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The Impact of the COVID-19 Pandemic on the Interconnectedness of Stocks in Bursa Malaysia

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Abstract Coronavirus (COVID-19) pandemic has a massive impact on economic growth and the stock market. Due to COVID-19's high transmission rate, a movement control order (MCO) was enforced by the Malaysian government in four stages. Consequently, this situation has affected the stability and the relationship of stocks listed on Bursa Malaysia. Thus, this study is motivated to investigate and visualize a correlation of securities listed on FTSE Bursa Malaysia KLCI by employing a network analysis approach. The limitation of correlation analysis is that it only provides the strength and direction of the association, which is not visually shown in the graph. As a result, the network analysis technique is used to highlight the correlations between the stocks. The input of the network is based on the rate of return of each stock. The data is divided into two parts. The first duration is the period before implementation of MCO which is from 17th December 2019 to 17th March 2020. The second duration is during four stages of MCO which cover from 18th March 2020 to 3rd May 2020. There are changes in the interconnection between stocks in which seventeen stocks increased in the correlation measure during MCO. The importance of stocks is determined by applying centrality measures to disclose a topological structure of a network. This study finds that the stock with the highest connectivity based on the degree centrality before the MCO was unable to maintain the status as the central hub during the MCO. The results can assist the market participant to strategize the asset allocation to obtain well diversified portfolio selection.

Keywords Bursa Malaysia; financial network; network analysis.

Mathematics Subject Classification 91B02

1 Introduction

The World Health Organization (WHO) declares the novel coronavirus (COVID-19) outbreak a global pandemic on 11th March 2020. The financial market worldwide becomes uncertain and more volatile

due to unprecedented situations caused by COVID-19 [1]. Since then, the COVID-19 outbreak affects Malaysian economic growth which the gross domestic product (GDP) dropped by a record low of −17.1%. As a response to the global pandemic, the Malaysian government implemented the four phases of the Movement Control Order (MCO) starting on the 8th March 2020 until the 12th May 2020. Consequently, Bursa Malaysia has sunk to its lowest in a decade. During the movement control order (MCO), as of 22nd April, the FTSE Bursa Malaysia KLCI (FBM KLCI) was down 19.62 points to 1,362.11. On Monday 20th April, after the prices of US crude oil futures dropped below zero for the first time in history, Bursa Malaysia's energy index fell by a considerably larger quantum.

Several empirical studies have shown that investors emotions influenced Malaysian stock returns [2–5]. The relationship between the returns of Malaysian stocks and investor feelings driven by fear of dangerous infectious diseases has been investigated and provided evidence that the SARS significantly affect the Malaysian stock market behaviour [6]. Chia *et al*. [7] investigated the impact of COVID-19 on the Malaysian stock market returns. The result showed that the number of daily new COVID-19 cases significantly impacted the returns on the indices. Instead of focusing on the stock return, investigating the interconnections between stocks in a financial market also plays a vital role. Financial interconnectedness is the network of credit exposures, trading links and other relationships as well as dependencies between financial representatives. Interconnectedness is important since it works as a channel for financial distress. The crash of a big interconnected body can disperse swiftly and broadly across the financial system, which can trigger global financial volatility [8].

According to [9–12], interconnectedness is studied to recognise a systemic risk and propagation of financial turbulence. Hence, measuring interconnectedness is of value and interest [13]. Besides, in the work of [14], the interconnectedness patterns assist investors to create portfolio strategies by applying the connectedness dynamics' direction and size. Besides, the information from interconnection also benefits policymakers in inventing policies to preserve and reinstate financial stability. Raddant and Kenett [15] examine the correlation of stock's returns that listed on trades in Australia, Brazil, China, Spain, France, the United Kingdom, Hong Kong, India, Japan, South Korea, the Netherlands, Singapore, United States, Canada, and Germany and visualised as a network. The examination aid to explain the financial system, its systemic structure, and elaborate potential infectious paths and transmission systems. To the author's best knowledge, no studies have been found investigating the impact of the interconnectedness of stock in Bursa Malaysia during the COVID-19 pandemic.

