Topological Properties of Malaysian Shariah-Compliant Securities

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Abstract. This research analyses the topological structure of shariah-compliant securities listed in the Bursa Malaysia market from a network perspective. The network is established from the relationships between the top hundred shariah-compliant securities based on market capitalization from 2015 to 2019. The minimum spanning tree (MST) technique applies to produce and portrays a simpler network. Besides, topological properties are explored and examined further to extract the structure embedded and entrenched in the network. As a result, this paper reveals that shariah-compliant securities with different sectors which were interconnected in the Malaysian market. In general, the securities with the same sectors tend to cluster together in the network. The topological properties provide insight to the market participants, especially investors, for the investment strategies.

1. Introduction

Islamic market has been introduced in Bursa Malaysia to be a hub of Islamic finance. There are several Islamic indices in the Malaysian market such as FTSE Bursa Malaysia Hijrah Shariah Index, FTSE Bursa Malaysia EMAS Shariah Index, FTSE Bursa Malaysia Small Cap Shariah Index, and FTSE Bursa Malaysia Mids Cap Shariah Index. For Malaysia context, the securities that listed in the Islamic indices should meet all the requirement of shariah law and regulation in which approved by Shariah Advisory Council Securities Commission Malaysia. The market capitalization of the Islamic market is expanding over the year, and to date, the total is RM1,218.99 billion as of November 2020 [1]. Besides, the shariah-compliant securities traded was 64% compared to shariah non-compliant which was 36% as reported by Bursa Malaysia. The statistics showed that the market participants are shifted to the shariah-compliance securities rather than conventional securities. Therefore, this study is driven to explore further the relationship between the shariah-compliant securities traded in Bursa Malaysia.

The minimum spanning tree is introduced by Mantegna [2] to exhibit the relationship between the stock that is traded in a financial market. Since then, the minimum spanning tree is used extensively with different objectives such as to investigate the effect of the financial crisis [3–13] measure the systemic risk [14–16], to examine the clustered securities in the market [17,18], to improve the asset allocation strategy[19]. In addition, previous literatures applied the minimum spanning tree...
approaches to examine the relationship of securities in the stock market, such as [3,20,21]. From the Malaysian market, the minimum spanning tree is used to construct a financial network to display the securities' correlation. Furthermore, the literature used the stock listed in Bursa Malaysia to identify the main stock among the conventional securities that play a crucial role in the market, such as [5,11,22–25].

Hence, this study is motivated to provide a deeper overview of the topological structure that focuses on shariah-compliant securities listed in Bursa Malaysia. This study aims to contribute to the literature in a way that not only constructs a network of shariah-compliant securities but also analyzing the properties embedded on the network.

The remainder of the paper is organized as follows. Section 2 present the data and the methodology used to achieve and attain the objectives. Section 3 presents the results. Then Section 4 summarizes and concludes the paper.

2. Data
This study used the shariah-compliant companies in the Malaysian stock market. The companies are listed continuously in the Shariah Advisory Council (SAC) during the period from 2015 until 2019. Furthermore, this paper covers only the top hundred average market value of consistent stocks between 2015 and 2019. After the data cleaning process, only 99 stocks were used due to the unavailability of data. The daily closing prices of stocks are retrieved from Eikon Datastream from 1st January 2015 to 31st December 2019, covering 1246 trading days.

3. Methodology
This subsection presents the procedure to construct and construe a network with a minimum spanning tree approach. In brief, the procedure involves the computation of rate of return, correlation matrix, and distance matrix. The distance matrix is then input for the minimum spanning tree in which employs the Kruskal algorithm. Next, the size, graph density, diameter, and degree distribution of the network are used to examine the network properties.

3.1. Logarithmic rate of return and correlation matrix
The extracted time series of stocks prices are converted to the logarithmic rate of return, \( r_i(t) \) between sequential daily closure prices by using the Eq. (1):

\[
r_i(t) = \ln \frac{P_i(t)}{P_i(t-1)}
\]

\( P_i \) is a price of stock \( i \) at time \( t \).

