

**A MINIMUM SPANNING TREE (MST) OF SHARIAH-
COMPLIANT STOCKS LISTED ON BURSA
MALAYSIA: AN EMPIRICAL STUDY**

BY

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A thesis submitted in fulfilment of the requirement for the
degree of Master of Science (Computational and Theoretical
Sciences)

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ABSTRACT

Stock market is remarkably complex since the growth of stock market is continuous via diverse interactions among them. This complexity motivated researchers to investigate the network structure and to access the situation of stock market. However, less attention has been paid by researchers on shariah-compliant stocks. Thus, in this study, historical prices of shariah-compliant stocks from Bursa Malaysia are used to construct a minimum spanning tree (MST) network. The main contribution of this thesis is to construct networks of Malaysian shariah-compliant stocks from the year 2000 until 2018 using MST method. The networks are constructed based on four periods namely pre-crisis, crisis, post-crisis and the latest five years from the year 2014 until 2018. The performance of every stock in each network is evaluated using eight centrality measures namely degree, betweenness, closeness, eigenvector, eccentricity, domination, strength and average of weight centrality measures. The overall performance of stocks is summarized using a principal component analysis (PCA). The findings show that the hubs of the network changed throughout the four periods. Particularly, ten main clusters are found in pre-crisis network and five main clusters during crisis. In the post-crisis and the latest five years network, there are seven clusters and twelve clusters, respectively. The networks are analyzed based on the different criterion using centrality measures method and the centrality measures are then concluded using PCA. The results of PCA show that in the pre-crisis and post-crisis periods KUB Malaysia Berhad (6874) played an important role in both networks. While, during the crisis period the important stock was Unisem (5005) and the latest five years network shows that MK Land Holdings (2291) was the most important stock. This thesis can be considered as a reference to investors in terms of the overview of Malaysian shariah-compliant stock's network and important stocks for different periods. This information will help investors to strategize their portfolio selection.

خلاصة البحث

إن سوق الأسهم عملية معقدة بشكل ملحوظ حيث أن نمو سوق الأسهم مستمر من خلال التداخلات المختلفة فيما بينها. وقد حفز هذا التعقيد الباحثين على التحقق في بنية الشبكة ومعرفة حالة سوق الأسهم، ولكنهم أعطوا الأسهم المتوافقة مع الشريعة الإسلامية القليل من الاهتمام. ولهذا استخدمت هذه الدراسة الأسعار السابقة للأسهم المتوافقة مع الشريعة من سوق البورصة (تتمثل المساهمة الرئيسية لهذه الأطروحة في بناء شبكات من الأسهم MST الماليزية لبناء الشبكات المتفرعة صغرى). تم إنشاء الشبكات بناء على أربع فترات MST الماليزية المتوافقة مع الشريعة من عام 2000 حتى 2018 باستخدام طريقة وهي: فترة ما قبل الأزمة، وفترة الأزمة، وفترة ما بعد الأزمة، والسنوات الخمس الأخيرة من 2014 حتى 2018. تم تقييم أداء كل سهم في كل شبكة باستخدام ثمانية مقاييس مركزية وهي: الرتبة، والبيئة، والقرب، والمتجه الذاتي، واللامركزية، والهيمنة، والقوة، ومتوسط مقاييس مركزية الحمل. تم تلخيص الأداء العام للأسهم باستخدام تحليل المكونات الرئيسية (PCA). أظهرت النتائج أن محاور الشبكة قد تغيرت خلال الفترات الأربعة. تم العثور على عشر مجموعات رئيسية في PCA شبكة ما قبل الأزمة، والشبكات الخمس الرئيسية في فترة الأزمة. في فترة ما بعد الأزمة كان هناك سبع مجموعات، واثني عشر مجموعة في شبكة الخمس سنوات الأخيرة. تم تحليل الشبكات بناء على السمة المختلف باستخدام طريقة المقاييس أنه في فترات ما قبل الأزمة وما بعد PCA. أظهرت نتائج PCA المركزية، بعد ذلك تم تحليل المقاييس المركزية باستخدام (6874) دورًا مهمًا في كلتا الشبكتين. أما في فترة الأزمة فقد كان KUB Malaysia Berhad الأزمة لعبت شركة (2291) كان MK Land Holdings (5005) السهم المهم، وأظهرت شبكة الخمس سنوات الأخيرة أن Unisem السهم الأكثر أهمية. بالإمكان اعتبار هذه الأطروحة مرجعًا للمستثمرين بناء على النظرة العامة المعطاة لشبكة الأسهم الماليزية المتوافقة مع الشريعة الإسلامية والأسهم المهمة لفترات مختلفة، وستساعد هذه المعلومات المستثمرين على وضع الاستراتيجيات لاختيار محافظهم الاستثمارية.