Correlation network analysis is useful to represent the linkages of securities that are traded in the stock market. The cross-correlations of stocks are essentially used as inputs to construct a financial network, as proposed in Mantegna's seminal work [16]. This approach is widely used with different purposes such as to investigate the changes of topological properties of the financial network [17-18], to identify the stocks to improve the portfolio strategy [19–21] and to examine the impact of the economic crisis on the stock market [22–24]. Recently, Aslam *et al.* [25] analysed the effects of COVID-19 on 56 global stock indices from 15th October 2019 to 7th August 2020 by using a correlation network method. They concluded that due to COVID-19, the network of global indices suggests a structural change in the form of node modifications, reduced connectedness, and significant variations in the network's topological features.

The application of correlation network in Bursa Malaysia can be found in several studies [26–31] in which used different types of data and duration. In addition, the effect of recession periods for conventional stocks listed on Bursa Malaysia can be found in seminal work of Lim *et al.* [29]. On other hand, there are studies took a different perspective by employing shariah-compliant stocks

to examine the global financial crisis's effect in the year 2008 [31-32]. Previous studies related to Malaysian's stock market provided evidence that the network topology has changed with respect to the different periods, different stocks, and different occasions.

Thus, this study aims to examine the impact of COVID-19 on FTSE Bursa Malaysia KLCI by using correlation network analysis. The contribution of this study is two-fold. Firstly, this paper contributes to the literature of the Malaysian financial market by examining the effect of the COVID-19 outbreak on Bursa Malaysia. Secondly, we contribute to the study, specifically investigating the changes in the stock linkages on Bursa Malaysia during the four phases of MCO.

The rest of the paper proceeds as follows: Section 2 presents the data, and Section 3 outlines the methodology. Section 4 presents the empirical results, and the final section concludes the study.

2 Data

This study uses the FTSE Bursa Malaysia KLCI, representing the top thirty stocks based on market capitalisation as depicted in Table 1. The data is collected from Eikon DataStream and this study used adjusted closing price for each stock. The adjusted price price is used because it reflects the impact of cash dividends, stock dividends or stock split that ensure the accuracy of the data. The government issued the Movement Control Order (MCO) to combat COVID-19, which went into effect on 18th March 2020, with the goal of effectively containing the outbreak and slowing the rate of transmission. Then, the duration of MCO is continue until 3rd May 2021 that consist of four phases as presented in the seminal work of [33].

Therefore, this study is motivated to used similar duration to see the impact of MCO in different perspectives in which form Malaysian stock market's condition. In order to observe an overview of the Malaysian market for short-term period, this study applies the data three months before the MCO takes place. Hence, the duration is divided into two; (i) three months before MCO and (ii) during MCO that consist of four phases as presented in Table 2. Therefore, the general comparisons of the analysis covered the whole four phases and before MCO.

3 Methodology

This section presents the procedure to construct a financial network of Bursa Malaysia. In brief, the method involves the computation of rate of return, correlation matrix, and distance matrix. The distance matrix is then the input for the minimum spanning tree in which employs the Kruskal algorithm. Next, the degree of centrality is used to identify the central hub of the network. This study uses RStudio for the computation and analysis.

3.1 Correlation Network Construction

Firstly, the adjusted closing price for each stock is converted to logarithmic return, $kk_i(t)$ as in Equation (1).

$$kk_i(t) = \ln \frac{ac_i(t)}{ac_i(t-1)} \tag{1}$$

where $ac_i(t)$ is the price of stock i at time t.

Table 1: The Number of Companies According to the Different Sectors in FTSE Bursa Malaysia KLCI

