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# The Impact of COVID-19 on Industrial Products and Services Sector of Bursa Malaysia by using Minimum Spanning Tree

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## ABSTRACT

The coronavirus (COVID-19) pandemic is causing broad concern and financial hardship for buyers, businesses, and communities worldwide. At the beginning of the pandemic, the Malaysian government implements the moving control order (MCO) to reduce infection through personal contact. The circumstance is changing rapidly with broad impacts, especially for the industrial sector. Thus, this paper is motivated to investigate the impact of COVID-19 on the industrial product and services sector of Bursa Malaysia. Explicitly, the changes of linkages among the companies in the industrial sector are examined. The data is based on the top 30 most capitalised stocks in the industrial products and services sector traded in Bursa Malaysia. The duration before the implementation of MCO covers from 17th December 2020 until 17th March 2020. Then, the four phases of MCO cover 18th March 2020 until 12th May 2020. The daily stock prices of the 30 stocks are utilised as inputs. A minimum spanning tree (MST) technique is used to demonstrate the linkages of the companies. The findings showed significant changes in the correlation of the companies before and during the MCO. Specifically, MYRS.KL, PMAS.KL, SCTH.KL, EKOV.KL, and FRKN.KL are the most prominent stocks three months prior to MCO. Throughout MCO, EKOV.KL and FRKN.KL remain the companies with the highest overall centrality scores, while GREA.KL, BOUS.KL, and DUFU.KL are added to the list.

**Keywords: Financial network, Bursa Malaysia, Minimum spanning tree**

## INTRODUCTION

Essentially, the network approach is used to visualise the interconnection between the entity in the stock market, such as minimum spanning tree , planar maximally graph (Nie & Song, 2018; Tumminello et al., 2005; Yan et al., 2015), and threshold network (Coletti & Murgia, 2016; Lee & Nobi, 2018; B. Li & Pi, 2018). However, the minimum spanning tree is used extensively in the financial market with different purposes such as to investigate the changes of topological properties of the financial network (Tabak et al., 2010; Yao & Memon, 2019), to identify the stocks to improve the portfolio strategy (Y. Li et al., 2018; Peralta & Zareei, 2016; Pozzi et al., 2013) and to examine the impact of economic crisis towards the stock market(Aswani, 2017; Bahaludin et al., 2019; Mahamood et al., 2019b; Memon et al., 2019; Memon & Yao, 2019). To date, the minimum spanning tree is used to explore the effect of the Coronavirus 2019 (COVID-19) pandemic on the financial market. For instance, (Zhang et al., 2020) investigate the effect of various stock market indices before and after the pandemic declaration, in which the World Health Organization (WHO) declared the outbreak in China a public health emergency of international concern (PHEIC) on 30 January 2020. Besides, Aslam et al. (Aslam et al., 2020) showed that the network characteristics changed in many forms due to the COVID-19 outbreak on world indices that consist of developed, emerging and frontier markets.

So far, the minimum spanning tree on the Malaysian stock market can be found in several literature works. The top hundred most capitalised stocks usually represent the Malaysian market's financial network, but with different periods (Bahaludin et al., 2019; Djauhari & Gan, 2014; Gan & Djauhari, 2012; Lim et al., 2018; Mahamood et al., 2019a; Sharif & Djauhari, 2012). The influence of recessions on conventional stocks listed on the Bursa Malaysia can be found in a seminal work by (Bahaludin et al., 2019). In addition, (Mahamood et al., 2019b) examined the effects of the global financial crisis in 2008 using shariah-compliant stocks from a specific viewpoint based on the minimum spanning tree. As mentioned earlier, the studies relating to the Malaysian stock market indicate that the network's topology has changed with different times, different stocks, and various occasions.

This study makes several contributions to financial network literature. Firstly, to the best of our knowledge, this paper is the first to examine the impact of COVID-19 on the Malaysian stock market using a minimum spanning tree approach. The impact is specifically focus on the implementation of moving control order (MCO) by Malaysian government. Prior to the emergence of new cases of COVID-19, the use of travel restrictions and quarantines was enacted, which caused a rise in the number of new cases. Once the rise was confirmed, the movement control order was implemented on March 18, 2020, prohibiting the operation of all businesses except those required for essential services and products. Secondly, this study fills a research gap by examining the implications of COVID-19 on the industrial product and services sector of Bursa Malaysia. Previous literature used all the sectors listed on Bursa Malaysia as in the top hundred stock, but do not provide a more in-depth insight for a specific industry. As reported on 29 January 2020, the industrial product and services sector has the largest number of constituents in which 217 listed in the main market of Bursa Malaysia. This sector's total market capitalisation is RM 198.42b and listed as a top-five sectorial high index return. Therefore, this paper examines the impact of COVID-19 on industrial product and services sector by using a minimum spanning tree approach. Besides, key stock is identified for the before and after the announcement of moving control order by Malaysian government that begin on 18 March 2020.