APPROVAL PAGE

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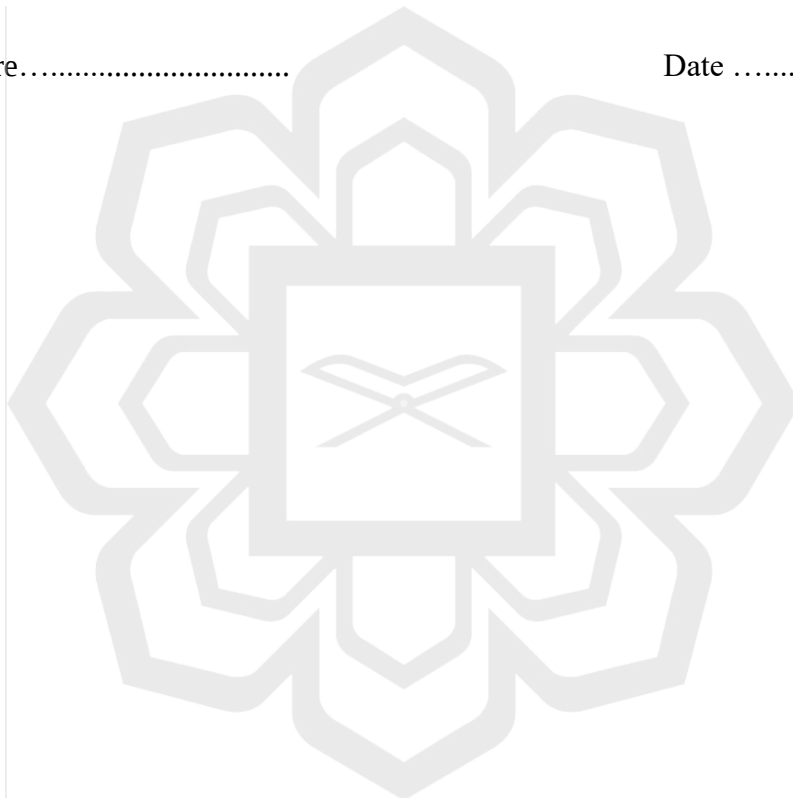
DECLARATION

I hereby declare that this thesis is the result of my own investigation, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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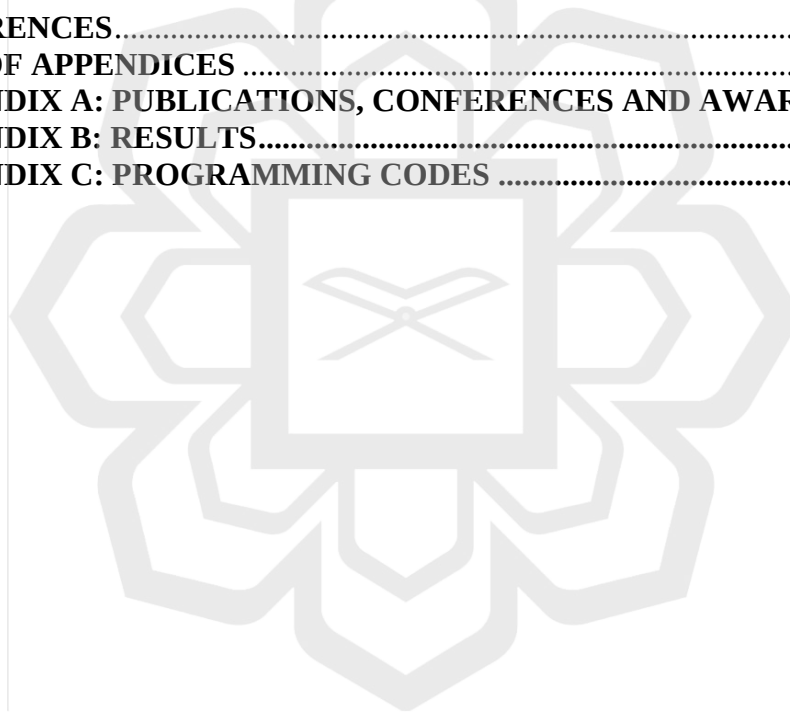
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Chapter One