	Name	Mnemonic	Sector
1	Axiata Group Bhd	AXIA	Telecommunications & media
2	Cimb Group Holdings Bhd	CIMB	Financial services
3	Dialog Group Bhd	DIAL	Energy
4	Digi.Com Bhd	DSOM	Telecommunications & media
5	Genting Bhd	GENT	Consumer products & services
6	Genting Malaysia Bhd	GENM	Consumer products & services
7	Hap Seng Consolidated Bhd	HAPS	Industrial products & services
8	Hartalega Holdings Bhd	HTHB	Health care
9	Hong Leong Bank Bhd	HLBB	Financial services
10	Hong Leong Financial Group Bhd	HLCB	Financial services
11	IHH Healthcare Bhd	IHHH	Health care
12	IOI Corporation Bhd	IOIB	Plantation
13	KLCCP Stapled Group	KLCC	Real estate investment trusts
14	Kuala Lumpur Kepong Bhd	KLKK	Plantation
15	Malayan Banking Bhd	MBBM	Financial services
16	Maxis Bhd	MXSC	Telecommunications & media
17	Misc Bhd	MISC	Transportation & logistics
18	Nestle (Malaysia) Bhd	NESM	Consumer products & services
19	Petronas Chemicals Group Bhd	PCGB	Industrial products & services
20	Petronas Dagangan Bhd	PETR	Consumer products & services
21	Petronas Gas Bhd	PGAS	Utilities
22	PPB Group Bhd	PEPT	Consumer products & services
23	Press Metal Aluminium Holdings Bhd	PMET	Industrial products & services
24	Public Bank Bhd	PUBM	Financial services
25	RHB Bank Bhd	RHBC	Financial services
26	Sime Darby Bhd	SIME	Industrial products & services
27	Sime Darby Plantation Bhd	SIPL	Plantation
28	Telekom Malaysia Bhd	TLMM	Telecommunications & media
29	Tenaga Nasional Bhd	TENA	Utilities
30	Top Glove Corporation Bhd	TPGC	Health care

Table 2: Duration of the Data

Before Movement Control Order (MCO)	
3 months before MCO	17th December 2019 – 17th March 2020
During Movement Control Order (MCO)	
Phase 1	18th March 2020 – 31st March 2020
Phase 2	1st April 2020 – 14th April 2020
Phase 3	15th April 2020 – 28th April 2020
Phase 4	29th April 2020 – 3rd May 2020

Secondly, in order to measure the interconnectedness between the stocks, the logarithmic return $kk_i(t)$ is transformed into Pearson correlation coefficient kc_{ij}, as in Equation (2). The results will yield to 30×30 correlation matrix

$$kc_{ij} = \frac{\left\langle m_i m_j \right\rangle - \langle m_i \rangle \left\langle m_j \right\rangle}{\sqrt{\left(\left\langle m_i^2 \right\rangle - \langle m_i \rangle^2\right)\left(\left\langle m_j^2 \right\rangle - \left\langle m_j \right\rangle^2\right)}} \tag{2}$$

where i and j are stocks and $\langle m_i \rangle$ is the average of return of stock i.
Thirdly, the correlation matrix kc_{ij}, is translated into Euclidean distance matrix as in Equation (3).

$$kd_{ij} = \sqrt{1 - 2kc_{ij}} \tag{3}$$

where kd_{ij} is a distance between stock i and stock j.

Fourthly, the network is constructed based on a minimum spanning tree approach. The spanning tree contains nodes and edges in which the node represents a stock, and the edge represents a correlation between two stocks. The construction of correlation network is based on Kruskal's algorithm as proposed by [16]. Essentially, the distances are rank according to the smallest to the largest value. Then, the shortest distance between two stocks is selected as a starting point to construct a network. The link is added until all the stocks are included without creating a loop. According to Kruskal [34], the correlation network should have an N-1 number of links with minimum weight in the outcome.

3.2 Degree Centrality

According to [35], degree centrality is defined as the number of links a node has. If the node has more links, then the node is more central in the network. In this study, the node is represented by the stock in the FTSE Bursa Malaysia KLCI. Thus, the total linkages to a stock i can be measured by using a degree centrality. The computation of degree centrality is as follows:

$$K_{Deg}(i) = \frac{\sum_j^N hk_{ij}}{N-1} \tag{4}$$

where $hk_{ij} = 1$ if the link exists between stock i and stock j and 0 otherwise. The degree centrality metric is used to determine the most significant node (stock) based on the number of connected nodes. The crash of the higher degree stock gives a big impact on the other stocks that are directly related to them [36].

4 Results and Discussions

This section presents the correlation network of FTSE Bursa Malaysia KLCI for two periods that covers three months before the MCO and during the four phases of MCO.

