Original Research Paper

Validation of Global Financial Crisis on Bursa Malaysia Stocks Market Companies via Covariance Structure

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Abstract: The global financial crisis of 2007 to 2009 affects the economic development around the world. It started with US in 2007 and followed by Malaysia in 2008. The purpose of this study is to validate the impact before and beginning of the crisis on seventy seven Bursa Malaysia stocks market companies. Two data sets of 2007 and 2008 were used in testing the differences of the covariance structures by using a new test known as S^* statistic that been developed for high dimensional data set such as the stock market. The test revealed that the covariance structure of 2007 and 2008 significantly different from each other. Thus, Optimal Minimum Spanning Tree (OMST), degree centrality measure and network topology were implemented in identifying the companies that contribute to the different covariance structure. The finding shows that HWAN is the most dominant for 2007 and MRES for 2008. The rise or fall (instability) of HWAN and MRES gave large impact on the stability structure of the stock market. The global financial crisis in 2008 affected HWAN but HONG seems to maintain in the network.

Keywords: Covariance Test, Degree Centrality, High Dimension, Optimal Minimum Spanning Tree, Stock Market

Introduction

The global financial crisis of 2007 to 2009 which started in 2007 with US as the epicentre is the worst financial crisis since the Great Recession in 1930s (Ergungor and Cherny, 2009). Economies all around the world experienced a sharp fall in the Gross Domestic Product (GDP). In emerging and developing countries, real GDP growth fell from 8.3% in 2007 to 6.1% in 2008 and just 2.4 % in 2009. The GDP of 2009 marked as the most serious shortfalls in all countries (Dolphin and Chappell, 2010).

Malaysia was also affected where the GDP dropped from 7.6% in the first quarter of 2008 to -6.2% in the first quarter of 2009. The global financial crisis caused Bursa Malaysia to tumble below 1000 percentage points (Abidin and Rasiah, 2009; Gokay, 2009). As a result, the Malaysian currency exchange rate dropped to 92% in January 2009.

The purpose of this study is to validate the impact before (2007) and beginning (2008) of the crisis on Bursa Malaysia stocks market companies. The stock prices were downloaded from Data stream maintained by Thomson Reuters. There are 850 companies in Bursa Malaysia, but only 77 companies with more than RM500

million market prices are chosen in this study. The data is retrieved for both quarter one of 2007 and 2008 from January 1 to March 31 on a daily trading basis and were used in testing the differences of the covariance structures. The data involved high dimensional data set due to the number of dimension, p (77 companies) is larger than the number of observation n (60 trading days stock prices of quarter one).

Testing the Difference between Two Covariance Structure

There are many methods available for testing the different between two covariance structure, such as, Box's M statistic (Box, 1949), Jennrich statistic (Jennrich, 1970) and generalized variance statistic (Wilks, 1932). However these methods unable to cater for high dimensional data set. Therefore a new test known as S^* statistic that been developed for high dimensional data set proposed by Sharif *et al*. (2016), was used in testing the covariance structure. Let $S_{1,L}$ and $S_{2,L}$ are lower elements of covariance matrix S_1 and S_2, respectively, to test the hypothesis $H_0: \Sigma_1 = \Sigma_2$ versus $H_1: \Sigma_1 \neq \Sigma_2$ and using the following formula:

$$S^* = [vec(S_{1,L}) - vec(S_{2,L})^t S_p^{-1}[vec(S_{1,L}) - vec(S_{2,L})] \qquad (1)$$

Where:

$$S_p = M^t(I_{p^2} + K)(S_{pooled,L} \otimes S_{pooled,L})M$$

With:

$$M = (m_{ij}) = \begin{cases} 1; (i,j) = (C_2^a + b, b) \text{ for } b = 1, 2, \dots, a \\ 0; \quad \text{elsewhere} \end{cases} \qquad (2)$$

In general, the duplication matrix M can be presented in matrix form as a block matrix $M = (M_1|M_2|\dots M_p)$ of size $(k \times p^2)$ where $k = \frac{1}{2}p(p+1)$ and this matrix can be partitioned into p blocks. Each M_r, $r = 1, 2, \dots, p$ is a matrix of the size $(k \times p)$ with its elements m_{ij} are defined in (2).