The log-returns are then substituted into Pearson’s Correlation Coefficient as in Eq. (2) to identify each stock's interrelationship. This will result in \( N \times N \) matrix, with \( N \) is the number of stocks. In this case, the correlation matrix is 99×99:

\[
\rho_{ij} = \frac{\langle r_i r_j \rangle - \langle r_i \rangle \langle r_j \rangle}{\sqrt{\langle r_i^2 \rangle - \langle r_i \rangle^2} \sqrt{\langle r_j^2 \rangle - \langle r_j \rangle^2}}
\]

where \( i \) and \( j \) are stocks and \( \langle r_i \rangle \) is the average of return of stock \( i \).
3.2. Distance matrix and Kruskal algorithm

As of Mantegna [2] procedures, the correlation coefficients, $\rho_{ij}$, are transformed into a distance matrix using Eq. (3):

$$d_{ij} = \sqrt{1 - 2\rho_{ij}}$$ (3)

$d_{ij}$ is a distance between stock $i$ and stock $j$.

Kruskal’s algorithm works by sorting all the distances in ascending order. Each distance is picked as long as it does not create a loop. The distance that forms a loop is eliminated. The process is continued until all the stocks are used. According to Kruskal[26], an MST should have an N-1 number of links with a minimum weight in the final outcome.

3.3. Network Properties

This paper used network size, network density, network diameter, and node degree distribution to quantify the properties of minimum spanning tree (MST).

1) Size of a network is referred to the number of edge [27,28]. Since this study uses MST, hence, the size of a network is determined by $N-1$. $N$ is the total of companies.

2) Graph density is the potential total number of edges divided by the total possible edges in the graph [28]. This means, a network density depicts the part of the potential links in a network that are real links. Hence, in this study, density of a graph can be written as $2(N-1)/N(N-1)$ or $2/N$.

3) A network's diameter is the length of the longest geodesic path between any pair of stocks [16,29–33].

4) Degree distribution: measures the frequency of nodes with different degrees in the network [16].

4. Results and Discussions

This section presents the outcomes of this study in which covers network presentation and network properties.

4.1. A minimum spanning tree of shariah-compliance securities

Figure 1 illustrates the minimum spanning tree (MST) of the top hundred shariah-compliance securities in the recent five years. In general, the MST is a star-like in which the property sector is the center of the network. The shariah-compliance securities with the same sector mostly tend to cluster together, which reveals the different structure with the conventional securities as reported in [11,25].

In addition, the subset of the shariah-compliant network presents that all companies are clustered into ten groups. The groups can be seen in Figure 2, where the biggest group of 10 are directly connected with UEMS. Hence, UEMS was the most connected company among ninety-nine (99) companies from 2015 until 2019 even though UEMS was not the top company in terms of average market value. EUMS only consisted of MYR 4532 billion compared to Taliworks Corporation (TENN) has MYR 78765.76 billion, was the highest in average market value but had lower connectivity with other companies.
Figure 1. A minimum spanning tree (MST) of shariah-compliant companies from the year 2015 to 2019
4.2. Network size and network density
Essentially, the size of a network is the most essential characteristic of a network [28]. According to Onnela et al. [27], the number of edges is the graph's size. It is fixed at $N-1$ for the minimum spanning tree (MST), where $N$ is the number of nodes (companies). Thus, this study identifies that the size of the Malaysian shariah-compliant securities network was 98. Furthermore, the MST density is 0.02, which means the practical ties or relations in a network over the supreme number of the possible relations is only 2%.