4.1 Correlation Analysis

The correlation matrix of FTSE Bursa Malaysia KLCI for two periods are visualised as depicted in Figure 1 and Figure 2. Each security presents in horizontal and vertical axes. The positive correlation implies by the blue coloured dot and the negative correlation implies by the red coloured dot. Correlations between stocks, both positive and negative, are critical for market participants to comprehend the link between two stocks. Generally, investor aims to select the stocks that has negative correlation in which has the opposite direction that led to well-diversified portfolio. In other words, two distinct stocks that have a negative correlation with one another are beneficial for diversification since they may improve projected returns while lowering total portfolio risk [37].

In general, the comparison of the correlation before and during MCO is observed and portrayed as in Figure 1 and Figure 2. The analysis shows that the strength of the correlation changed for both durations. The correlogram presented helps the market participant to get an overview of the relationship and easier to identify which stocks has positive or negative relationship. If the investor only interested with negative correlation, he or she can identify the with red coloured dot from Figure 1 and Figure 2.

Figure 1 illustrates the correlogram for all thirty stocks for the three months before the MCO. Out of 900 pairs of a correlation matrix, 884 pairs have positive correlation, which is approximately 98%, while the rest is 1.7% has negative correlations. However, during the MCO, the total pairs with negative correlations increase to 4.65%, belonging to 42 pairs of correlations. Before the MCO, only eight stocks have negative correlation pairs: HTHB, TPGC, AXIA, MXSC, TLMM, NESM, IOIB, PCGB. In contrast, during the MCO, AXIA and PCGB, no longer have negative correlation pairs, but there exist thirteen additional stocks. The stocks are HLBB, SIME, DSOM, IHHH, MISC, HLCB, PMET, SIPL, RHBC, TENA, KLCC, PEPT, and PGAS. Surprisingly, during the MCO, SIME has the most stocks with a negative relationship with DSOM, HTHB, HLCB, MXCS, MISC, PGAS, and PMET. As a result of the correlation study, investors may choose which stocks to invest in to create an ideal portfolio.

Figure 3 demonstrates the comparison of average correlation of each stock before MCO and during MCO. Out of thirty stocks, seventeen stocks increased in correlation measure during the MCO: AXIA, TPGC, PCGB, MXSC, DIAL, PHAS, GENT, IOIB, KLKK, TENA, HTHB, HLCB, TLMM, PETR, PUBM, and CIMB. The increment in correlation values means more strength in the relationship for a particular stock to other stocks. This situation implies that the direction of fluctuation of stock's closing price same as others, and the stocks will have similar risk. It seems that the potential company has similar direction with the same risk, so it is not advisable to construct a portfolio based on these seventeen companies. Thus, in order to establish a well-diversified portfolio, the investor might pick the remaining firms as a prospective stock in the portfolio since these stocks have a weaker link to other stocks.