Let S_1 and S_2 be the covariance matrices of 77 companies for the first quarter in 2007 and 2008 respectively defined as follows:

$$S_1 = \begin{bmatrix} 0.0471 & 0.0317 & \cdots & 0.0183 \\ 0.0317 & 0.0363 & \cdots & 0.0167 \\ \vdots & \vdots & \ddots & \vdots \\ 0.0183 & 0.0167 & \cdots & 0.0104 \end{bmatrix}$$

$$S_2 = \begin{bmatrix} 0.0419 & 0.0226 & \cdots & 0.0133 \\ 0.0226 & 0.0186 & \cdots & 0.0092 \\ \vdots & \vdots & \ddots & \vdots \\ 0.0133 & 0.0092 & \cdots & 0.0065 \end{bmatrix}$$

Since both matrices are symmetric, the lower and upper elements of contain the same elements. Thus, in computing S^* statistic, only the lower elements are considered in order to avoid the redundancy and singularity problem. Based on that two matrices, the following pooled covariance matrix, S_{pooled} is obtained where $S_{pooled} = \frac{1}{n}(n_1 S_1 + n_2 S_2)$:

$$S_{pooled} = \begin{bmatrix} 0.0481 & 0.0341 & \cdots & 0.0268 \\ 0.0341 & 0.0404 & \cdots & 0.0334 \\ \vdots & \vdots & \ddots & \vdots \\ 0.0268 & 0.0334 & \cdots & 0.0405 \end{bmatrix}$$

Based on the above information, the values of $S^* = 70.34$ are determined. Referring to Chi-square distribution, the value of $\chi^2_{\alpha;r} = 31.31$ for $\alpha = 0.05$. Therefore, the null hypothesis is rejected which implies that both covariance structures are significantly different which leads to identifying which companies influence the stability of stock exchange using optimal minimum spanning tree, network topology and degree centrality measure.

Optimal Minimum Spanning Tree

There are a few methods to monitor the structure of interrelated variables. For example, principal component analysis (Loretan, 1997), neural network (Fu and Kara, 2011; Kara *et al.*, 2011), minimum spanning tree (Sharif *et al.*, 2012; Rostrup *et al.*, 2013; Setiawan, 2014) and optimal minimum spanning tree (Djauhari, 2013; Djauhari and Gan, 2015). In this case, every stock is considered as a complex network system consisting of 77 stocks as nodes connected by several numbers of links. Each of links is related to the correlation coefficient between the two nodes adjacent to it. Later, the nodes and links will be considered as a network (Sharif *et al.*, 2012).

Let X_i and $\langle X_i \rangle$ denote the i-th characteristic and the average of X_i, respectively; $i = 1, 2, \dots, p$. The correlation networks are summarized in correlation matrix C. It is a symmetric matrix of size $p \times p$ where the element in i-th row and j-th column is:

$$\rho_{ij} \frac{X_i X_j - X_i X_j}{\sqrt{(X_i^2 - X_i^2)(X_j^2 - X_j^2)}} \qquad (3)$$

The correlation coefficient of vectors X_i and X_j that serves to quantify the degree of their linear relationship. By definition, $p_{ii} = 1$ for all i and p_{ij} is between -1 to 1 for all $i \neq j$. Thus, C is a numerical summary representing the complex system of characteristics together.

In general, the standard practices to use this method are as follows:

(i) Transform C into a distance matrix D where

$$D_{ij} = \sqrt{2(1 - \rho_{ij})} \text{ for all } i, j = 1, 2, \dots, n \qquad (4)$$

(ii) Find an optimal MST in D which represents the filtered important information contained in D
(iii) Analyse the topological property of all characteristics using degree centrality (Borgatti, 1995)

Let A be the adjacency matrix with element $a_{ij}(u) = 1$ if the nodes are links in the MST from node i to node j, otherwise $a_{ij}(u) = 0$. Therefore, the degree centrality of node u is denoted by:

$$E_{(u)} = \sum a_{ij}(u) \qquad (5)$$

(iv) Solve (i)-(iii) using Matlab and simplify complex structure using Pajek software

OMST Algorithm

From fuzzy relation view point, these properties show that D is a symmetric and antiflexible fuzzy relation with D as the membership function. Subsequently, the SDU of D is the min-max transitive closure denoted by D^{*K} for an integer; $2 \leq K \leq n$ (Djauhari and Gan, 2015).

By using D^{*K}, we construct the forest of all MSTs in D. Let F be a forest of all MST and $(i = i_1, i_2, ..., i_p = j)$ be the chain from i to j in F. If we define the distance d between i and j in F by:

$$\hat{d}(i,j) = \sum_{k=1}^{p-1} d(i_k i_{k+1}) \tag{6}$$

Then, D is the SDU of D. Therefore, there exists an integer f; $1 \leq f < p$; such that $d^{*k}(i,j) = \hat{d}(i,j) = d(i_f, i_{f+1})$.