4.3. The diameter of the network
In 2015 until 2019, the network of top hundred Malaysian shariah-compliant companies had a diameter of 16 paths as portrayed in Figure 3. It means that the longest route for sending information in the network is 16 paths. It is also illustrated in Figure 3 that companies from the plantation and healthcare sectors had a diameter of 16. The evidence shows that 2 out of 14 companies in the plantation sector (BATU and ASIC) and 2 out of 7 companies from the healthcare sector (HARA and KOSS) had the lengthiest route to disseminate their influence to other companies in the network. Furthermore, as can be seen from Figure 1, all 4 companies that had the longest path are located at the network's edge. In other words, this study finds that the longest path belongs to the peripheral nodes in the network. Hence, these 4 companies are the less volatile companies in the network.
4.4. Degree distribution of the companies in the network
The degree of company $i$, $k_i$, in an undirected network is simply the number of connected companies. If the degree increases, then the company becomes more connected and more central in the network. Figure 4 illustrates that more than half of companies had a degree of 1, which indicates approximately 52% of companies are the “leave” or periphery of the MST as in Figure 1. In other words, only a small percentage of companies in the network are very much interrelated, while most companies comprise a comparatively low number of connections. Therefore, such topological arrangement implies a star-like structure of MST as shown in Figure 1, with EUMS as a center of the star. It can be said that EUMS is the most important company in the network, yet, EUMS also the most volatile company in the network.

Figure 3. The diameter of the Malaysian shariah-compliant network from 2015 to 2019 for each sector

Figure 4. Histogram of the degree distribution of shariah-compliant securities
5. Conclusions
Overall, this study investigates the topological configuration of the top hundred average market value Malaysian shariah-compliant companies from 2015 until 2019 using minimum spanning tree (MST). Besides, this paper also analyses the topological properties of the MST by identifying the network size, density, diameter, and degree distribution. The findings elucidate that there is ten cluster form during the period. Furthermore, MST of shariah-compliant companies also illustrates that all the securities' majorities with the same sector fell under the same clusters. This result shows that a strong correlation existed between the securities from the same industry. Furthermore, the network size is 98 and exhibits a relatively low network density in which only 0.02 or 2%. In 2015 until 2019, the longest path that information can be transferred in the network was 16 paths. Lastly, the MST also only had a few companies that had high connectivity with others, while almost 52% of companies were a comparatively low number of linkages.

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References
[1] Malaysia B Statistics for Islamic Capital Market in Malaysia
[2] Mantegna R N 1999 Hierarchical structure in financial markets Eur. Phys. J. B 11 193–7
[3] Tabak B M, Serra T R and Cajeueiro D O 2010 Topological properties of stock market networks: The case of Brazil Physica A 389 3240–9
[4] Aswani J 2017 Impact of global financial crisis on network of Asian stock markets Algorithmic Financ. 6 79–91
[5] Mahamood F N A, Bahaludin H and Abdullah M H 2019 A Network Analysis of Shariah-Compliant Stocks across Global Financial Crisis: A Case of Malaysia Mod. Appl. Sci. 13 81–93
[6] Majapa M and Gossel S J 2016 Topology of the South African stock market network across the 2008 financial crisis Physica A 445 35–47
[7] Lee J W and Nobi A 2018 State and Network Structures of Stock Markets Around the Global Financial Crisis Comput. Econ. 51 195–210
[8] Memon B A and Yao H 2019 Structural Change and Dynamics of Pakistan Stock Market During Crisis: A Complex Network Perspective Entropy 21 248
[9] Coletti P and Murgia M 2016 The Network of the Italian Stock Market during the 2008–2011 Financial Crises Algorithmic Financ. 5 111–37
[10] Memon B A, Yao H, Aslam F and Tahir R 2019 Network Analysis Of Pakistan Stock Market During The Turbulence Of Economic Crisis Business, Manag. Educ. 17 269–85
[11] Bahaludin H, Abdullah M H, Siew L W and Hoe L W 2019 The Investigation on the Impact of Financial Crisis on Bursa Malaysia Using Minimal Spanning Tree Math. Stat. 7 1–8
[12] Kantar E, Keskin M and Deviren B 2012 Analysis of the effects of the global financial crisis on the Turkish economy, using hierarchical methods Physica A 391 2342–52
[13] Xia L, You D, Jiang X and Guo Q 2018 Comparison between global financial crisis and local stock disaster on top of Chinese stock network Phys. A Stat. Mech. its Appl. 490 222–30
[14] Kuzubaş T U, Ömercikoğlu I and Saltoğlu B 2014 Network centrality measures and systemic risk: An application to the Turkish financial crisis Phys. A Stat. Mech. its Appl. 405 203–15
[15] Huang W, Zhuang X, Yao S and Uryasev S 2016 A financial network perspective of financial institutions’ systemic risk contributions 456 183–96
[16] Li W, Hommell U and Paterlini S 2018 Network topology and systemic risk: Evidence from the...
Euro Stoxx market *Financ. Res. Lett.* 27 105–12