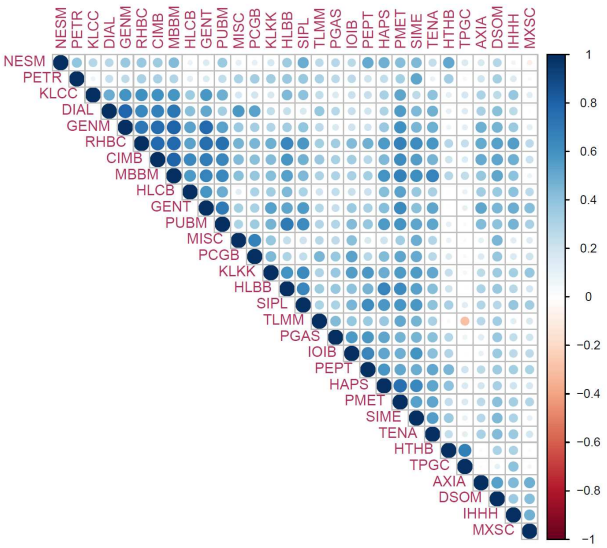

Figure 1: Correlogram of FTSE KLCI 3-months before MCO

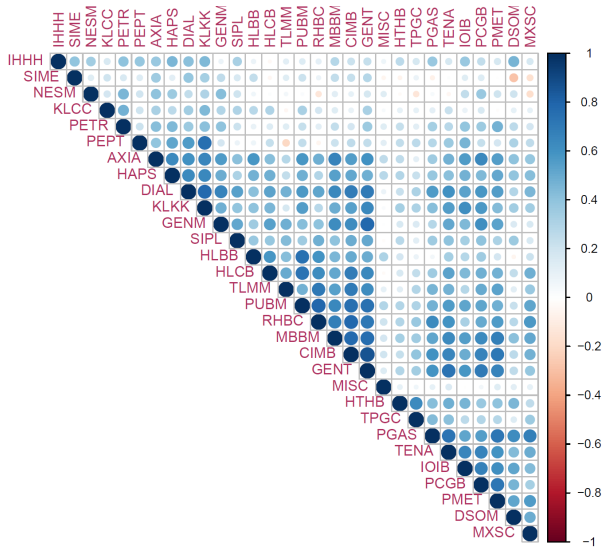

Figure 2: Correlogram of FTSE KLCI during four phases of MCO

4.2 Correlation Network of FTSE Bursa Malaysia KLCI

The correlation network method is used as a tool to visualise the correlation of stocks. Figure 4 shows the interconnectedness of top thirty largest stocks listed on Bursa Malaysia for three months before the MCO. The node's colour represents the sector belong to the stock and the lines (edges) connected between two stock is based on the correlation measure.

The results show that the stocks with the same sector tend to cluster together such as the plantation (yellow), financial services (chartreuse), and industrial product and services (royal blue). In general,

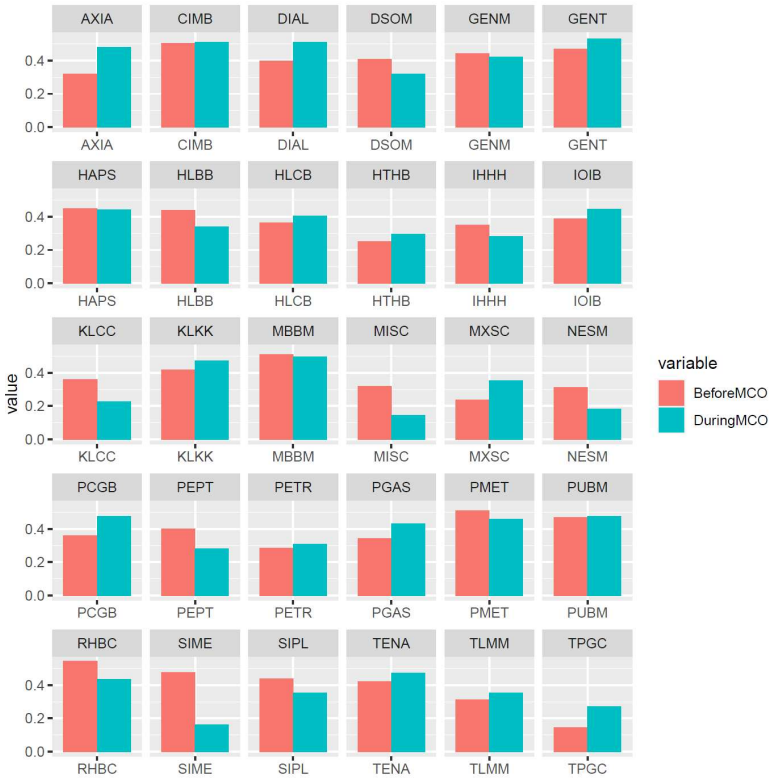

Figure 3: Average Cross-correlation for Each Stock

a clustering coefficient is a measure of the degree to which stocks in a graph tend to cluster together, thus, the stocks in the same cluster have a similar characteristics, for example, the direction of price fluctuation [38]. Besides, clustering also discloses the topological configuration of the network and information for each stock in the clusters. However, this study does not employ clustering coefficient analysis, the cluster in the network is determined based on the observation of the group form in the network.

As described by [17], if the stocks are in the same cluster, it indicates that each stock in mentioned sectors exhibits strong correlation and have same economic factors. Hence, the stocks have been moving together consistently through the study period. This result implies that the stocks have a similar direction and risk. Thus, investors should diversify their stocks to reduce risk as stated by [39], whereas using separate clusters or group in a portfolio helps for portfolio diversification and risk management. In view of the investor, the cluster form in the network gives a good insight to select the stocks before building a portfolio.

