemnet (Heikki et al.2014,pp.28). They used DCC, ADCC and GO-GARCH models for empirical analysis and verified that, without considering the impact of market crash, the co-mobility of Shanghai and Hong Kong stock markets did not increase significantly after the implementation of the Shanghai-Hong Kong Stock Connect, and the high co-mobility of the two markets was mainly attributed to the impact of market crash (Rufei et al. 2019,pp.50). And also used the EGARCH model to study the speculation on whether the interactivity of stock markets in the world would be enhanced under the background of financial globalization in the United States (C.L. Huang, 2020,pp.69). The analysis results showed that foreign direct investment and foreign asset investment were the main influencing factors for the interactivity of stock markets in the world before and after the subprime crisis in 2018.

Some scholars selected Shanghai Composite Index, Shenzhen Composite Index, Dow Jones Composite Index and Nasdaq Composite index from January 1, 2018 to November 8, 2018. Through GARCH (1, 1) model, they concluded that the US stock market had a lasting impact on the Chinese stock market. And have an impact on the future volatility of the Chinese stock market; The VAR model proves that US stocks have weak transmission effect on Chinese stocks. Through the Granger causality test, we can know that the Jones index and Nasdaq index are the reasons for the volatility of Shanghai Composite Index, and only the Dow Jones index is the reason for the volatility of Shenzhen Composite index (Zhang & Zhang, 2019, pp.166-168). The establishment of VAR model for causality analysis and impulse response analysis are also often used in literature on stock market comovement.

Zhong Xiwei is early scholar who studies the comovement of stock markets under the COVID-19 pandemic. By establishing a vector autoregressive model and applying its main functions to study the risk transmission path and the impact of dynamic shocks among Shanghai Composite Index, Dow Jones Index and Hang Seng Index during the COVID-19 pandemic, they provide insights into investment and regulation under the background of COVID-19 (Zhong &Wu, 2020.pp.29-37). There are other scholars studied the impact of COVID-19 on China's financial market from the perspective of global foreign exchange risk contagion (Fang & Jia, 2020, pp.1-15). They conducted a study on transnational risk transmission caused by COVID-19 based on the ESA method (Jiang, Wu & Wei, 2021, pp.3-13).

1.2 Some Key Problems for Studies

1) The shock of an emergency will have a profound impact on market prices and equilibrium prices.

2) Different types of emergencies have different dynamic impact effects on financial markets, and their duration is different.

3) Using different models for empirical analysis, it is verified that the higher comovement of the stock market is mainly attributed to the influence of the market crash when the influence of the market crash is not taken into account.

4) The establishment of a vector autoregressive model provides insight into investment and regulation in the context of COVID-19.

5) Discuss the impact of COVID-19 on financial markets from the perspective of global foreign exchange risk contagion.

The impact of COVID-19 has a significant impact on the correlation of global stock markets. Therefore, stock investors can make use of the hysteresis of the impact of uncertainty in the investment process to predict the change of the correlation of stock markets in advance, adjust their portfolios in advance, improve the effectiveness of investment strategies and reduce risk losses. At the same time, since the impact of uncertainty shocks on the co-activity of the stock market is different in the short and long term, differentiated decisions can be made according to different investment term preferences. In addition, stock investors should always pay attention to the development and changes of external financial markets, energy markets and national economic policies. When major uncertainty shocks occur in the market, investors should be alert and make timely investment responses to avoid potential risks.

1.3 Purpose of the Research and Significance

This study aims to explore the comovement of global stock market returns under the background of COVID-19 outbreak, explain the co-mobility mechanism of global stock market through different hypotheses, set models, select and process data, use VAR model and DCC-GARCH model to make descriptive statistical analysis of sample countries' market returns, and test the co-mobility of returns. Through the analysis of the experimental results, the stock market volatility of Brazil is the highest in the whole sample. After the epidemic, the influence

of VIX index and WTI on the dynamic correlation coefficient is enhanced, which has a significant positive impact on each dynamic correlation coefficient, enhancing the co-movement of the stock market

2. The Definition of Stock Market Comovement and the Theory of Financial Crisis Contagion

2.1 The Definition of Stock Market Comovement

Most foreign literatures use the word "co-movement" to express the meaning of correlations. According to Dirk Baur(2004), “co-movement”probably comes from the verb commove, meaning to cause to shake violently. Furthermore, according to Dirk Baur(2004,pp.23-26), we can try to understand the connotation of associativity mathematically: suppose X= (x1,x2,... xn) is an n-dimensional vector if phi (x) = min(x 1... ,x n)Ix+>0, then vector x presents positive linkage; If phi (x) = max(x 1,... ,x n)Ix-<0, then vector x presents negative associativity. Ix+ (Ix-) is an indicator variable if all the elements of the vector X are positive (negative). The co-movement of stock market can be understood as the fluctuation of one stock market causes the fluctuation of one or several stock markets, which can be measured by stock price, stock trading volume and other real-time stock data.