The rest of this paper is organised as follows. Section 2 present the data, section 3 explains the procedure to construct the minimum spanning and the centrality measure. The results and discussions elaborated in section 4. The concluding remarks is presented in section 5.

## DATA

This study uses the top 30 stocks based on market capitalisation from the industrial products and services sector traded in Bursa Malaysia as in Table **1**. The data is extracted from Datastream. This study will use the daily closing prices of the 30 companies three months before movement control order (MCO) and during the four phases of MCO. Before MCO, the duration is from 17$^{th}$ December 2019 until 17$^{th}$ March 2020 while the MCO period ranged from 18$^{th}$ March 2020 until 12$^{th}$ May 2020.

**Table 1:** List of companies

| No | Identifier (RIC) | Company Name | No | Identifier (RIC) | Company Name |
|---|---|---|---|---|---|
| 1 | MISC.KL | MISC Bhd | 16 | AIRA.KL | AirAsia Group Bhd |
| 2 | HAPS.KL | Hap Seng Consolidated Bhd | 17 | MYRS.KL | Malaysian Resources Corporation Bhd |
| 3 | SIME.KL | Sime Darby Bhd | 18 | GDEX.KL | GD Express Carrier Bhd |
| 4 | WPHB.KL | Westports Holdings Bhd | 19 | BPOT.KL | Bintulu Port Holdings Bhd |
| 5 | GAMU.KL | Gamuda Bhd | 20 | DUFU.KL | Dufu Technology Corp Bhd |
| 6 | MAHB.KL | Malaysia Airports Holdings Bhd | 21 | UEME.KL | UEM Edgenta Bhd |
| 7 | YINS.KL | Yinson Holdings Bhd | 22 | GHLS.KL | GHL Systems Bhd |
| 8 | IJMS.KL | IJM Corporation Bhd | 23 | EKOV.KL | Ekovest Bhd |
| 9 | GREA.KL | Greatech Technology Bhd | 24 | WIDA.KL | Widad Group Bhd |
| 10 | FRKN.KL | Frontken Corporation Bhd | 25 | BOUS.KL | Boustead Holdings Bhd |
| 11 | PMAS.KL | Pentamaster Corporation Bhd | 26 | FREN.SI | Frencken Group Ltd |
| 12 | HLIB.KL | Hong Leong Industries Bhd | 27 | SCTH.KL | Supercomnet Technologies Bhd |
| 13 | SCOG.KL | Sunway Construction Group Bhd | 28 | KREJ.KL | Kerjaya Prospek Group Bhd |
| 14 | MMCB.KL | MMC Corporation Bhd | 29 | BGRO.KL | Berjaya Corporation Bhd |
| 15 | LTKH.KL | Lingkaran Trans Kota Holdings Bhd | 30 | ATLA.KL | Atlan Holdings Bhd |

## METHODOLOGY

This subsection presents minimum spanning tree (MST) procedures, centrality measures, and principal component analysis (PCA).

*Minimum spanning tree procedures*

Firstly, the adjusted stock prices are converted into the logarithmic return. The return of stock *i*, $w_i(t)$, is calculated by substituting the stock's prices, $L_i(t)$, into the $w_i(t) = \ln \frac{L_i(t+1)}{L_i(t)}$ where $t = 1, 2, 3, ..., m$, where $m$ is the number of trading days and $i$ is a stock. Secondly, the relationship between two companies is measured by Pearson's Correlation Coefficient (PCC) as in equation (1).

$$LC_{ij} = \frac{\langle w_i w_j \rangle - \langle w_i \rangle \langle w_j \rangle}{\sqrt{(\langle w_i^2 \rangle - \langle w_i \rangle^2)(\langle w_j^2 \rangle - \langle w_j \rangle^2)}} \tag{1}$$

where $LC_{ij}$ is the correlation between stock $i$ and stock $j$, $w_i$ is the rate of return of stock $i$, $w_j$ is the rate of return of stock $j$, $\langle w_i \rangle$ is the mean of return of stock $i$, $\langle w_j \rangle$ is the mean of return of stock $j$, $\langle w_i \times w_j \rangle$ is the average of rate of return of stock $i$ times stock $j$, $\langle w_i^2 \rangle$ is the average of square of rate of return of stock $i$, and $\langle w_j^2 \rangle$ is the average of square of rate of return of stock $j$. The correlation matrix should be obtain $N \times N$ matrix in which $N$ is the total number of stocks. Then, the correlation matrix is transformed into distance matrix as in equation (2).