According to Figure 4, there are three nodes with high connectivity namely PMET (industrial product and services), SIPL (plantation), and PUBM (financial services). A cluster that dominated by PMET is connected to six stocks with different sectors: DIAL (energy), TENA (utilities), PGAS (utilities), TLMM (telecommunication and media), HAPS (industrial product and services) and PCGB (industrial product and services).

The interconnection between stocks during the four phases of MCO is illustrated in Figure 5. The result shows that stocks from the financial services sector tend to cluster together compared to that from other sectors which are scattered throughout the network. In terms of connectivity, GENT and

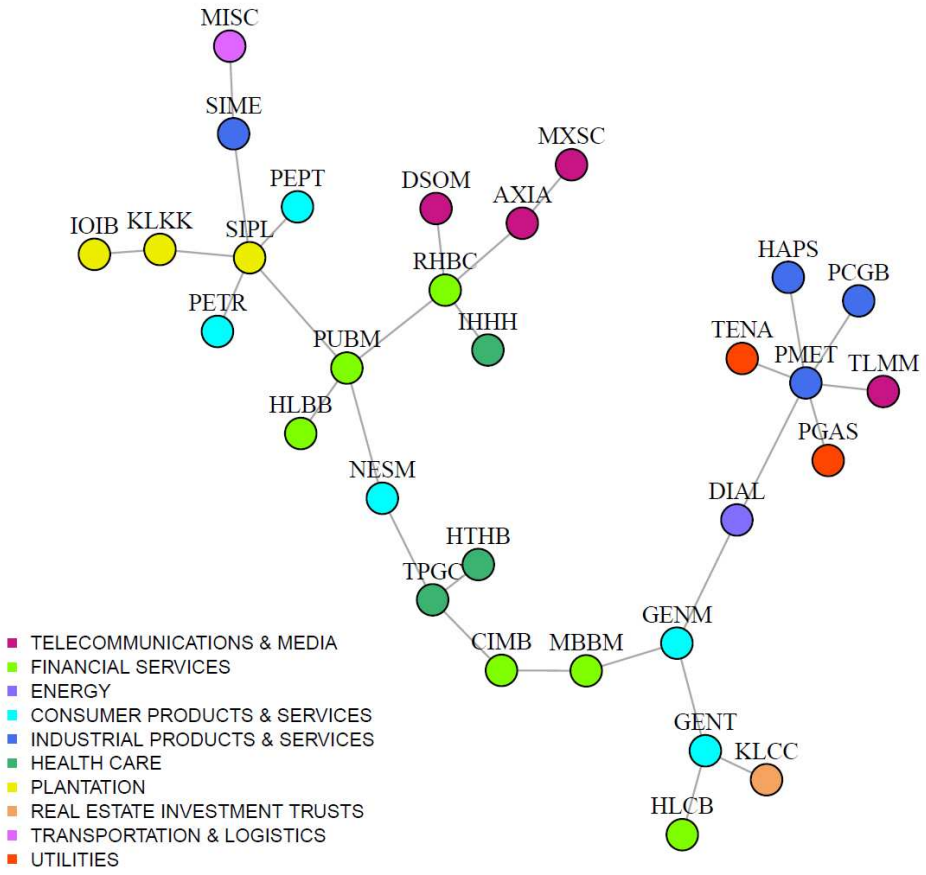

Figure 4: Correlation Network of FTSE Bursa Malaysia during Three Months before MCO

PGAS are considered as are considered major hub with four nodes. GENT is connected to GENM (consumer product and services), CIMB (financial services), TENA (utilities) and DIAL (energy). Meanwhile, PGAS is linked to TENA (utilities), MXSC (telecommunication and media), DSOM (telecommunication and media) and PMET (industrial product and services). As mentioned by [40], the fluctuation of individual stock price is tremendously interconnected with other stocks and also to the sector that belongs to the individual stock. Above all, this result portrays that every stock affects each other.

The market conditions can be evaluated based on the main hub in the network. [41] stated that the questions regarding the importance of nodes (stocks) are answered by implying centrality measures, which are the most fundamental and often employed measures to disclose a topological structure of a network. The decision making in selecting stocks for investment is generally gained by selecting a dominant (major hub) or non-dominant stock from the network. According to [42], a portfolio that comprises stocks that are positioned on the peripheral of the network has better diversification aptitude since subjected to less risk. Based on the findings, risk-taker investors are advised to invest in central stocks. However, investor who are risk-averse, are advised to invest in peripheral stocks on the network.

