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A MINIMUM SPANNING TREE STOCK MARKET ANALYSIS OF MALAYSIA TECHNOLOGY COMPANIES

(Analisis Pepohon Rentangan Minimum Pasaran Saham Syarikat Teknologi Malaysia)

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ABSTRACT

In this study, the topological structure of Malaysian technology companies stock market was investigated for a one-month period, and a three-month period, before and after the 15th Malaysian General Election. The collected data is the daily closing prices of Malaysia's top 20 most active companies based on the volume traded in the list of technology companies. The minimum spanning tree was used to construct the network via Kruskal's algorithm, and the centrality measures of the stocks, such as degree, betweenness, closeness, and eigenvector, were measured to identify influential stocks. The results show that the connection between stocks in one and three months prior to the election is inconsistent, where variations were exhibited during both periods. Based on centrality measures of degree, betweenness, closeness, and eigenvector, the analysis reveals that over a one-month period, THET, AWAN, GREA, and JHMC consistently rank among the top five most influential stocks before the election, while MMST, MYEG, and GREA dominate as the most influential stocks after the election.

Keywords: minimum spanning tree; Kruskal algorithm; stock market; centrality measures

ABSTRAK

Dalam kajian ini, struktur topologi pasaran saham syarikat teknologi Malaysia disiasat untuk tempoh sebulan dan tempoh tiga bulan, sebelum dan selepas Pilihan Raya Umum Malaysia ke-15. Data yang dikumpul ialah harga penutupan harian 20 syarikat paling aktif di Malaysia berdasarkan jumlah dagangan dalam senarai syarikat teknologi. Pepohon rentangan minimum telah digunakan untuk membina rangkaian melalui algoritma Kruskal, dan ukuran kepusatan saham, seperti tahap, keterkaitan, kedekatan dan vektor eigen, diukur untuk mengenal pasti saham yang berpengaruh. Keputusan menunjukkan bahawa hubungan antara saham dalam satu dan tiga bulan sebelum pilihan raya adalah tidak konsisten, di mana kepelbagaian ditunjukkan semasa kedua-dua tempoh masa. Berdasarkan ukuran kepusatan tahap, keterkaitan, kedekatan, dan vektor eigen, analisis mendedahkan bahawa dalam tempoh sebulan, THET, AWAN, GREA, dan JHMC secara konsisten berada di kedudukan antara lima saham paling berpengaruh sebelum pilihan raya, manakala MMST, MYEG , dan GREA mendominasi sebagai saham paling berpengaruh selepas pilihan raya.

Kata kunci: pepohon rentangan minimum; algoritma Kruskal; pasaran saham; ukuran pemusatan

1. Introduction

A stock market is a marketplace where buyers and sellers of shares of stock come together to trade. Shares of stock represent ownership in a corporation, and the stock market provides a way for investors to buy and sell shares in corporations. In short, one is purchasing a small portion of the business if one purchases a share of stock. Supply and demand play a role in determining the price of a share of stock. Furthermore, there are several reasons why the stock market is significant. It enables companies to raise capital for growth. Buying and selling stocks

is another way that investors might profit from it. Note that the stock market can serve as an indicator of the health of the entire economy.

A stock market is a well-known, complicated system. The price changes among different stocks suggest complicated linkages that reflect a complex network. The challenges in depicting the interaction between those companies have drawn much interest in this field. Therefore, a financial network must be established to accurately represent the links between stocks. Market participants can obtain a summary of the links between the stocks traded in the market thanks to financial networks. Moreover, a minimum spanning tree (MST) provides a distinctive perspective on how technology businesses respond to the dynamics of a key political event by utilizing the concepts of graph theory to make it easier to identify essential linkages and trends. Several papers, such as Bahaludin *et al.* (2019); Ibrahim *et al.* (2018); Kazemilari *et al.* (2017); Mbatha & Alovokpinhou (2022); Jiang *et al.* (2021), construct the stock market network using the same method, MST, to get an overview of financial market during global financial crisis and other events. Moreover, Landmesser-Rusek (2024) constructed an MST of the foreign exchange market due to the COVID-19 pandemic and after the Russian invasion of Ukraine by using the dynamic time warping distances between pairs of time series for individual currencies.