$$LD_{ij} = \sqrt{2(1 - LC_{ij})} \tag{2}$$

Finally, Kruskal's algorithm is applied to construct the minimum spanning tree(Kruskal, 1956). The distances are effectively ranked based on the smallest to the largest value. The shortest distance between two stocks is then chosen as a starting point to create a network. The connection is added until, without making a loop, all stocks are included. According to Kruskal (Kruskal, 1956), the correlation network should have an N-1 number of minimally weighted ties in the result.

*Centrality measures*

The centrality measures are used to collect information from a financial network, and the criteria are used to classify the main players based on various characteristics. According to Freeman (Freeman, 1977) , centrality measures assess each node's value in a network. This paper determines the prominent stocks based on degree, betweenness, closeness, and eigenvector centrality measures.
A degree centrality can determine the total linkages to a stock *i* computed as in equation (3).

$$D(i) = \frac{\sum_{j}^{N} wk_{ij}}{N-1} \tag{3}$$

where $wk_{ij} = 1$ if there was a correlation between stock *i* and stock *j* and 0 otherwise.

If a stock has the highest degree of centrality value on a financial network, it is considered the most valuable stock. It means a stock with the highest degree centrality value has the most connection with other stocks.

Betweenness centrality examines a node's tendency to act as a mediator or bridge in a network (Freeman, 1977). Betweenness centrality can be computed by using equation (4)
.

$$B(i) = \sum_{j<q} \frac{u_{jq}(i)}{u_{jq}} \tag{4}$$

where $u_{jq}(i)$ is the total shortest paths from node *j* to node *q* that go through node *i*. Meanwhile, $u_{jq}$ is the total minimum distances from *j* to *q*.

The proximity of vertices to other vertices on a network is determined by closeness centrality. The minimum distance between each vertex and all other vertices is determined(Freeman, 1977). Since it can reach other nodes through the shortest path, a node with the highest value has the potential to disperse information the fastest. The closeness centrality of stock *i* is signified as in equation (5)

$$C(i) = \left[ \sum_{j=1}^{N} h(i, j) \right]^{-1} \tag{5}$$

with $h(i, j)$ is the shortest path from node *i* to node *j*.

Eigenvector centrality considers a prominence node, which is a node connected to other significant nodes. (Bonacich, 1987). Since the node is connected to other crucial nodes, a node with the smallest number of neighbouring nodes can be called an essential node. Eigenvector centrality is expressed as follows:

$$Eig(i) = \lambda^{-1} \sum_{j=1}^{N} K_{ij} y_j \text{ for } i = 1, 2, ...N. \tag{6}$$

Besides, the expression can be written as $K_{ij} Eig(i) = \lambda Eig(i)$, where $K_{ij}$ is an adjacency matrix and $Eig(i)$ is an eigenvector of the leading eigenvalue, $\lambda$.

*Principal Component Analysis*

In overall, the key stock can be identified by using a principal component analysis (PCA) method. PCA eliminates a large complex matrix with the least amount of information loss (Jolliffe, 2002). Each node is evaluated based on the performance of total centrality measures based the PCA. The method for calculating the overall centrality measure begins with the construction of a matrix in which *N* denotes the total number of stocks and *M* denotes the number of centrality measures used. Next, a covariance matrix, *Q*, is set up. Then, eigenvector, $wp = (wp_1, wp_2, wp_3, ..., wp_M)$ of the maximum eigenvalue, $\theta_{\max}$, is determined using the formula $Qwp = \theta_{\max} wp$. The maximum eigenvalue is generally referred to as a first principal component where it contains the major percentage of variance (Jolliffe, 2002). The procedures end by taking the linear combination of the original centrality value, defined as, $O(i) = w_1 D(i) + w_2 B(i) + w_3 C(i) + w_4 Eig(i)$, where $D(i)$, $\mathrm{B}(i)$, $C(i)$ and $\mathrm{Eig}(i)$ are the respective degree, betweenness, closeness and eigenvector.