2.2 The Theory of Financial Crisis Contagion

According to the financial crisis contagion theory, the transmission mechanism of financial market risk includes different effects based on investor behavior, namely herd effect, demonstration effect. First of all, "herd effect" investors often decide their choices in the market according to the behavior of other investors. Investors have a herd mentality. A crisis in one country can lead to currency speculation in other markets, even if financial conditions are different, when investors do not have sufficient information to distinguish the underlying conditions in different markets. Secondly, "demonstration effect", also known as "wake up effect", when a financial crisis occurs in a country, if investors grasp relatively sufficient economic and financial information of the crisis occurring country and the invested country, investors will compare the invested country with the crisis occurring country, reevaluate the risk of the invested country and change their asset portfolio accordingly.

Some scholars used the traditional asset price expectation model of a variety of assets to explain the financial market contagion, pointing out that the pattern and severity of financial contagion depend on the market's sensitivity to shared macroeconomic risk factors and the amount of information asymmetry in each market (Chen. Yang &Ma 2006, pp.36-48), and another scholar studied the rational channels through which infection might be transmitted and highlighted the factors that make a country susceptible to infection (Diao, 2009,pp.44-45).And some used a simple multi-country asset pricing model to solve the main factors for contagion and demonstrated how crises can be transmitted across countries without assuming market immaturity or especially portfolio management rules (Lin &Wan, 2008, pp.52-53).

Therefore, from the perspective of financial crisis contagion, we can find that the price discovery of the financial system is not as effective as described in the traditional theory, mainly because the irrational behavior of investors plays a key role, which is mainly manifested in: The first is the attitude to risk, that is, the evaluation of loss is higher than the benefit, the second is the irrational treatment of expectations, and the third is the sensitivity to the framework of the problem.

2.3 The Comovement Mechanism of Global Stock Markets

Global stock markets comovement is the linkage and interplay of stock markets between different countries, the occurrence of which is explained as that for closely related global economic entities, a change in one of the economic entities brings about varying degrees of change in other ones, the magnitude of which is reliant on the countries’ overall stage of development as well as the level of openness of their financial markets, etc. (Yang, Chen & Chen, 2020,65-81). Ongoing researches on the comovement of global stock markets have mainly two explanations for its mechanism. The economic base hypothesis believes that the fundamentals of the stock market are the main reasons for such comovement. Macroeconomic variables such as multilateral trade exchanges and foreign direct investment contribute to increasingly closer economic ties between countries. Meanwhile, the ever expanding opening-up of financial markets in various countries made possible by scientific and transportation breakthroughs also strengthened the comovement of global stock markets. Market contagion hypothesis, however, believes that the comovement of global stock markets brings about influence of various degrees as the result of international investors’ behaviors. The specific processes are shown as follows (see Diagram 1).

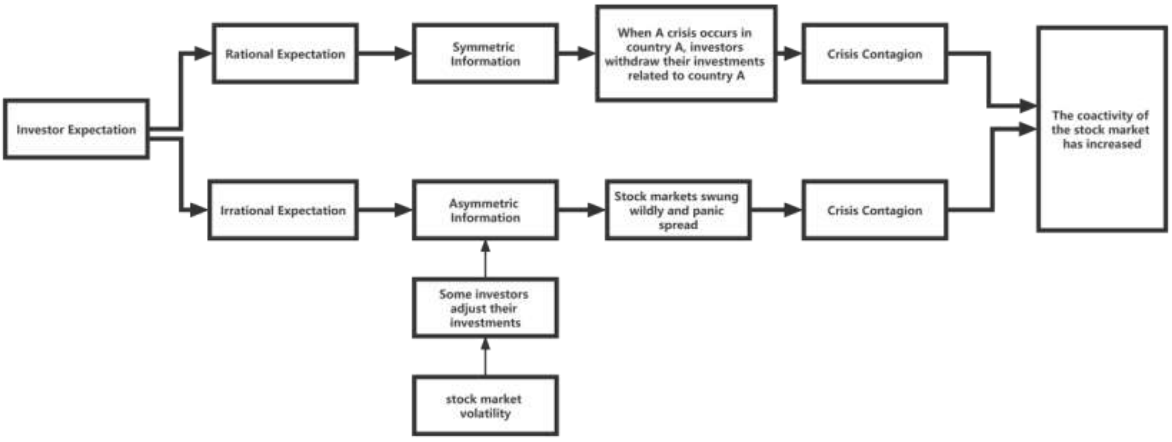

Diagram 1. Schematic Diagram of the Comovement of Global Stock Markets

As is shown in Diagram 1 the main reason for market contagion includes category investment and range preference which have little effect on the comovement though. Herd effect, or crowd effect, provides another explanation, claiming that the behavior consistent with the group made by individual investors under the influence of the group has greater impact on the comovement: investors trade in financial markets in their own ways with various degrees of rationality which is more likely to cause the stock price to deviate from its true value, thus affecting the market price of securities, making the whole market more volatile, and causing fluctuations in other stock markets in the meanwhile. Stock market comovement occurs as a result.