In the Malaysian market, the representation of a financial network typically revolves around the top one hundred most capitalized stocks, albeit with variations across distinct timeframes (Bahaludin *et al.*, 2019; Yee *et al.*, 2018; Mahamood *et al.*, 2019). The impact of recession periods on conventional stocks listed on Bursa Malaysia has been extensively explored in the seminal work of Bahaludin *et al.* (2019). Additionally, Mahamood *et al.* (2019) adopted a distinct approach by utilizing Shariah-compliant stocks to analyze the repercussions of the global financial crisis in 2008. The outcomes of the studies pertaining to the Malaysian stock market offer evidence that the network topology undergoes alterations across various periods, stocks, and events.

The stock market is a complex network impacted by many local and global influences. A study by Jiun (2018) discovered that the general election significantly affects stock volatility, while Misman *et al.* (2020) stated that during Malaysia's 14th General Election, the daily returns decreased by about five per cent 15 days after the election and continued to decrease to about nine per cent 30 days after the election. Additionally, Nazir *et al.* (2014) discovered that positive abnormal returns were observed on the stock market on the day following the Pakistan General Election in 2002. Work of Eboigbe & Modugu (2018) also showed that the election affects the Nigerian stock market. In this paper, we aim to study if the 15th Malaysian General Election held on November 19, 2022, influenced the stock market network of Malaysia's technology companies by constructing a minimum spanning tree (MST) for the technology stocks.

The technology sector in Malaysia is considerably one of the largest and fastest-growing sectors, where technology businesses make significant R&D investments resulting in new products and services to increase productivity and create jobs. Technology development in Malaysia is mostly progressive, with high returns in industries where the country has a definite comparative advantage and where better partnerships exist (Wong & Govindaraju, 2012; Bahaludin *et al.*, 2025).

The structure of the remaining of this paper is as follows. In the next section, we describe the data and methodology that is used to construct the MST. Then, we document the results and discussion. Finally, we conclude the study based on our findings.

2. Materials and Methods

In this section, we present the data that is used in this study and describe the methodology for building a financial network using a minimum spanning tree (MST) for the chosen data.

2.1. *Data*

This study uses the daily closing prices of Malaysia's top 20 most active companies based on the volume traded in the list of technology companies, which was obtained from Investing.com. The top 20 companies are the most frequently traded on the stock market with a high trading volume within the technology sector in Malaysia during the period of the study. The top 20 companies are listed in Table 1. This study focuses on the changes on the stock network during the 15th Malaysia General Election which was held on November 19, 2022. To observe the effects that the 15th Malaysian General Election may have to the stock network of the technology companies, we construct an MST for four different periods. The data used was divided into the following:

(1) One month before the general election: October 17 until November 17, 2022.
(2) One month after the general election: November 21 until December 23, 2022.
(3) Three months before the general election: August 15 until November 17, 2022.
(4) Three months after the general election: November 21, 2022, until February 24, 2023.

Table 1: Malaysia's top 20 most active technology companies.

No.	Symbol	Name
1	AWAN	AWANBIRU TECHNOLOGY BHD
2	CNSH	CENSOF HOLDINGS BHD
3	DATA	DATAPREP HOLDINGS BHD
4	DNEX	DAGANG NEXCHANGE BHD
5	FRKN	FRONTKEN CORPORATION BHD
6	GHLS	GHL SYSTEMS BHD
7	GNIC	GLOBETRONICS TECH BHD
8	GREA	GREATECH TECHNOLOGY BHD
9	HONG	HONG SENG CONSOLIDATED BHD
10	INDU	INDUSTRONICS BHD
11	JCY	JCY INTERNATIONAL BHD
12	JHMC	JHM CONSOLIDATION BHD
13	KYAC	KEY ASIC BHD
14	MMST	MMS VENTURES BHD
15	MPIM	MALAYSIAN PACIFIC INDUSTRIES
16	MYEG	MY EG SERVICES BHD
17	NVTE	NOTION VTEC BHD
18	OPYS	OPENSYS M BHD
19	THET	THETA EDGE BHD
20	UNSM	UNISEM M BHD