INTRODUCTION

1.1 BACKGROUND OF STUDY

Complex system is a system in which a behaviour is difficult to be represented, to predict and control such as the human brain and the world economy. In many cases, a complex system is in fact useful to be represented as a network. A complex network is one of the most broadly used in the analysis of a complex system such as a complex correlation-based network. The advantage of a complex network is that it is able to visualize a correlation network graphically which makes complex network dominant in various applications in social science, transportation, biology, communication and financial studies.

In financial study, the structure of a stock market is tremendously complex as stock market is always developing through various interactions among the stocks. Generally, correlation between stocks is based on the stock's price in which a stock's price fluctuates from time to time. This price mechanism makes the correlation among stocks very complicated and complex. Such complexity consequently makes it difficult to illustrate a network. This complication has motivated researchers to further their studies and explore the configuration within a financial network (Bonanno et al., 2008; Zhuang, Hu, & Ye, 2008; Jang, Lee, & Chang, 2011; Cheong et al., 2012; Wiliński et al., 2013; Kazemilari &man Abdurachman, 2015; Majapa & Gossel, 2016; Huang, Yao, Zhuang, & Yuan, 2017; Jo et al., 2018; Li & Pi, 2018; Yao & Memon, 2019). Also, in Malaysia, there are studies investigate financial network using stocks listed in Bursa

Malaysia (Hafizah et al., 2019; Hafizah, Mimi Hafizah, & Supian, 2015; Yee & Rohayu, 2018; Yee, Rohayu, & Norhaidah, 2018).

Additionally, a correlation-based network concept is beneficial in the study of financial markets in which it is an appropriate representation of a relationship between stocks. A financial market network also provides an insight that is vital to the development of a stock market and risk control for investors. Furthermore, investigating a financial market network is a continuing concern particularly regarding association between the financial crisis and the stock market structure. However, there are problems raised.

1.2 RESEARCH GAPS

This thesis raised three problems. The first problem is related to data in which the previous literatures only focus on the conventional stocks on Bursa Malaysia. Previous studies only pay attention on the top 100 stocks based on market capitalisation with distinctive time frame. Lee and Maman Abdurachman (2012) analysed the the top 100 stocks of Bursa Malaysia from the year 2007-2009 and Hafizah et al. (2015) in the year 2011 until 2013. Later, Yee and Rohayu (2018) extended the period from the year 2011 until 2017, while, Hafizah et al. (2019) covers from the year 2006 to 2010.

However, there has been no little empirical evidence that related to minimum spanning tree (MST) with the use of shariah-compliant stocks. The motivation to explore the financial network of shariah-compliance stocks because of the increasing demand of shariah-compliant securities from market participants. Annual report of Securities Commision Malaysia (2016) recorded that there were 671 totals of shariah-compliant securities in 2016. The number increases to 686 in the year 2017. As at end December 2018, the number of shariah-compliant securities continue to increase with