## RESULTS AND DISCUSSIONS

*Minimum spanning tree of industrial product and services*

The minimum spanning tree of the industrial product and services sector is presented in Figure 1. The node denoted as a stocks, and the link between two stock is based on the correlation. We observe that the stocks are clustered into four clustered that dominated by MYRS.KL, PMAS.KL, SCTH.KL and FRKN.KL. As can be seen in Figure 1, MYRS.KL acts as a central node before the MCO that connected to six nodes. The second highest connectivity on the network belongs to PMAS.KL with five connected stock ( DUFU.KL, MYRS.KL, SCTH.KL, FRKN.KL and EKOV.KL).

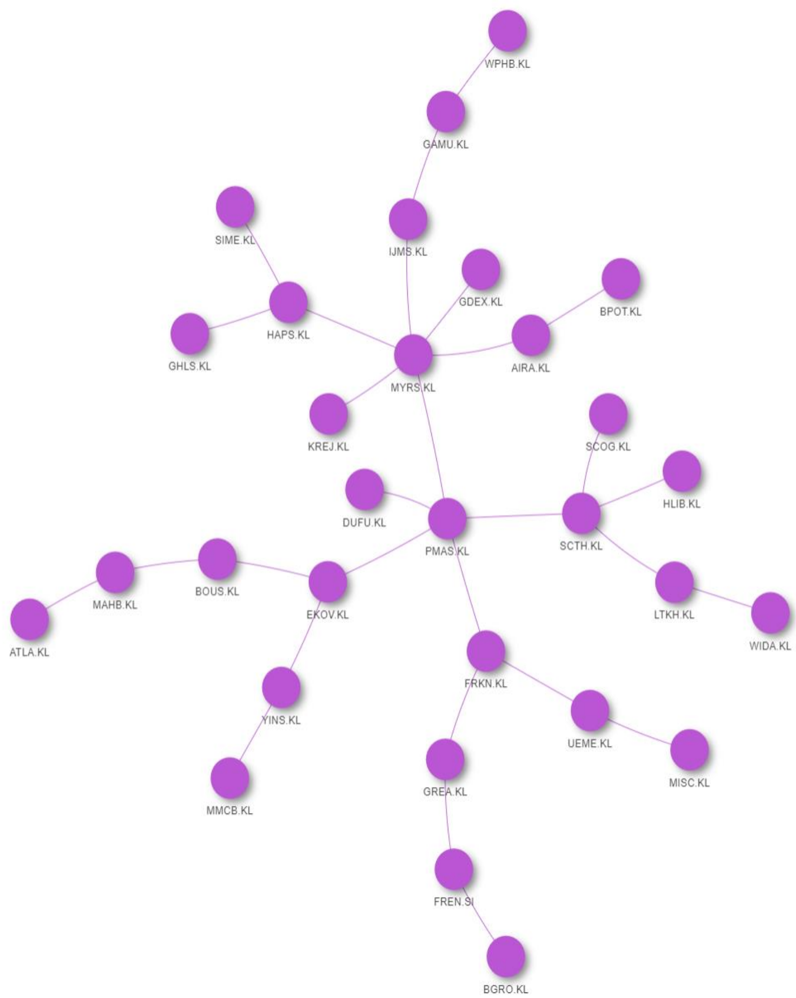


**Figure 1:** Minimum spanning tree of industrial product and services before MCO

During the MCO, the structure of MST changed in terms of stock connectivity as depicted in Figure 2. The stock with the most remarkable connection before the MCO was no longer in the same position afterwards. For example, the position of MYRS.KL as a central hub before the MCO is replaced by EKOV.KL during the MCO. There are six connections with MYRS.KL before MCO, and after MCO, there are only two connections. The connected stock for all nodes before and during MCO is different for the vast majority of the nodes.


**Figure 2:** Minimum spanning tree of industrial product and services during MCO

The financial network of the industrial products and services sector changed before and during the MCO. The critical difference is the structure of the minimum spanning tree. Before implementing MCO, the stocks are evenly distributed across a single central node, and they form a tree-like diagram. During the MCO, the stocks are found in various locations throughout the network. Moreover, these changes take place as a result of the number of clusters. Four clusters are seen in the network before the MCO, whereas five clusters are present during the MCO. The changes illustrate that the stocks are now arranged into five clusters rather than four clusters due to MCO. The MCO left with only two domain nodes: EKOV.KL and FRKN.KL. Additionally, before the MCO, other domain nodes include MYRS.KL, PMAS.KL, SCTH.KL, FRKN.KL, and EKOV.KL. Later, GREA.KL, DUFU.KL, and HAPS.KL replaced these domains.