2.2. *Methodology*

2.2.1. *Minimum spanning tree*

In constructing the minimum spanning tree (MST) for the chosen data, we first determine the logarithmic returns of the stock's daily closing prices, $r_i(t)$, over a period, to define the synchronization of the stocks:

$$r_i(t) \quad = \quad \ln P_i(t+1) - \ln P_i(t), \tag{1}$$

where $P_i(t+1)$ is the closing price at present, $P_i(t)$ is the closing price the day prior, and $i = 1, 2, \ldots, N$, is the index corresponds to each listed company. Following that, we compute

the cross-correlation matrices using the logarithmic returns of the stock's daily closing prices. The correlation coefficient between two stocks, i and j, is computed using Pearson's correlation coefficient, C_{ij}, defined as such:

$$C_{ij} = \frac{\langle r_i r_j \rangle - \langle r_i \rangle \langle r_j \rangle}{\sqrt{(\langle r_i^2 \rangle - \langle r_i \rangle^2)(\langle r_j^2 \rangle - \langle r_j \rangle^2)}} \tag{2}$$

where r_i is the vector of the logarithmic returns for stocks i, r_j is the vector of the logarithmic returns for stock j, and $\langle r_k \rangle = \sum r_k$ for $k = i, j$. The value of the coefficient determines the correlation between the two stocks as follows:

$$C_{ij} = \begin{cases} 1 & \text{completely correlated} \\ 0 & \text{uncorrelated} \\ -1 & \text{inversely correlated} \end{cases} \tag{3}$$

Additionally, the strength of the correlation between the two stocks can be determined with the following:

$$C_{ij} = \begin{cases} 0.1 - 0.3 & \text{weak} \\ 0.3 - 0.5 & \text{moderate} \\ > 0.5 & \text{strong} \end{cases} \tag{4}$$

On that account, we then compute the distance matrix by transforming the correlation coefficients to a distance equation as follows:

$$D_{ij} = \sqrt{2(1 - C_{ij})} \tag{5}$$

where D_{ij} is the distance between each pair of stock i and j. Finally, we construct the MST via Kruskal's algorithm that uses the distance matrix. Kruskal's algorithm is implemented to determine the edge between two distinct trees with the least weight feasible. The step is repeated until the MST is constructed.

2.2.2. *Centrality measures*

Once the MST is constructed, we further investigate the stock network by computing the centrality measures to determine the companies that are crucial to other companies in the network. The centrality measures that we consider in the study are degree, betweenness, closeness, and eigenvector. These measures can reveal which stocks significantly affect the volatility, information flow, and general behavior of the market. Based on selected connections, the degree centrality suggests how many other stocks is related to each other directly. A stock with a high degree centrality may suggest that the stock is strongly connected to several other stocks, which possibly reflects the significance of the stock in transmitting information. The degree centrality is computed as follows:

$$C_{Degree}(i) = \frac{\sum_{j=1}^{N} A_{ij}}{N - 1} \tag{6}$$

where $A_{ij} = 1$ if the stock i and stock j are connected, and $A_{ij} = 0$ otherwise.

The closeness centrality, on the other hand, assesses the efficiency of a stock in spreading information to other stocks in the network. It is the average length of all the shortest paths from one node to every other node in the network (Golbeck, 2015). A stock with a high closeness centrality may suggest that it has a strong relationship with other stocks. The closeness

centrality is computed as follows:

$$C_{Closeness}(i) = \left[\sum_{j=1}^{N} d(i,j)\right]^{-1} \quad (7)$$

where $d(i,j)$ is the shortest path from stock i and stock j.

Then, we compute the betweenness centrality to identify stocks that lie on many shortest paths between other stocks in the network. A stock with a high betweenness centrality may serve as a pathway for information flow, and it is likely to be aware of what is happening in their surroundings (Golbeck, 2015). The betweenness centrality is computed as follows:

$$C_{Betweenness}(i) = \sum_{j<k} \frac{g_{jk}(i)}{g_{jk}}, \quad (8)$$

where $i \neq j \neq k, g_{jk}$ is the total number of shortest paths from node j to k, and $g_{jk}(i)$ is the number of paths that passes through i.