689 out of 915 listed securities in Bursa Malaysia. According to the annual report of Securities Commission Malaysia (2018) there are 33 new securities are added in the list of shariah-compliant securities in the period of June 2018 until December 2018. In addition, it is reported by annual report of Securities Commission Malaysia (2018) that the ICM represented 60.55% Malaysia's capital market in 2018. In the year 2018, the size of ICM documented as MYR 1,880.73 billion compared to MYR 1,893.47 billion in 2017 and MYR 1,691.64 billion in 2016. The increasing demand gives an indication that shariah-compliant securities are received much attention from market participants in Malaysia. This is might be due to market participants realized the importance of following the ethical administration in business activities in order to build an upcoming sustainable economy (Siti Kholifatul & Radjie Fauzan, 2016). Thus, the market participants support the shariah-compliant companies because shariah-compliant companies are free from interest, gambling, uncertainty and non-permissible activities as reported by Shariah Advisory Council of Securities Commission Malaysia (2018). To some extends, the characteristics of shariah-compliant attract not only muslims but also non-muslims community whose value the ethical conduct in their business (El Qorchi, 2005).

The second problem raised is about the centrality measure used in analysing an MST of Bursa Malaysia. A lot of the studies of Bursa Malaysia have been limited to the four centrality measures namely degree, betweenness, closeness and eigenvector to identify the importance of each stock in MST. Example of such studies are Hafizah et al. (2019), Yee and Rohayu (2018), Yee et al. (2018) as well as Lee and Maman Abdurachman (2012), in which these studies identified the important stocks among the top 100 stocks in Bursa Malaysia by using degree, betweenness, closeness and eigenvector. The four common centrality measures focus on identifying the importance

of stocks based on the number of adjacent links, the intermediary player, the total shortest distance (Freeman, 1978) and the connectivity with important stocks (Bonacich, 1987). However, these four centrality measure have failed to measure the the importance of stocks according to the total of shortest paths (Hage & Harary, 1995), the direction and weight (Van Den Brink and Gilles, 2000), the weight of the links (Barthélemy, Barrat, Pastor-Satorras, & Vespignani, 2005) and the average of weight of a particular stock (Shamshuritawati & Maman Abdurachman, 2012). Thus, the centrality measure should be extended into another four centrality measure such as eccentricity, domination, strength and average of weight in order to accurately evaluate the importance of each stocks.

The third problem is related to the selection of the most influence stock on the network. To date, the most influence stocks has been determined by using the principal component analysis (PCA) as in seminal works of Hafizah et al. (2019), Yee and Rohayu (2018), Yee et al. (2018) as well as Lee and Maman Abdurachman (2012). However, the computation of the PCA as in previous literature only based on the degree, betweenness, closeness and eigenvector centrality.

1.3 RESEARCH OBJECTIVES

The main objective of this thesis is to construct a Malaysian shariah-compliant stock network from the year 2000 until 2018 by using a minimum spanning tree (MST). Then, the most importance stock on the network is identified.

The specific objectives are as follows:

1. to construct a networks of shariah-compliant stocks that listed on Bursa Malaysia by using a minimum spanning tree (MST) method for full cycle of financial market (pre-crisis, during crisis, post-crisis) and also, for the latest five years (2014-2018).

2. to propose another four centrality measures such as eccentricity, domination, strength and average of weight in order to identify the most importance stock on the network.
3. to determine the central hub of the networks using principal component analysis (PCA) method based on eight centrality measure namely degree, betweenness, closeness, eigenvector, eccentricity, domination, strength and average of weight.

In order to achieve these objectives, this follows a research flow as shown in Figure 1.1



