The Impact of COVID19 on Stock Market: a Study of Stock Market Interdependency

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ABSTRACT
Because of the Covid pandemic, the financial market, particularly the stock market, suffered a significant decline. The stock market peaked on February 19, 2020, just before the COVID-19 epidemic resulted in a precipitous decline in share prices. During the crisis, several sectors demonstrated a high degree of interdependence, which piqued our interest and prompted us to look into it further. As a result of the findings, the dependence structure between sectors is relatively similar during the pre-pandemic and post-pandemic periods, with relatively fewer linkages between sectors. The dependence of the industrial sector index has also risen and fallen in varying degrees over time. However, when the world is experiencing a COVID crisis, the performance between sectors is much more consistent, with certain sectors demonstrating stronger connections than others.

Keywords: *Stock market, Covid-19, Influential factors, GARCH models*

1. INTRODUCTION

COVID-19 was declared a pandemic by the World Health Organization (WHO) on March 11, 2020. [1]. The pandemic has had a substantial influence on the global economy [2]. It has had a profound effect on almost everyone's existence and way of life [3]. Almost no one has fled without being harmed. In addition to this disease, there is another pandemic of misinformation and deception that has spread fear and anxiety among the public [4]. Around 107 million people were affected by the pandemic, with around 2.3 million deaths, and the number of cases continues to climb daily. Since the outbreak of COVID-19, various governments have taken a range of necessary procedures to effectively limit the pandemic's spread, including industrial and commercial closures, as well as residential isolation. Economic development and corporate operations have been significantly impacted by the implementation of these rigorous regulations.

The world's financial markets are said to have taken an unprecedented tumble. On March 23, 2020, the S&P 500 Index plummeted 35% from its record high on February 18, 2020. Within days, the intensity of this historic collapse was likened to the 2008 financial crisis, 1987's Black Monday, and the October-November 1929 Great Depression[5]. In March 2020, the S&P 500 index in the United States plunged by a third, but the financial markets in the United Kingdom and Germany did worse. Returns on these two markets have reduced by 37% and 33%, respectively[6]. Brazil (48%) and Columbia, on the other hand, had the poorest returns on global stock markets (47%). Global stock markets, on the other hand, rebounded and began a bullish trend in April 2020. S&P 500 index climbed 29 percent and reached its August 2019 high [7]. May 2020 saw a rise of about 8 percent in the Shanghai Composite Index.

Additionally, the study explored companies and countries from other regions. In the aftermath of the pandemic, sectors such as healthcare, food, natural gas, and software did reasonably well, but the oil, real estate, entertainment, and hotel sectors saw sharp declines and significant volatility. Global financial crises did not have the same impact on Europe and America as COVID-19. COVID-19 disrupted communications between economies and provoked a financial crisis[9].

Not only are investors developing their investment portfolios throughout the pandemic but also regulatory agencies managing financial risks are dependent on understanding the stock market's interdependence structure. Recent research has uncovered a substantial amount of information about stock market

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interdependence[10,11]; in these studies, the GARCH model, Copula model, Granger causality test, and Dual Consumer Choice Model were used to investigate the interdependence structure between different sectors of the stock market in different nations.

Studies on the interdependence structure of the stock market have found that the study may be able to establish which sector is most important to the national economy, as well as provide investors with new opportunities to construct appropriate portfolios[12]. However, at the time of COVID-19, there is a dearth of studies on the stock sector's dependence structure. Investors have increasingly turned to diversification investing, in which assets are spread among stocks of publicly traded companies in a wide range of industries. Investing in closely related assets can cause investors to suffer financial losses. The COVID-19 event was the second severe economic and social recession since the 2008 global financial crisis. Understanding how and why various sectors behaved during the COVID-19 event is crucial guidance for investors looking to diversify during crisis periods such as COVID-19. We will examine the interconnectedness of the American stock market from the month of March 2020 to the month of June 2021, for instance.

2. METHODOLOGY

As an explanation of financial market volatility, Kodres and Pritsker proposed a rational expectations model. They observed that changes in investor portfolios can cause market shocks to spread across markets[13]. Investing in categories and investment choice can also lead to stock dependency, say Barberis et al.[14]. By copying other investors' moves, investors tend to rely too much on public opinion and ignore their own expertise. Stocks will gain more importance because of investors' proximity.