Additionally, we compute the eigenvector centrality to discover stocks with ties to other highly central stocks. It measures the influence that a node has in a network (Golbeck, 2015). A stock with a high eigenvector centrality may have a greater impact on a wider variety of stocks by being influenced by other influential stocks in the network. The computation of the eigenvector centrality is as follows:

$$C_{Eigenvector}(i) = \frac{1}{\lambda}\sum_{j=1}^{N} A_{ij}x_j \quad (9)$$

where x_j is the eigenvector of stock j, and A_{ij} is an element of the adjacency matrix.

3. Results and Discussion

This section presents the minimum spanning tree (MST) that is constructed for Malaysia's top 20 most active technology companies.

Figure 1 illustrates the MST for one month before and after the 15th Malaysian General Election. It can be seen in Figure 1, one month before the election, there are two clustered groups, mainly THET and GREA, where THET is the primary hub of the network since it is linked to eight other companies, whereas GREA is linked to only five. On the other hand, one month after the election shows MMST is linked to the other ten companies which suggests that MMST is the primary network hub one month after the election. This is followed by GREA that was able to maintain its position as a central hub even though the connection is different than the connection before the election. Moreover, MYEG became one of the network's hubs one-month after the election, and it linked to other companies, namely UNSM and MPIM.

In Figure 2, it shows the MST for three months before and after the 15th Malaysian General Election, where there are two major clustered groups, led by JHMC and GREA three months before the election, where GREA is connected to eight other companies, and JHMC is connected to ten companies. However, three months after the election, the MST displays a different connection for all stocks, where all the stocks scattered throughout, making UNSM the central hub of the network.

Tables 2 and 3 document the degree centrality measures for a one-month and a three-month before and after the election. Tables 2 and 3 show that GREA has the highest degree one month before and after election. This can also be observed in Figure 1, where GREA is connected to six stocks one month before election, and to five stocks one month after election. The orientation changes when we observe the degree centrality three months before and after the election. The