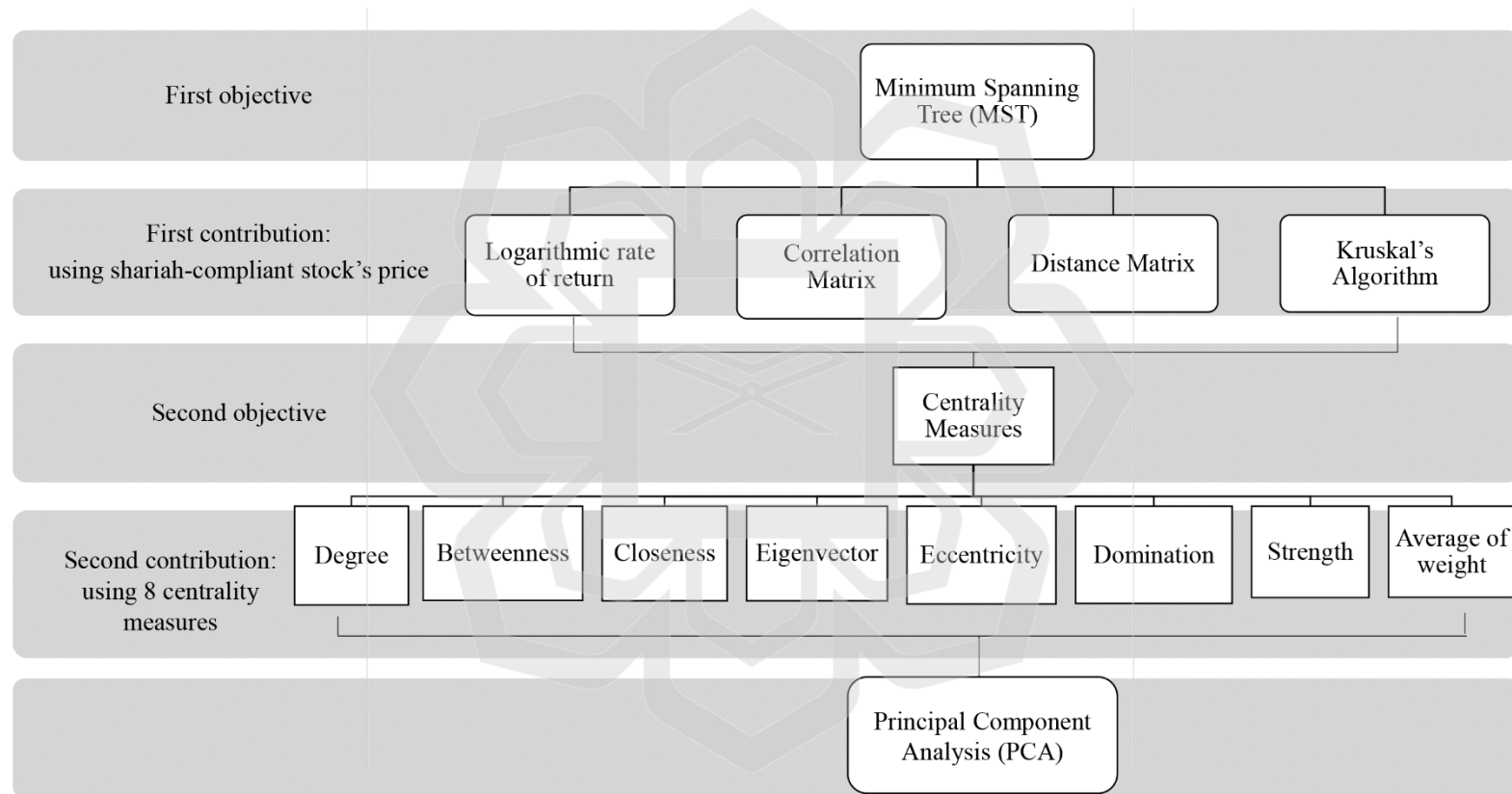


Figure 1.1 Research Flowchart

1.4 RESEARCH SCOPE

This study uses the historical prices of Malaysian shariah-compliant stock in which retrieved from the Eikon Datastream database. The data covers from the year 2000 to 2018. This thesis only considers shariah-compliant stocks in Bursa Malaysia that are consistently appear in the list of Shariah Advisory Council of the Securities Commission Malaysia (SAC) from the year 2000 until 2018.

1.5 SIGNIFICANT OF STUDY

This study makes a major contribution to finance in which the research is on shariah-compliant stocks network and consequently determining the important stocks in each duration. This study aims to offer a few important insights to investors who are interested in shariah-compliant stocks by giving them an overview of the network's structure and providing the most important stocks in the network for the periods given. Therefore, this study can be capitalized as guidelines to investors for determining the correlation between stocks and for selecting stocks to build a better portfolio. This study is different in certain ways when compared with previous research as depicted in the Table 1.1. Consequently, providing the justification of the study.