Presently, the majority of studies examining stock market dependence use linear assumptions or a specific model and parameters. We cannot examine the nonlinear relationship between variables using the Pearson correlation coefficient method, for example. Grander causality tests and multivariate GARCH models are only applicable in linear situations.

There are, however, a number of nonlinear scenarios on financial markets, according to recent research. Copula requires parameters to be selected and parameters to be set, which impacts the accuracy of the results. The choice of the model and parameter settings has a significant impact on the validity of the results. In order to calculate nonlinear dependence, a method that appears to exclude models and parameter settings must be developed. Through its application to financial markets, the entropy theory has led to the development of mutual information methods[15,16].

3. MUTUAL INFORMATION

An important method of quantifying how much one random variable reveals about another is the mutual information metric. Information about one random variable decreases uncertainty about the other. The degree of correlation information between two random variables is related to the amount of uncertainty that is reduced. A high level of correlation information indicates a large reduction, while a low degree of correlation information indicates a moderate reduction. An independent relationship is indicated by zero mutual information.

In a joint probability distribution PXY(x,y), the mutual information is calculated as I(X,Y) between two distinct variables X and Y [17]:

$$I(X;Y) = \sum_{x,y} P_{xy}(x,y)\log\frac{P_{xy(x,y)}}{P_X(x)P_Y(y)} = E_{PP_{xy}}\log\frac{P_{XY}}{P_X P_Y} \quad (1)$$

The marginal distribution, PX(x) and PY(y), are:

$PX_{(x)}=\sum_y PXY(x,y)$

$PY_{(y)}=\sum_x PXY(x,y)$

Although the emphasis is on discrete variables, the vast majority of findings from discrete variables can be applied to continuous variables as well.

Next, we must define entropy and conditional entropy in order to grasp the full implications of I(X;Y).

The greater the entropy of a random variable, the greater the degree of uncertainty associated with it. Shannon provided evidence for this claim. When PX(x) is uniform, it should be maximal, which means that it should increase in proportion to the number of possible values for X. It should also remain unchanged if the probabilities associated with various values of X are reordered. Shannon then demonstrated that entropy, a measure of uncertainty, is the only one that satisfies all of these criteria:

$$H(X) = -\sum_x P_X(x)\log P_x(x) = E_{P_x}\log P_X \quad (2)$$

In statistical terms, conditional entropy of a random variable X refers to its average uncertainty in relation to another random variable Y.

$$H(X|Y) = \sum_y P_{Y_{(y)}}\left[\sum_x P_{x|y}(x|y)\log\left(P_{x|y}(x|y)\right)\right] = E_{P_Y}\left[-E_{P_{X|Y}}\log P_{x|y}\right] \quad (3)$$

Where the conditional probability of x given y is $P_{X|Y}(x|y)(\equiv P_{XY}(x,y)/PY(y))$.

The mutual information equation may be stated using the definitions of H(X) and H(X|Y) as follows:

$$I(X;Y) = H(X) - H(X \mid Y) \quad (4)$$

Thus, the term "mut$_u$al information" refers to the anticipated reduction in the number of yes-or-no questions necessary to estimate X after viewing Y, or the

reduction in uncertainty surrounding variable X as a consequence. Although infinitely many questions are required to estimate a continuous variable, the number of yes-or-no questions required to estimate X before and after viewing Y may be limited, and this difference constitutes the mutual information.

4. DATA

Our data set spans the period December 11, 2019 to June 11, 2021, and includes the daily closing values of ten stock indexes. The S&P 500 Communication Services, S&P 500 Energy, S&P 500 Financials, S&P 500 Health Care, S&P 500 Industrials, S&P 500 Information Technology, S&P 500 Materials, S&P 500 Real Estates, S&P 500 Utilities, and S&P 500 Cons Staple are the indexes being considered. In the United States, the interval is divided into three phases based on case counts and COVID-19 development states: pre-pandemic era, pandemic era, and post-pandemic era The pre-pandemic phase is scheduled to begin on December 11, 2019 and end on March 11, 2020. From March 11th, 2020 to March 11th, 2021, the epidemic will last. From March 11th to June 11th, 2021, the post-pandemic phase will last. The data presented here is based on daily percent logarithmic returns. The means of the return series are near zero, while the standard deviations are approximately 1.5. The returns on all indexes exhibit significant negative asymmetry. The return kurtosis for all indices is approximately 10.5, which is greater than 3, indicating that their return rate distribution is more skewed than the normal distribution.