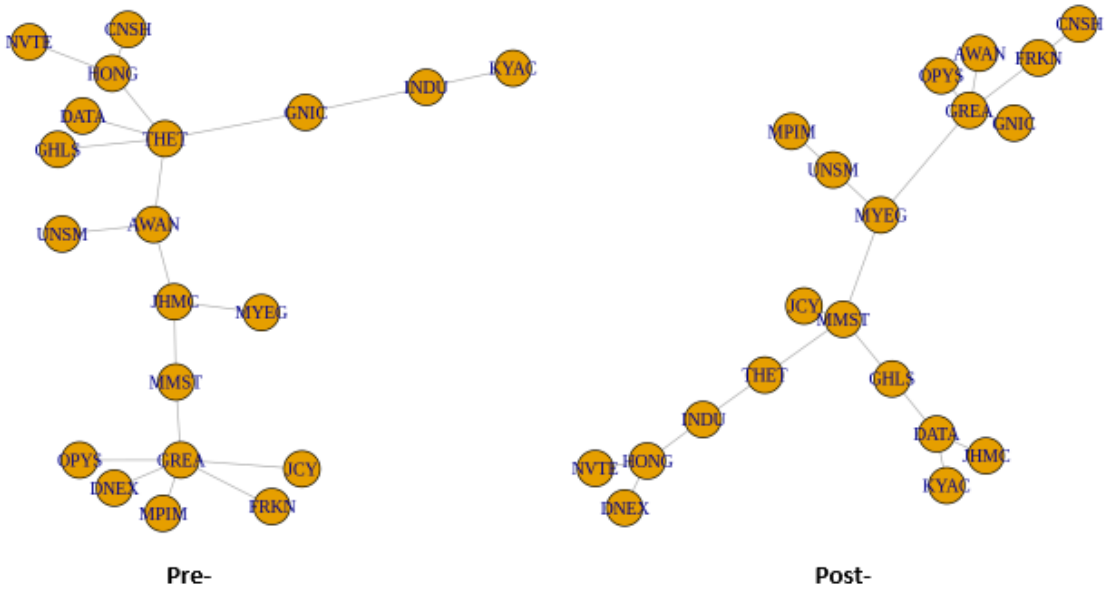

Figure 1: One month before and after the general election

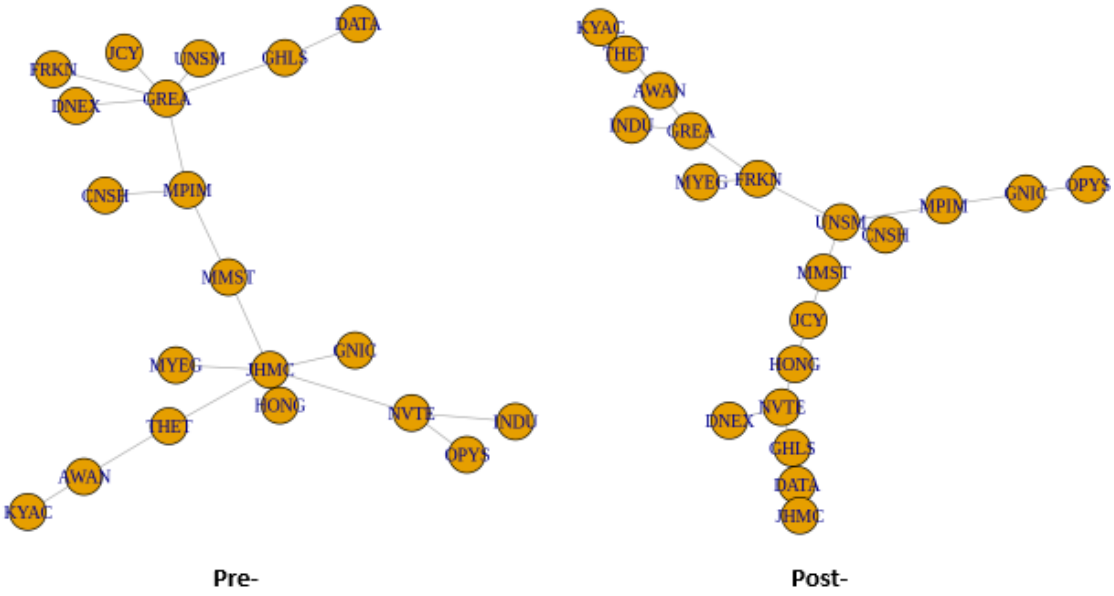

Figure 2: Three months before and after the general election.

JHMC has the highest degree three months before election with six stocks connected to it, while this changes to UNSM with four stocks connected to it, three months after election. Based on the degree centrality measures for one-month and three-month before and after election in Tables 2 and 3, we can see that the GREA can be perceived as the leading influential company as it maintained in the top 5 stocks with high degree centralities.

The first five stocks with the highest closeness centrality measures are tabulated in Tables 4 and 5 for one-month and three-month before and after the election. One month before the election, AWAN has the highest closeness centrality. However, one month after the election, this changed to MMST. Three months before the election, JHMC and MMST are the two stocks

Table 2: Degree centrality measures: one-month period

No.	Pre-Election		Post-Election	
	Stock	Degree	Stock	Degree
1	GREA	6	GREA	5
2	THET	5	MMST	4
3	AWAN	3	DATA	3
4	HONG	3	HONG	3
5	JHMC	3	MYEG	3

Table 3: Degree centrality measures: three-month period

No.	Pre-Election		Post-Election	
	Stock	Degree	Stock	Degree
1	JHMC	6	UNSM	4
2	GREA	6	FRKN	3
3	MPIM	3	GREA	3
4	NVTE	3	NVTE	3
5	AWAN	2	AWAN	2

with the same highest closeness measures, which shows that these stocks have the strongest relationship with other stocks. Meanwhile, three months after the election, UNSM topped the list with the highest closeness centrality values compared to other stocks. Nevertheless, there is no one stock that is significant in all four cases.