As shown in Figure 4 and Figure 5, the network structure of FTSE Bursa Malaysia KLCI has changed due to MCO's implementation by the Malaysian government. Generally, there are four clusters before MCO, but no outstanding cluster formed during MCO. The position of each node

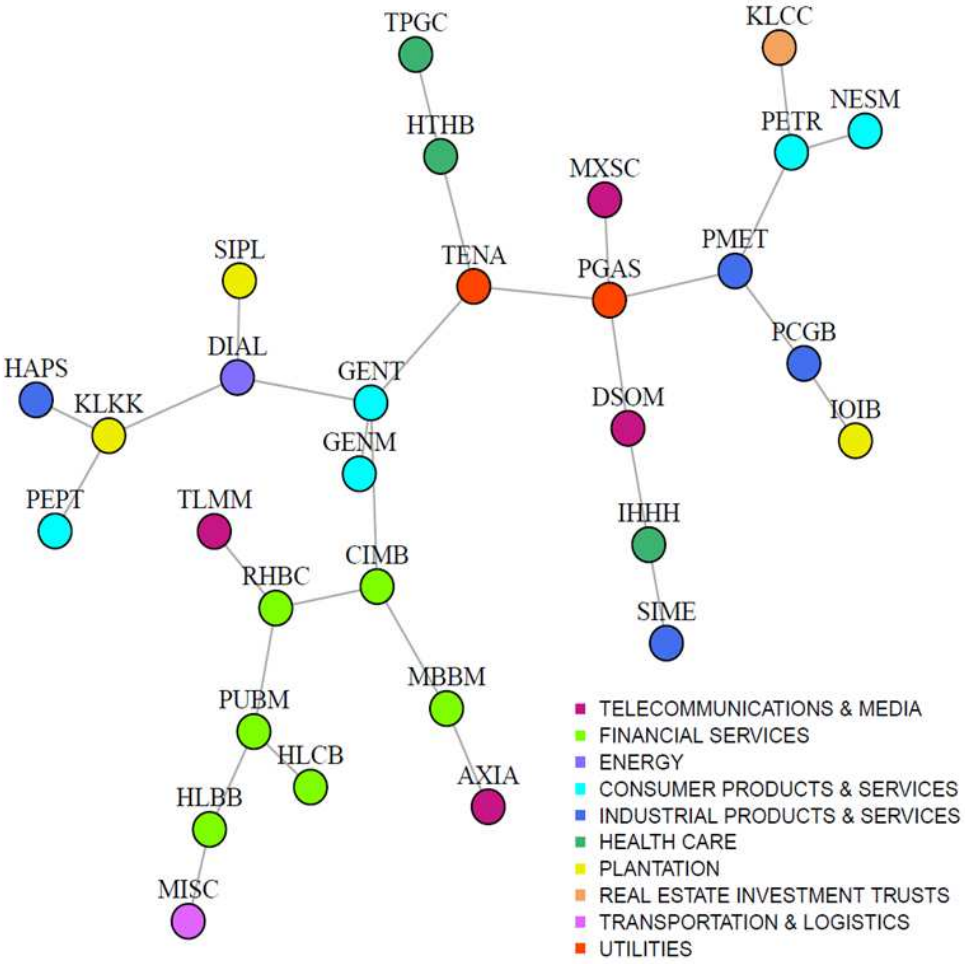

Figure 5: Correlation Network of FTSE Bursa Malaysia during the Four Phases of MCO

in the network is different in these two periods. For instances, CIMB linked to TPGC and MBBM before MCO, but CIMB linked to GENT, MBBM and RHBC during MCO. The core position of the stock in the network is not similar in both periods. The PMET, SIPL and PUBM are no longer core positions during MCO replaced by GENT and PGAS. Besides, the consumer product and services and the utilities sectors have become dominated sectors during MCO. The periphery position of the stocks on the network differs for both periods. Before MCO, the IOIB, MISC and MXCS located at the outermost of the network. Nevertheless, during the MCO period, the periphery spot belongs to MISC, AXIA, SIME, IOIB and TGPC.