The linked cluster varies between the two time periods. Before the MCO, MYRS.KL is the most-linked node. GDEX.KL, HAPS.KL, KREJ.KL, IJMS.KL., AIRA.KL, and PMAS.KL are connected. EKOV.KL became the most linked-to node during the MCO. It is linked to HLIB.KL, MYRS.KL, WPHB.KL, BOUS.KL, GDEX.KL, and FRKN.KL. Following that, it can be shown that prior to the MCO, the distances between domain nodes and the central node are nearly equal. The distances range from 0.69 to 0.76 metres. During the MCO, the distances change as well. It varies between 0.57 and 0.98. Before the MCO, PMAS.KL serves as a bridge to DUFU.KL, FRKN.KL, SCTH.KL, EKOV.KL, and MYRS.KL, and during the MCO, it serves as a bridge between HAPS.KL and DUFU.KL. Finally, before the MCO, WIDA.KL, MISC.KL, BGRO.KL, WPHB.KL, and ATLA.KL found the network's periphery. BGRO.KL, MISC.KL, and WIDA.KL remain at the network's outer edges during the MCO. Meanwhile, MPHB.KL and ATLA.KL replaced by MMCB.KL and LTKH.KL and become the network's outer edges during MCO.

*Centrality Measure*

The measure of centrality is used to identify the most critical stocks on the network. Tables 2 and Table 3 demonstrate the value of degree, betweenness, closeness, and eigenvector centrality for the measurement period's duration. It appears that MYRS.KL and PMAS.KL are the most influential stocks before the MCO because these two stocks appeared on the list of top five in centrality measure. While conducting the MCO, EKOV.KL and FRKN.KL are found to be a crucial position on the network.

**Table 2:** The top five centrality measure of stocks before moving control order (MCO)

| **Centrality measure before MCO** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Degree | | Betweenness | | Closeness | | Eigenvector | |
| 1 | MYRS.KL | 0.207 | PMAS.KL | 0.766 | PMAS.KL | 0.558 | MYRS.KL | 1.000 |
| 2 | PMAS.KL | 0.172 | MYRS.KL | 0.562 | MYRS.KL | 0.504 | PMAS.KL | 0.699 |
| 3 | SCTH.KL | 0.138 | FRKN.KL | 0.310 | EKOV.KL | 0.450 | HAPS.KL | 0.586 |
| 4 | HAPS.KL | 0.103 | EKOV.KL | 0.310 | FRKN.KL | 0.444 | AIRA.KL | 0.482 |
| 5 | FRKN.KL | 0.103 | SCTH.KL | 0.259 | SCTH.KL | 0.440 | IJMS.KL | 0.365 |

**Table 3:** The top five centrality measure of stocks during moving control order (MCO)

| **Centrality measure during MCO** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Degree | | Betweenness | | Closeness | | Eigenvector | |
| 1 | EKOV.KL | 0.207 | FRKN.KL | 0.685 | FRKN.KL | 0.546 | EKOV.KL | 1.000 |
| 2 | GREA.KL | 0.138 | EKOV.KL | 0.599 | EKOV.KL | 0.509 | BOUS.KL | 0.642 |
| 3 | FRKN.KL | 0.138 | GREA.KL | 0.525 | GREA.KL | 0.506 | WPHB.KL | 0.552 |
| 4 | HAPS.KL | 0.103 | DUFU.KL | 0.360 | DUFU.KL | 0.453 | GDEX.KL | 0.439 |
| 5 | WPHB.KL | 0.103 | BOUS.KL | 0.197 | SCOG.KL | 0.424 | FRKN.KL | 0.436 |

The most influential stock in the network for each duration is calculated using principal component analysis. The most prominent stocks three months before MCO belongs to MYRS.KL, PMAS.KL, SCTH.KL, EKOV.KL, and FRKN.KL. During MCO, EKOV.KL, and FRKN.KL remain selected as the companies with the highest overall centrality scores, while GREA.KL, BOUS.KL, and DUFU.KL are still added to the selection. Thus, the position of each stock is changed due to MCO except EKOV.KL and FRKN.KL. In other words, EKOV.KL and FRKN.KL are the least impacted by the MCO.

## CONCLUSIONS

The minimum spanning tree approach is used to visualise the connection between the stock of industrial goods and services listed on Bursa Malaysia. The results showed the changes of network topology for before MCO and during four phases of MCO. The changes can be observed on each node's number of connections, the cluster form, and the node's position on the network. The critical node of the stock on the network is determined by a centrality measure. The most influential companies of three months before MCO failed to remain in the position during MCO except Ekovest Bhd (EKOV.KL) and Frontken Corporation Bhd (FRKN.KL). It is essential for market participants, especially investors, to bear in mind the current situation of COVID-19 when developing a portfolio strategy.

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