Table 4: Closeness centrality measures: one-month period

No.	Pre-Election		Post-Election	
	Stock	Closeness	Stock	Closeness
1	AWAN	0.0224	MMST	0.0251
2	THET	0.0217	MYEG	0.0243
3	JHMC	0.0216	GREA	0.0224
4	MMST	0.0196	THET	0.0210
5	GREA	0.0174	GHLS	0.0193

Table 5: Closeness centrality measures: three-month period

No.	Pre-Election		Post-Election	
	Stock	Closeness	Stock	Closeness
1	JHMC	0.0207	UNSM	0.0158
2	MMST	0.0207	MMST	0.0148
3	MPIM	0.0199	FRKN	0.0146
4	GREA	0.0179	JCY	0.0135
5	NVTE	0.0157	MPIM	0.0131

Tables 6 and 7 tabulate the betweenness centrality measures. One month before the election, it suggests that THET is the top company that may serve as a pathway for information flow. MMST then rose to be the most influential company one month after the election. Three months before the election shows that JHMC was the most significant stock, while UNSM was the most

significant stock three months after the election.

Table 6: Betweenness centrality measures: one-month period

No.	Pre-Election		Post-Election	
	Stock	Betweenness	Stock	Betweenness
1	THET	0.6433	MMST	0.6959
2	AWAN	0.5790	MYEG	0.5848
3	JHMC	0.5556	GREA	0.4620
4	GREA	0.4678	THET	0.3509
5	MMST	0.4561	GHLS	0.2807

Table 7: Betweenness centrality measures: three-month period

No.	Pre-Election		Post-Election	
	Stock	Betweenness	Stock	Betweenness
1	JHMC	0.7018	UNSM	0.6959
2	MPIM	0.5556	MMST	0.4912
3	GREA	0.5380	FRKN	0.4854
4	MMST	0.5263	JCY	0.4561
5	NVTE	0.2047	HONG	0.4094

In Tables 8 and 9, the eigenvector centrality measures are documented. Different companies scored the highest value for each of the time periods. One month prior to the election indicates THET as the top scorer, while one month after shows MMST as the top scorer. Meanwhile, JHMC was the most influential stock three months before the election, while UNSM is the most influential stock three months after.

Table 8: Eigenvector centrality measures: one-month period

No.	Pre-Election		Post-Election	
	Stock	Eigenvector	Stock	Eigenvector
1	THET	1.0000	MMST	1.0000
2	GNIC	0.6944	GHLS	0.7719
3	AWAN	0.5961	THET	0.7000
4	HONG	0.5745	INDU	0.6346
5	INDU	0.4732	DATA	0.5920

Table 9: Eigenvector centrality measures: three-month period

No.	Pre-Election		Post-Election	
	Stock	Eigenvector	Stock	Eigenvector
1	JHMC	1.0000	UNSM	1.0000
2	NVTE	0.6012	MMST	0.6929
3	THET	0.4524	FRKN	0.6573
4	MMST	0.4340	MPIM	0.5793
5	HONG	0.4124	JCY	0.5389

The centrality results for the technology sector of the top 20 companies show that UNSM is the most influential stock, followed by MMST and GREA. All centrality measures for UNSM

are high three months after the election, while MMST has high closeness, betweenness, and eigenvector centrality measures one month after the election. Overall, GREA is listed in the top 5 stocks with high centrality measures for all measures. Furthermore, MMST appears as the most influential stock before and after the election based on all centrality measures, which implies that MMST is a significant stock in the technology stock market.

4. Conclusion

This study aims to analyse the changes in the network for Malaysia's top 20 most active technology stocks before and after the 15th Malaysian General Election, by the construction of a minimum spanning tree (MST) via Kruskal's algorithm. The periods considered in this study are divided into two periods – one month and three months before and after the election. There is a disparity in the number of clusters observed one and three months prior to the election. The interconnections among companies demonstrate notable differences before and after the election. The previously established relationships between stocks, for instance, GREA's central hub position, exhibit variations during both periods. Significantly, the most influential stock varies between the two periods.