Let Δ be a fuzzy relation where its membership function is given by:

$$\delta(i,j) = \begin{cases} 1; d(i,j) - d^{*K}(i,j) = 0 \text{ and } i \neq j \\ 1; d(i,j) - d^{*K}(i,j) = 0 \text{ and } i \neq j \end{cases} \tag{7}$$

Then, Δ is the adjacency matrix that corresponds to the forest of all MSTs in D. In other words, that forest is defined by all pairs (i, j) where $i > j$ and $\delta(i,j) = 1$. Consequently, forest of all MST in D is unique if and only if the number of pairs (i, j), where $i > j$ and $\delta(i,j) = 1$, is $n-1$. Based on (7), we find the optimal minimum spanning tree (Djauhari and Lee, 2012; Djauhari, 2013).

Findings and Discussion

OMST Results

This section presents the comparison network between the first quarter of 2007 and the first quarter of 2008 in identifying which companies are causing the differences of the covariance structure. In this analysis the information of $77 \times (77\text{-}1)/2 = 2926$ correlation coefficients is considered to be filtered by using OMST algorithm.

There are 90 and 87 number of links were produced in 2007 and 2008, respectively. To elaborate the findings more clearly, we present the centrality measure for both network. In Fig. 1 and 2, companies are differentiated by different colour and size subject to their centrality scores as presented in Table 1. The centrality scores are arranged from largest to smallest scores.

In the first quarter of 2007 as in Fig. 1 and Table 1, HWAN (green) has the highest number of links in the network with 11 scores which indicates as the most dominant company. It was followed by the second highest HONG (white) and IGOB (white) with 6 scores respectively. This means that in 2007 the rise or fall (instability) of HWAN, HONG and IGOB will give large impact on the stability structure of the stock market. Since there are interrelated to each other, the companies around of these dominant companies will be directly influenced once the occurrence of global financial crisis. The company that only has one (1) score was less significant to the network and more likely to be influenced by the other companies.
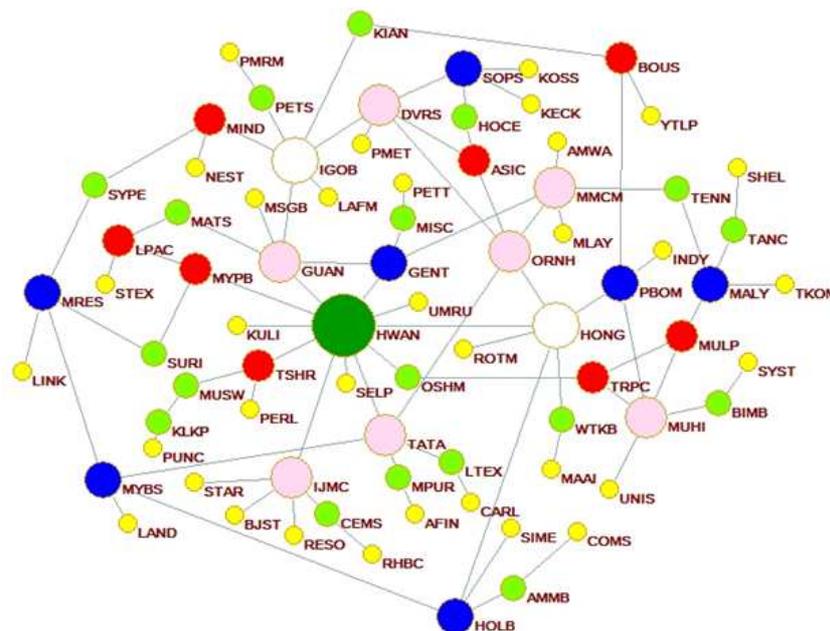

Fig. 1. OMST first quarter of 2007
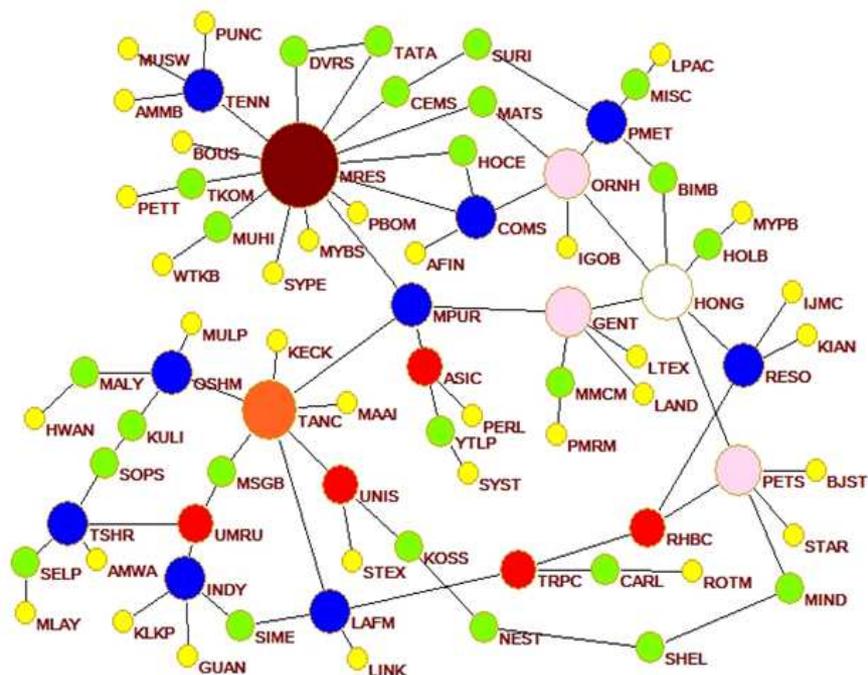
Fig. 2. OMST first quarter of 2008