Table 1.1 Comparisons between Previous Literature and This Thesis

Authors	Previous literature	Contribution of this thesis
Hafizah et al. (2019, 2015), Yee and Rohayu (2018), Yee et al. (2018), Maman Abdurachman and Siew Lee (2014), Siew Lee and	The MST of Malaysian financial network was constructed using conventional stocks.	This thesis uses the Malaysian shariah-compliant stocks to construct financial network using MST.

Maman Abdurachman
(2012, 2013),
Shamshuritawati and
Maman Abdurachman,
(2012)

Hafizah et al. (2019,
2015), Yee and Rohayu,
(2018) and Yee et al.
(2018), Siew Lee and
Maman Abdurachman,
(2012)

The importance of
every stock was
determined only using
at most four common
centrality measures
such as degree,
betweenness,
closeness and
eigenvector centrality.

This thesis extends other four
centrality measures such as
eccentricity, domination,
strength and average of
weight centrality measure.

Hafizah et al. (2019), Yee
and Rohayu (2018), Yee et
al. (2018), Siew Lee and
Maman Abdurachman,
2012)

The overall
performance of stocks
was summarised based
on four centrality
measures using
principal component
analysis (PCA).

This thesis summarised the
overall performance of stocks
based on eight centrality
measures by using principal
component analysis (PCA).

1.6 THESIS ORGANIZATION

This thesis consists of seven chapters. Chapter 2 introduces a brief concept of graph theory that employed in the minimum spanning tree (MST) as well as a few definitions related to the MST.

Chapter 3 provides the applications of minimum spanning tree in distinctive studies including financial network. Then, the chapter introduces prior study related to financial network using minimum spanning tree (MST) with different financial markets such as foreign markets and Malaysian market. Lastly, it shows the application of centrality measures in different financial markets.

Chapter 4 describes the data used in this study and includes the introduction of Securities Commission and Syariah Advisory Council (SAC). Besides, this chapter

provides the core definition of shariah-compliant stock according to SAC. Finally, the detailed descriptions of data used is provided.

Chapter 5 presents the methodology used which consist of three main methods namely minimum spanning tree (MST), centrality measures and principal component analysis (PCA). These methods are applied in order to achieve all the objectives. The first method is applied in order to construct a financial network and the second method is used to examine the importance of each stock in the network. Lastly, PCA is employed to conclude the overall importance of each stock in the network.

Chapter 6 provides results and discussions of the analysis for four durations namely pre-crisis, crisis, post-crisis and the latest five years from the year 2014 to 2018. Additionally, the summary of findings is provided at the end of this chapter. Finally, Chapter 7 gives the conclusion of the study and also includes a discussion of the implication of the findings and suggestions for future research. The remaining part of the thesis consists of references and appendices.

Chapter Two

AN OVERVIEW OF GRAPH THEORY

2.1 INTRODUCTION

This chapter gives an introduction to the concept of graph theory in which a basis for minimum spanning tree (MST). The definitions presents in this chapter is referred to the book that written by Diestel (2017). In the section 2.2 depicts the very basic definitions in graph theory such as the definition of a graph, vertices and edges. Then, the types of graphs also provided in the section 2.3. In the last section 2.4, the definition of tree is illustrated.

2.2 CONCEPT OF GRAPH THEORY

Graph theory concept is one of the most widely used concept in network science. According to Newman (2010), in real-world systems, a graph is also called as a network. The application of a graph theory such as in the demonstration of the relationships between two objects of study makes it dominant in various applications including in the field of physics (Garziad & Saka, 2017), biology (Gao et al., 2018), social science (Chakraborty et al., 2018) and transportation (Asrah et al., 2017).

Graph is a pair $G = (V, E)$ of sets such that $E \subseteq [V]^2$; thus, the elements of E are 2-element subsets of V . The elements of V are the vertices (or nodes, or points) of the graph G , the elements of E are its edges (or lines). Diestel (2017) stated that in order to picture a graph is by drawing a dot for each vertex and joining two of these dots by a line if the corresponding two vertices form an edge.