The most influential stocks in the network are also identified using measures of degree, betweenness, and closeness centrality. The findings indicate that over a one-month period, THET, AWAN, GREA and JHMC are the stocks that lead the centrality measures prior to the general election. In contrast, MMST, MYEG, and GREA led the centrality measures after the general election. Meanwhile, over a three-month period, JHMC and GREA are the two stocks that lead the centrality measures before the general election, whereas UNMS is the only stock that leads the centrality measures after the election. In conclusion, all these stocks significantly influence the network based on the respective period.

Future research direction of this study is to use machine learning techniques to improve the selection of edges and weights in the MST. This enables a more accurate representations of the dynamics of the market, and reduce noise in the data. Also, MST assumes normally distributed returns, which may not hold in practice. Hence, by addressing these future research direction and limitation, practitioners can enhance the effectiveness of stock market network analysis using MST and contribute to a better understanding of market dynamics.

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References

Bahaludin H., Abdullah M.H., Hussin M., Laham M.F. & Ismail Z. 2025. Analysing malaysian technology sector during covid-19: A minimum spanning tree approach. *Journal of Advanced Research in Applied Sciences and Engineering Technology* **44**(2): 210–220.

Bahaludin H., Abdullah M.H., Siew L.W. & Hoe L.W. 2019. The investigation on the impact of financial crisis on Bursa Malaysia using minimal spanning tree. *Mathematics and Statistics* **7**(4A): 1–8.

Brealey R.A., Myers S.C. & Allen F. 2020. *Principles of Corporate Finance*. 13th Ed. New York, NY: McGraw-Hill Education.

Eboigbe S.U. & Modugu K.P. 2018. Stock market reaction to election cycles: The nigerian experience. *Journal of Accounting and Finance in Emerging Economies* **4**(1): 63–76.

Golbeck J. 2015. *Introduction to Social Media Investigation: A Hands-on Approach*. Rockland, Massachusetts: Syngress.

Ibrahim S.N.I., Muhammad S.A. & Abdullah M.H. 2018. A network analysis of the stock market in malaysia, singapore and indonesia. *International Journal of Engineering & Technology* **7**(4.1): 99–101.

Jiang Q., Ma Q. & Liu X. 2021. Research on the stock correlation network entropy and its influencing factors in the Chinese interbank market. *Mathematical Problems in Engineering* **2021**: 1–8.

Jiun R.C.C. 2018. The effect of political elections on stock market volatility in Malaysia. *International Journal of Engineering & Technology* **7**(3.21): 114–119.

Kazemilari M., Mardani A., Streimikiene D. & Zavadskas E.K. 2017. An overview of renewable energy companies in stock exchange: Evidence from minimal spanning tree approach. *Renewable Energy* **102**: 107–117.

Landmesser-Rusek M.J. 2024. Network analysis of the foreign exchange market using minimum spanning trees constructed from the dynamic time warping distance measure. *Argumenta Oeconomica* **52**(1): 56–70.

Mahamood F.N.A., Bahaludin H. & Abdullah M.H. 2019. A network analysis of shariah-compliant stocks across global financial crisis : A case of malaysia. *Modern Applied Science* **13**(7): 80–93.

Mbatha V.M. & Alovokpinhou S.A. 2022. The structure of the south african stock market network during covid-19 hard lockdown. *Physica A: Statistical Mechanics and Its Applications* **590**: 375–389.

Misman F.N., Roslan S. & Mat Aladin M.I. 2020. General election and stock market performance: A Malaysian case. *International Journal of Financial Research* **11**(3): 139–145.

Nazir M.S., Younus H., Kaleem A. & Anwar Z. 2014. Impact of political events on stock market returns: Empirical evidence from pakistan. *Journal of Economic and Administrative Sciences* **30**(1): 60–78.

Wong C.Y. & Govindaraju V.G.R.C. 2012. Technology stocks and economic performance of government-linked companies: The case of Malaysia. *Technological and Economic Development of Economy* **18**(2): 248–261.

Yee L.S., Salleh R.M. & Asrah N.M. 2018. Multidimensional minimal spanning tree : The bursa malaysia. *Journal of Science and Technology* **10**(2): 136–143.

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