3. Experiment Method

3.1 Selection of the Analysis Models

VAR model and DCC-GARCH model are applied in this paper to examine the comovement of the returns. The VAR model, commonly used to analyze the correlation and the impact of random disturbances in time series problems, is adopted hereunder to analyze the comovement between variables. The model is expressed as:

$$X_t = S_1 Y_{t-1} + \ldots + S_n Y_{t-n} + P_1 Y_{t-1} + \ldots + P_n Y_{t-n} + \gamma_t Y \tag{1}$$

S_1 and P_1 of the formula represent respectively the parameter matrix to be estimated, and Y_1 the endogenous variable. Granger causality test is normally used then to analyze whether the lag value of the time series X has an effect on the time series Y in the two time series. The specific methods are as follows:

$$\begin{aligned} Y_t &= S_{10} + \sum_{i=1}^{m} S_{1i} Y_{t-1} + \gamma_{1t} \\ Y_t &= S_{20} + \sum_{i=1}^{m} S_{2i} Y_{t-1} + \sum_{j=1}^{m} P_{2j} Y_{t-1} + \gamma_{2t} \end{aligned} \tag{2}$$

S_{2i} and S_{li} are the lag coefficients, and P_{2j} the lag regression coefficient of X_t. Should P_{2j} be not all 0, it is then considered that the lag value of X has a significant impact on Y, and X is the Granger cause of Y. The DCC-GARCH model can measure the dynamic volatility correlation between time series data. The model assumes that the covariance matrix between time series is not constant, but changes with time, which fully reflects the volatility spillover relationship between variables. The model is expressed as:

$$r_t = \eta_t + e_t \tag{3}$$

r_t is the returns series matrix and e_t the residual series matrix, and the data is processed by the univariate GARCH model considering the correlation coefficient between volatility. The disturbance term in the GARCH model does not follow normal distribution pattern, and shows obvious peak and fat tails. Maximum likelihood estimation method is used in the study to calculate the dynamic correlation coefficient, and the software applied for calculation is WinRATS 8.0.

3.2 Data Selection and Processing

With the impact of COVID-19 epidemic on the comovement of global stock markets being the research focus and in order to make the dynamic correlation coefficient more intuitive, the paper chooses stock market indexes with extensive global influence in 9 sample countries from Jul. 1, 2018 to Dec. 31, 2020, and uses direct quotation method by taking the closing price of the US dollar against each sample country as the exchange rate indicator. The selected sample stock markets and the countries they belong to are shown in Table 1:

Table 1. Stock Market Indexes and Country Codes

Country	Stock Market Index	Country Code	Quantity
United States of America	S&P 500	USA	845
United Kingdom	FTSE100	UK	712
France	CAC40	FR	689
Australia	S&PAUX200	AU	536
Singapore	STI	SG	587
China	SZZS	CN	931
Malaysia	KLSE	MY	527
Russia	MOEX	RU	654
Brazil	IBOVESPA	BR	527

Table 1 shows the sample data included covers that both before and after the Covid-19 epidemic. Stock price in all sample markets fell sharply around March 2020 after the outbreak while domestic exchange rates in most developing countries depreciated accordingly. Since then, stock price in most countries began to rise again, followed by a gradual appreciation in exchange rate. A total of 6008 sets of data are obtained within this research with which the time series data of stock market closing prices are processed. The specific formula applied is as follows:

$$R_t = 100 * Ln(F_t / F_{t-1}) \tag{4}$$

Rt stands for the rate of return on a specific day, which is dependent on *Ft*, the closing price of the day, and F_{t-1}, the closing price of the day before. The paper applied EViews8 for econometric analysis, with which the data got processed.