[17] Abbasian-Naghneh S, Tehrani R and Tamimi M 2020 The Network Analysis of Tehran Stock Exchange using Minimum Spanning Tree and Hierarchical Clustering *Iran. J. Financ.* 4

[18] Balci M A, Akgüller Ö and Can Güzel S 2020 Hierarchies in communities of UK stock market from the perspective of Brexit *J. Appl. Stat.* 1–19

[19] Li Y, Jiang X, Li S and Zheng B 2018 Portfolio optimization based on network topology *Physica A* 515 671–81

[20] Yao H and Memon B A 2019 Network topology of FTSE 100 Index companies: From the perspective of Brexit *Phys. A Stat. Mech. its Appl.* 523 1248–62

[21] Zhang W, Wen J and Zhu Y 2016 Minimal Spanning Tree Analysis of Topological Structures: the Case of Hang Seng Index *Iber. J. Inf. Syst. Technol.* 7 145–55

[22] Djauhari M A and Gan S L 2014 Bursa Malaysia Stocks Market Analysis: A Review *ASM Sci. J.* 8 150–8

[23] Gan S L and Djauhari M A 2012 Stock Network Analysis in Kuala Lumpur Stock Exchange *Malaysian J. Fundam. Appl. Sci.* 8 60–6

[24] Sharif S and Djauhari M A 2012 A Proposed Centrality Measure: The Case of Stocks Traded at Bursa Malaysia *Mod. Appl. Sci.* 6 p62

[25] Lim S Y, Salleh R M and Asrah N M 2018 Multidimensional Minimal Spanning Tree: The Bursa Malaysia *J. Sci. Technol.* 10 136–43

[26] Kruskal J . 1956 On the Shortest Spanning Subtree of a Graph and the Traveling Salesman Problem *Am. Math. Soc.* 7 48–50

[27] Onnela J P, Kaski K and Kertész J 2004 Clustering and information in correlation based financial networks *Eur. Phys. J. B* 38 353–62

[28] Metcalf L and Casey W 2016 Graph theory *Cybersecurity and Applied Mathematics* pp 67–94

[29] Djauhari M A and Gan S L 2014 Optimality problem of network topology in stocks market analysis *Phys. A Stat. Mech. its Appl.* 419 108–14

[30] Šoltés V and Danko J 2017 Proposal of creation of a portfolio with minimal risk *Invest. Manag. Financ. Innov.* 14 107–15

[31] Maman Abdurachman D and Lee G S 2015 Dynamics of NYSE Correlation Structure during Global Crisis in 2008: Evidence from Complex Network Analysis *International Conference on Advanced Computer Science and Information Systems 2015 (ICACSIS 2015)* (IEEE) pp 7–11

[32] Hage P and Harary F 1995 Eccentricity and centrality in networks *Soc. Networks* 17 57–63

[33] Luke D A 2015 *A User ‘s Guide to Network Analysis in R* ed R Gentleman, K Hornik and G Parmigiani (St.Louis: Springer)