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A Network Analysis of the Stock Market in Malaysia, Singapore and Indonesia

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Abstract

In this study, we investigate the stock market network among the stocks traded in Malaysia, Singapore and Indonesia using the minimal spanning tree approach. Based on the market capitalization, the monthly adjusted closing prices from 2016 until 2017 of 10 companies for each stock market are chosen to construct the network, and the most influential stocks between Malaysia, Singapore and Indonesia stock markets are identified. Findings of this study show that 3 out of 30 companies are identified as the most influential in the Malaysia, Singapore and Indonesia stock market.

Keywords: *Stock market; Minimal spanning tree; Centrality measures.*

1. Introduction

Stock market is a complex system of economic transactions for the trading of company stocks and derivatives at an agree price. The difficulties in illustrating the relationship between the companies have given much attention to researchers to explore this field. They are interested in the behavior of stocks traded in the market like the way the stocks relate to each other. The relation among the stocks is represented by the correlations among the logarithm of their stock returns.

According to [1], the minimum spanning tree (MST) is a graph that connects all nodes with minimum total weight. In [2], MST is used to study the clustering of companies using correlation of returns, by transforming the correlation returns into metric distance and constructing a network using MST which is derived from graph theory. Using data obtained from London Stock Exchange, [3] builds a stock market network, while [4] builds a stock market network using data from New Tokyo Stock Exchange. Recently, [5] studies the performance of Bursa Malaysia using MST, and earlier, [6-8] also demonstrates MST with data from Bursa Malaysia.

Based on market capitalization, we aim to construct a stock network of 30 companies listed on Bursa Malaysia, Singapore Exchange and Indonesian Stock Exchange and determine the importance of each stock in the network. This paper is organized as follows. In Section 2, we present the data and methodology, and document the results and discussion in Section 3. Section 4 concludes the paper.

2. Data and Methodology

2.1. Data

The data used in this study is the monthly adjusted closing prices for 30 companies from January 1, 2016 until December 31, 2017 collected from Bursa Malaysia (KLSE), Singapore Exchange (SGX) and Indonesia Stock Exchange (IDX).

2.2. Minimum Spanning Tree (MST)

The steps to construct the minimum spanning tree (MST) are as follows (see [9]):

1. Calculate the logarithm of monthly stock return at month t in a given period is defined as:

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

where $P_i(t)$ is the adjusted closing stock price of a company i for $i = 1,2,...,N$.

2. Calculate the correlation coefficient between stock i and stock j as such:

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

to determine the correlation matrix $C = \rho_{ij}$ for $N \times N$ matrix. $\langle r_i \rangle$ is the average of $r_i(t)$ for all t.

3. Construct metric distance $D = d_{ij}$ from C by transforming the correlation coefficient ρ_{ij} into distance function as follows:

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

4. The adjacency matrix, A is symmetry ($N \times N$) where N is the number of vertices or nodes in the obtained network. Elements in the adjacency matrix are $A_{ij} = 1$, if there exist edges connected stock i and stocks j. Otherwise, $A_{ij} = 0$. Adjacency matrix can be used as a guideline to measures the centrality.

The MST is constructed by using Kruskal's algorithm which is based on matrix distance, by assuming the selected vertices, V represent the stocks and the edge, E represents the distances between two stocks. The Kruskal algorithm is as follows:

i) The distances between two stocks are arranged in ascending order.
ii) The initial (root) is chosen by taking the smallest distance between two stocks.
iii) The nearest pair that has not been linked to the same tree is connected without forming a cycle.

Step (iii) is repeated until all vertices are connected.

2.3. Centrality Measures

Centrality measures determine the relative importance for each particular stock in the network, which are the degree, betweenness, closeness and eigenvector centrality. These measures are computed based on MST. The centrality measures given in this study follows from [9,10]. The degree centrality of stock i is defined as:

$$C_D(i) = \frac{\sum_{j=1}^{N} A_{ij}}{N-1}, \tag{4}$$

where A_{ij} is the element of the i-th row and j-th column of the adjacency matrix. $A_{ij} = 1$, if the i-th and j-th stocks are linked. Otherwise $A_{ij} = 0$. The higher the value of $C_D(i)$, the higher the number of other stocks influenced directly by (or influencing directly) stock i. The betweenness centrality of stock i is given as:

$$C_B(i) = \sum_{j \neq k \neq i}^{j,k \in V} \frac{\sigma_{jk}(i)}{\sigma_{jk}}, \tag{5}$$

where $\sigma_{jk}(i)$ denotes the number of path passing through stock i between two different stocks, and σ_{jk} is the number of all possible paths from j to k for all j and k where $j \neq i$ and $k \neq i$. The higher the value of $C_B(i)$, the more crucial the role of stock i in the network. Then, $C_B(i) = 0$ means that stock i have no role in such coordination.

Next the closeness centrality of stock i is computed as follows:

$$C_C(i) = \left[\frac{\sum_{j=1}^{N} d_G(i,j)}{N-1} \right]^{-1}, \tag{6}$$

where $d_G(i,j)$ is the shortest path from stock i to j. In this case, $C_C(i)$ is the average number of shortest paths between i and all other stocks reachable from it. Finally, the eigenvector centrality of stock i is as such:

$$e_i = \frac{1}{\lambda_{\max}} \sum_{j=1}^{N} A_{ij} x_j\,, \tag{7}$$

for $i = 1,2,...,N$ where $\bar{x} = (x_1, x_2, \ldots, x_N)^T$ is the eigenvector associated with the largest eigenvalue $\lambda_{\max}$ of the adjacency matrix. It is the weighted average of the scores x_j of all stocks linked to stock i. The higher the value of e_i, the more the influence of stock i to other stocks directly or indirectly.