4.3 Degree Centrality

Centrality measure is vital to access the behaviour of a network [10]. The higher the degree score means more links a stock set up with other stocks, hence, the stock be able to transmit risks to other stocks [36]. This study employs degree centrality to measure the linkages of stocks that connected to stock i. Figure 6 presents the degree centrality measure of stocks for the period before and during MCO. The number of connectivity reduces due to MCO. The highest value of degree centrality before

MCO is 0.2069 but drop to 0.1379 during MCO. However, the number of stocks with high connections during MCO increase compared to before MCO. Precisely, 46.6% of total stocks before MCO has more than one link and increased to 53.3% during MCO. Degree centrality provides an overview that the stock with high connection before MCO did not retain the position on the network during MCO, such as SIPL and TPGC. SIPL reduced from four connections to one connection during the pandemic as shows in Figure 4. While TPGC reduced from three connections to one connection during MCO as displays in Figure 5.

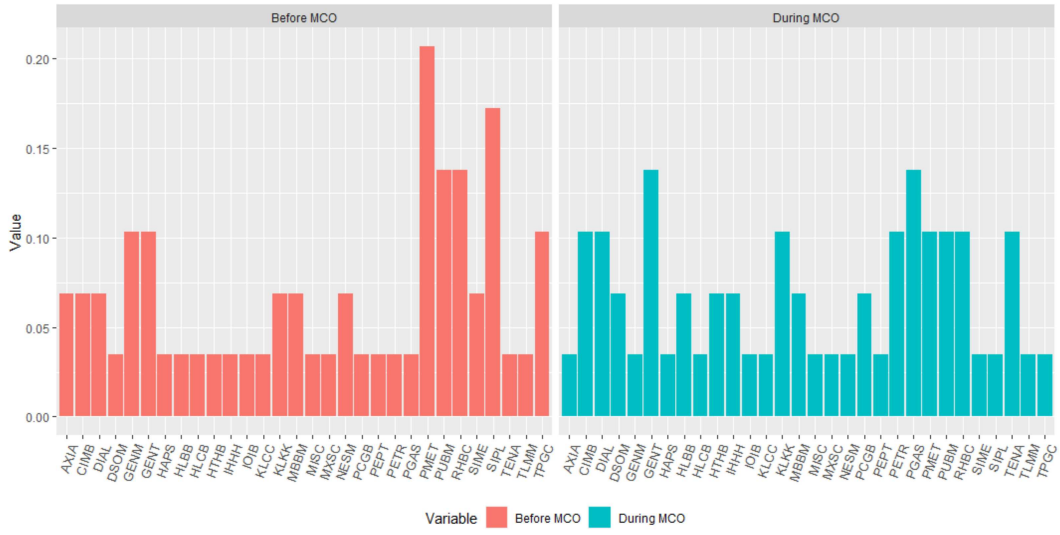

Figure 6: Degree centrality for FTSE Bursa Malaysia KLCI

5 Conclusions

At the beginning of COVID-19 pandemic outbreak, the Malaysian government implemented a movement control order in four phases as recommended by the World Health Organization (WHO). Since then, the Malaysian stock market has experienced the worst economic crisis and is still in the recovery phase. Therefore, this paper is motivated to examine the relationship between the thirty largest stocks based on Bursa Malaysia's market capitalisation due to the movement control order (MCO). The comparison of correlation is based on the three months before MCO and during the four phases of MCO. The findings reveal changes in the correlation between stocks in terms of direction and strength. Also, the structure of the correlation of the network differs for both periods. Specifically, the clusters formed before MCO disappear during MCO. This means that stocks do not group in similar pattern as before MCO. Besides, the stocks with high connectivity before MCO cannot maintain the position as the central stock during MCO. This gives information that during MCO stocks lose its connection, hence, the reduced connectivity will reduce the risk to invest and may obtain an optimal portfolio. Therefore, market participants can invest in non-dominant stock. The outcomes of this study assist market participants on portfolio stock's selection to optimize the return and to reduce the risk. The findings in this paper are subject to limitation in terms of coverage period, in which, this study has only covered the early stage of the MCO. Hence, further research is needed to account for the longer period to see the changes in the market and show on how the network will assist the asset allocation strategies.

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