4. Analysis of the Experiment Results

4.1 Descriptive Statistical Analysis

Tabulate data drafted upon the descriptive statistical analysis of stock market returns for sample countries made by EViews8 are shown in Table 2:

Table 2. The Overall Descriptive Statistics for all Sample Countries

CY	Ave	St.D.	df. Skew	df. Kurt	J-B Value
USA	0.0005	0.0132	-1.1394	23.6524	17705.42***
UK	-0.0001	0.0115	-1.3758	22.3541	15801.65***
FR	0.0001	0.0126	-1.3775	22.1018	15304.51***
AU	0.0001	0.0112	-1.4658	20.2369	12537.98***
SG	0.0001	0.0104	-0.0265	11.5965	7008.75***
CN	9.01E-05	0.0105	0.1247	8.5558	1260.78***
MY	0.0003	0.0121	-0.7435	16.2341	16776.03***
RU	0.0003	0.0110	-0.8312	15.9428	6894.35***
BR	0.0006	0.0178	-1.6738	23.9539	18480.02***

*** indicates significance at 1% level. As far as mean values are concerned, average returns in all developed countries (except for the UK) are all positive. However, only China shows a positive skew (above 0) while figures for the remaining countries are all negative (below 0). Standard deviations for all countries range between 0.01 and 0.02 with Brazil capturing the highest value, which means Brazil's stock market is the most volatile among all sample countries. As for kurtosis, all sample countries have values of above 5, indicating a peak state.

4.2 Comovement Test of the Returns

DCC-GARCH model is applied to measure the correlation between the stock markets of each sample country. By processing time series and maintaining details of the data, dynamic correlation coefficient is obtained through calculating standardized residuals. This paper selects VIX and the original price of WTI as the explanatory variables. Results of the dynamic correlation coefficient regression before and after the epidemic are shown in

Table 3.

Table 3. Regression Result Statistics for Dynamic Correlation Coefficients

CY	Before Covid-19 Outbreak		
	VIX	WTI	R-SQUARE
USA	0.0014***（0.0003）	0.2245（0.0003）	0.0109
UK	-0.0003（0.0005）	0.0495（0.1125）	0.0009
FR	0.0002（0.0004）	-0.0379（0.0798）	0.0007
AU	-0.0015***（0.0004）	0.0384（0.0879）	0.0193
SG	0.0002***（0.0003）	0.0185（0.0287）	0.0354
CN	0.0032***（0.0003）	0.0674（0.0599）	0.1465
MY	0.0003***（0.0003）	0.0321（0.0457）	0.0857
RU	0.0027***（0.0003）	0.0169（0.0748）	0.0918
BR	0.0063***（0.0008）	0.2378（0.1645）	0.0839
CY		After Covid-19 Outbreak	
	VIX	WTI	R-SQUARE
USA	0.0078***（0.0005）	0.0826***（0.0786）	0.3657
UK	0.0060***（0.0005）	0.1543（0.0995）	0.3901
FR	0.0045***（0.0005）	0.1302（0.0895）	02998
AU	0.0073***（0.0005）	0.2688***（0.0897）	0.5374
SG	0.0069***（0.0003）	0.0367（0.0346）	0.2958
CN	0.0007***（0.0001）	0.0704***（0.0201）	0.1892
MY	0.0022***（0.0003）	0.0680***（0.266）	0.2973
RU	0.0010***（0.0002）	0.0900**（0.0352）	0.3148
BR	0.0053***（0.0005）	-0.0838（0.0905）	0.3894

VIX stands for the market volatility index of the Chicago Board Options Exchange and WTI the crude oil futures price. As can be seen in Table 3, before the outbreak, VIX had a positive and significant comovement impact in seven countries. WTI, however, provided no evident explanations to the dynamic correlation coefficients in other countries. Small R^2 numbers, again, could hardly provide any possible interpretations. After the outbreak, both VIX and WTI showed strengthened impact on the dynamic correlation coefficients. VIX, more specifically, had significantly positive impact on all coefficients which increased as compared with those before the outbreak. This shows that investor sentiment had greater impact on stock market comovement during the epidemic. WTI, on the other hand, showed significant positive impact on the comovement of China, Australia, Russia and the United States, which, in turn, strengthened the comovement of the entire global stock market.

5. Conclusion and Suggestion

With well-established analysis models for data processing, the paper explained the comovement mechanism of global stock market and achieved a measure of fruitful results for global stock market comovement during the Covid-19 epidemic. According to the research conclusions, the following suggestions are put forward: 1)Investors should pay attention to the risk contagion in the stock market and adjust the allocation ratio of assets between markets. Global stock markets are linked. When a country's stock market has sudden risks, it is necessary to make a corresponding prediction for each market, adjust the proportion of funds timely and pay attention to diversification of investment. 2) Improve the awareness of risk prevention and prepare for long-term investment. Through the test of relevant models, it is proved that the dynamic impact of COVID-19 on the stock market has durability. In the background of China's good economic development prospects, A shares will become a bellwether of the financial market. Investors can be prepared for the proportion of short-term and long-term investments. Yet the research contains as well deficiencies due to a limitation in time and other conditions. Granger causality test, for example, could well be launched in future studies. In-depth analysis on asset allocation shall also be carried out in further researches so as to provide references for investments.

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