3. Results and Discussion

The network studied in this paper represents the stocks traded in Bursa Malaysia (KLSE), Singapore Exchange (SGX) and Indonesia Stock Exchange (IDX). We only consider 10 stocks for each stock exchange. The monthly adjusted closing prices from January 1, 2016 until December 31, 2017 are used to calculate the correlation matrix.

We study the network of 30 stocks traded in KLSE, SGX and IDX. From the correlation matrix, there are 900 correlation elements and filtered into 435 correlations by using MST. Then, the adjacency matrix is needed to represent the MST and the total edges are 29 edges obtained to show the relationship among the stocks. By using Kruskal's algorithm provided in Python 3.6 32-bit, we obtained the MST and analysed the network by using Python NetworkX.

Figure 1 illustrates the network of the 30 stocks, and it can be seen that KRIS and CIMB are the most dominant stocks. In terms of the metric distance, the nearest stocks to KRIS are EZION, SEMBCORP, FALCON, GENTINGS and NICO, while the nearest stock to CIMB is UNILEVER followed by HONGLEONG, ALLIED, INDOCEMENT and IMPERIUM. In general, the position of a given stock in a network has its own characteristics and reflects its relationship with other stocks. In order to give further interpretation of the structural position of the stocks in Figure 1, we calculate the centrality measures.

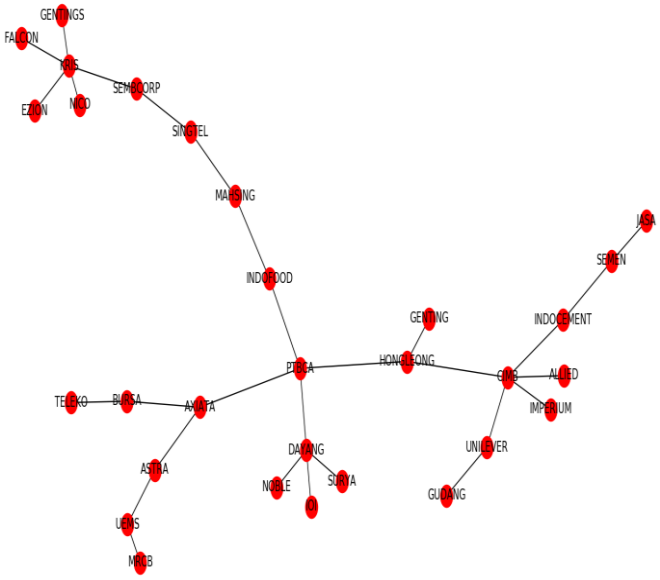

Fig. 1: Stock market network of 30 stocks traded in KLSE, SGX and IDX

Table 1 documents the degree centrality measures for the top ten stocks with the highest values among the stocks traded in KLSE, SGX and IDX. Based on the degree centrality measure, the most influential stocks in these three exchanges are CIMB and KRIS with the highest number of connections of stocks—5.

Table 1: Degree centrality measures for stocks traded in KLSE, SGX and IDX

Company	C_D
CIMB	0.1724
KRIS	0.1724
DAYANG	0.1379
PTBCA	0.1379

AXIATA	0.1034
HONGLEONG	0.1034
BURSA	0.0690
MAHSING	0.0690
UEMS	0.0690
SEMBCORP	0.0690

Meanwhile, based on the betweenness centrality measure, PTBCA has the highest value in betweenness centrality measure; hence it is the best position stock among other stocks traded in KLSE, SGX and IDX which means that the behavior of the stocks surrounding PTBCA are affected by the PTBCA's price behaviour.
Therefore, based on the betweenness centrality measure, PTBCA plays an important role in KLSE, SGX and IDX. The betweenness centrality measure for the top ten stocks with the highest values are tabulated in Table 2.

Table 2: Betweenness centrality measures for stocks traded in KLSE, SGX and IDX

Company	C_B
PTBCA	0.7488
HONGLEONG	0.4631
CIMB	0.4212
INDOFOOD	0.4138
MAHSING	0.3793
SINGTEL	0.3399
AXIATA	0.3103
SEMBCORP	0.2956
KRIS	0.2611
DAYANG	0.1995

We also compute the closeness centrality measure as shown in Table 3, and we find that PTBCA has the highest value. This implies that PTBCA strongly influences the behaviour of other stocks traded in KLSE, SGX and IDX.

Table 3: Closeness centrality measures for stocks traded in KLSE, SGX and IDX

Company	C_C
PTBCA	0.3187
HONGLEONG	0.2871
INDOFOOD	0.2816
AXIATA	0.2661
DAYANG	0.2566
CIMB	0.2522
MAHSING	0.2479
GENTING	0.2248
SINGTEL	0.2180
ASTRA	0.2180

Finally, we computed the eigenvector centrality measure for the stocks traded in KLSE, SGX and IDX. It can be seen from Table 4 that PTBCA has the highest score.

Table 4: Eigenvector centrality measures for stocks traded in KLSE, SGX and IDX

Company	e
PTBCA	0.4517
CIMB	0.4208
HONGLEONG	0.3919
DAYANG	0.3094
AXIATA	0.2661
INDOFOOD	0.2114
INDOCEMENT	0.1948
UNILEVER	0.1890
IMPERIUM	0.1613
ALLIED	0.1613

4. Conclusion

This study constructs minimum spanning trees (MST) between stocks traded in KLSE, SGX and IDX. Based on the centrality measures, PTBCA has the highest score for betweenness, closeness and eigenvector centrality measures. This implies that PTBCA is a dominant stock and plays an important role which influences other stocks that are used in this study. Hence, investors can use MST to find the relationship between stocks, and determine the influences among these stocks have on each other.

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