5. RESULTS AND DISCUSSION

First, we calculate the mutual information between ten industrial sector indices, each functioning as a node. Two nodes are weighted based on the mutual information created between their sector indices. The two industry sector indexes of the two nodes have a strong mutual information link, and there is also a strong correlation between them when the weight between the two nodes is high. However, when the weight between two nodes is low, the mutual information is low, and the correlation is weak.

The network of US industry sector stock market dependence is constructed by computing the mutual information between the returns of ten industry sector indexes and using the result as the edge weight.

5.1 Pre-pandemic period

Before the pandemic, the mutual information value between sectors was generally low, especially in the Cons Staples and the Real Estates sectors. There were the fewest correlations and connections between these two sectors, indicating that they are less dependent on other sectors. Businesses in these two sectors, the Cons Staples and the Real Estates sectors, are not like those in the Material sector. These firms have extensive commercial and industrial ties with firms in other sectors. It is very unlikely that the products and services provided by the enterprises in the preceding two sectors will change substantially during the calm period. This is because their aggregate demand is necessity for people's everyday lives, and there is hardly any change in enterprise profitability, so investors are not obliged to adjust their investment portfolios or make up for investment losses during the calm period. Currently, Cons Staples and Real Estates are less dependent on other sectors as the asset portfolio is difficult to move from one industry to another without modification; hence, these two sectors are not so dependent on other industries.

Materials and Industrial Sectors are highly interconnected and have a great deal of mutual information value. These two sectors always maintain a high degree of interdependence during pandemics and post-pandemic, as enterprises in the Materials sector provide sustainable raw materials and resources production, while enterprises in the Industrial sector produce capital goods used in manufacturing, and resource extraction, and construction. The situation is similar in both sectors, resulting in a high degree of dependency between them. In addition, when investing in one of the two sectors investors will unavoidably invest in the sectors with the same products and services. Limited energy and costs will encourage investors to behave this way, increasing the interdependence between the two sectors.

5.2 Pandemic period

The ten sectors' interconnectedness has usually improved throughout this period. This is consistent with the lessons learned from the 2008 financial crisis, during which stock market interconnectedness expanded considerably. During periods of market uncertainty or volatility, investors always pay more attention to the stock market's performance, boosting trading operations or converting investment aims; these activities strengthen the stock markets' dependency on one another. It's worth mentioning that the Communication Services and Information Technology sectors are the most interlinked, while the Utilities and Industrial sectors are also significantly reliant on the Energy sector.

5.3 Post- pandemic period

Study results indicate that the interdependence between the ten measures has decreased dramatically in comparison to the period of pandemics, but remains more pronounced than in the calm period. It is noticeable that the dependency pattern of the post-pandemic period is similar to that of the calm period. In spite of the post-pandemic era, this study shows that stock market

performance and investor behavior have returned to pre-crisis levels.

5.4 Dependence Overview

Following this, for each period, every node in the industrial sector index network is evaluated based on its node strength (NS). Based on the formula below, node strength is a measure of the mutual information value of a sector index with all its peers:

$$NS_i = \sum W_{ij} \quad (5)$$

where Wij denotes the information shared between nodes I and j [18].

Using node strength to compare each sector during the calm, epidemic, and post-epidemic phases, it was determined that sector index dependence increases during the epidemic phase, while node strength decreases during the post-epidemic phase. This suggests that sector dependence is lower, but still greater than during the quiet period. During the three periods, industry maintained the highest node strength. However, consumer staples, which had the lowest node strength during the calm period, grew rapidly during the pandemic period, moving from the fifth to the first.

6. CONCLUSION

During December 11, 2019 to June 11, 2021, ten American stock sector indexes were selected for this study. During the development of COVID-19 in the United States, the entire sample was divided into three periods: tranquil, pandemic, and post-pandemic. The dynamics of the dependency structure are analyzed by computing the mutual information value between sectors over time using a sliding window approach. An overview of the findings is presented in this paper.

By comparison to the other two periods, the pandemic era has significantly increased the reliance on American industrial sector indices. While dependency decreases in the post-pandemic phase, it remains higher than in the calm phase, and the patterns of dependency in the post-pandemic phase are comparable with those in the calm phase.