Table 1. Degree centrality of bursa Malaysia stock price of 2007 and 2008

Code	2007	2008	Code	2007	2008	Code	2007	2008	Code	2007	2008
AFIN	1	1	HONG	6	6	MIND	3	2	SOPS	4	2
MYPB	3	1	HWAN	11	1	MRES	4	14	STEX	1	1
AMMB	2	1	IGOB	6	1	MISC	2	2	SYST	1	1
AMWA	1	1	IJMC	5	1	MMCM	5	2	SELP	1	2
BJST	1	1	INDY	1	4	MUHI	5	2	SHEL	1	2
BIMB	2	2	KECK	1	1	MULP	3	1	SIME	1	2
BOUS	3	1	KIAN	2	1	NEST	1	2	SYPE	2	1
ROTM	1	1	KOSS	1	2	ORNH	5	5	STAR	1	1
CEMS	2	2	KLKP	2	1	OSHM	2	4	SURI	2	2
CARL	1	2	KULI	1	2	MATS	2	2	TATA	5	2
COMS	1	4	LAFM	1	4	PMRM	1	1	TANC	2	7
MUSW	2	1	LAND	1	1	PETS	2	5	TKOM	1	2
DVRS	5	2	LINK	1	1	PETT	1	1	TENN	2	4
MLAY	1	1	LPAC	3	1	LTEX	2	1	TRPC	3	3
GENT	4	5	MPUR	2	4	PERL	1	1	TSHR	3	4
RESO	1	4	MSGB	1	2	PMET	1	4	UNIS	1	3
ASIC	3	3	MALY	4	2	PBOM	4	1	UMRU	1	3
GUAN	5	1	MAAI	1	1	PUNC	1	1	WTKB	2	1
HOCE	2	2	MYBS	4	1	RHBC	1	3	YTLP	1	2
HOLB	4	2									

On the other hand, in the first quarter of 2008 as in Fig. 2, MRES (brown) has the highest scores (14) which indicate as the most dominant company. It was followed by the second highest, TANC (orange, 7 scores) and the third highest HONG (white, 6 scores). This result showed that there was a changed in the structure before (2007) and the beginning (2008) of global financial crisis. It was obvious as displayed by Fig. 1 and 2 where the network topology of the companies was totally different.

Based on Table 1, we computed the difference of scores between those two networks. The highest different in the scores was HWAN and MRES. Both share the same score which was 10 but with different role. HWAN has changed from the most dominant (11) to be the less dominant (1), while MRES has changed from the less dominant (4) to the most dominant (14). The same behaviour was also faced by IGOB and TANC. IGOB shifted 5 scores from 6 scores to 1 scores

and TANC shifted 5 scores from 2 score to 7 score. As for HONG has a score of 0. Based on these scores, the global financial crisis in 2008 affected HWAN but HONG seems to maintain in the network.

Concluding Remarks

HWAN was the most dominant in 2007 before the financial crisis but the scenarios changed in the beginning of the crisis in 2008 where MRES was the most dominant but HONG maintain in both situations. This finding of companies was triggered by the new test known as S^* statistic that been developed for high dimensional data set which existed in this study. The structure changed was significantly detected by the new test and lead to identifying which company affected by the global financial crisis. Thus, highlighted the importance of the new covariance test (S^* statistic) for handling high dimensional data set and optimal minimum spanning tree, degree centrality measure and network topology in visualizing and monitoring the difference of Bursa Malaysia structure stocks market.

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Author's Contributions

Shamshuritawati Sharif: Her main contribution is in research design, statistical test and writing the manuscript.

Suzilah Ismail: Her main contributions are research discussion and reviewing the manuscript.

Zurni Omar: His main contributions are mathematical concept and reviewing manuscript.

Low Huey Theng: Her main contributions are data collection and data analysis.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues involved.

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