In order to remain highly interdependent over the three decades of the Second Industrial and Materials Sectors, goods and services are provided by both sectors to each other. In the period following the pandemic period, investors focused their attention on the Communication Services sector, and at the same time, these investors also turned their attention to the Information Technology sector. The result was that the Financial sector became increasingly dependent on other sectors during the period of the pandemic. Since the Financial sector was heavily reliant on various industrial sectors during the pandemic period, there was a strong correlation between the Financial sector and other industries, especially utilities, construction, and healthcare.

REFERENCE

[1]Cucinotta, D., and Vanelli, M. (2020). WHO declares COVID-19 a pandemic. Acta Biomed. Ateneo Parm. 9, 157–160. doi: 10.23750/abm.v91i1.9397

[2]Shafi, M., Liu, J., and Ren, W. (2020). Impact of COVID-19 pandemic on micro, small, and medium-sized enterprises operating in Pakistan. Res. Glob. 2:100018. doi: 10.1016/j.resglo.2020.100018

[3]Aqeel, M., Shuja, k,. H., Abbas, J., and Ziapour, A. (2021). The influence of illness perception, anxiety, and depression disorders on student mental health during COVID-19 outbreak in Pakistan: a web-based cross sectional survey. Int. J. Hum. Rights Healthc. 14, 1–20. doi: 10.1108/IJHRH-10-2020-0095

[4]Koley, T. K., and Dhole, M. (2020). COVID-19 pandemic: The Deadly Coronavirus Outbreak in the 21st Century, 1st Edn. Oxfordshire: Routledge. doi: 10.4324/9781003095590

[5]Helppie McFall, B. (2011). Crash and wait? The impact of the great recession on the retirement plans of older Americans. Am. Econ. Rev. 101, 40–44. doi: 10.1257/aer.101.3.40

[6]Fernandes, N. (2020). Economic effects of coronavirus outbreak (COVID-19) on the world economy. doi: 10.2139/ssrn.3557504

[7]Cox, J., Greenwald, D. L., and Ludvigson, S. C. (2020). What explains the COVID-19 stock market. Natl. Bur. Econ. Res. doi: 10.3386/w27784

[8]M. Mazur, M. Dang, and M. Vega, "COVID-19 and the March 2020 stock market crash. evidence from S&P1500," Finance Research Letters, vol. 38, Article ID 101690, 2020.

[9]K. Shehzad, L. Xiaoxing, and H. Kazouz, "COVID-19's disasters are perilous than global financial crisis: a rumor or fact?" Finance Research Letters, vol. 36, Article ID 101669, 2020.

[10]K. Sukcharoen and D. J. Leatham, "Dependence and extreme correlation among US industry sectors," Studies in Economics and Finance, vol. 33, no. 1, pp. 26–49, 2016.

[11]J. Ji, C. Huang, Y. Cao, and S. Hu, "The network structure of Chinese finance market through the method of complex network and random matrix theory," Concurrency and Computation: Practice

and Experience, vol. 31, no. 9, Article ID e4877, 2019.

[12]J. G. Poynter, J. P. Winder, and T. Tai, “An analysis of co-movements in industrial sector indices over the last 30 years,” Review of Quantitative Finance and Accounting, vol. 44, no. 1, pp. 69–88, 2015.

[13]L. E. Kodres and M. Pritsker, “A rational expectations model of financial contagion,” The Journal of Finance, vol. 57, no. 2, pp. 769–799, 2002.

[14]N. Barberis, A. Shleifer, and J. Wurgler, “Comovement,” Journal of Financial Economics, vol. 75, no. 2, pp. 283–317, 2005.

[15]P. Fiedor, “Networks in financial markets based on the mutual information rate,” Physical Review E, vol. 89, no. 5, Article ID 052801, 2014.

[16]X. Wang and X. Hui, “Mutual information based analysis for the distribution of financial contagion in stock markets,” Discrete Dynamics in Nature and Society, vol. 2017, 13 pages, 2017.

[17]Cover, T.M. and Thomas, J.A. (1991). Elements of information theory. John Wiley & Sons, New York, NY.

[18]Xianbo Wu, Xiaofeng Hui, "The Impact of COVID-19 on the Dependence of Chinese Stock Market", Discrete Dynamics in Nature and Society, vol. 2021, Article ID 5588562, 11 pages, 2021.