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A NETWORK ANALYSIS OF MALAYSIAN ECONOMIC SECTORS

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Abstract: Over the past 50 years, the Malaysian economy has seen many changes in line with its economic policies. In the early 70s, the country's economic achievements were driven by the agricultural sector, but today it has shifted to the services sector. There are specific sub-sectors in the services sector that have played a larger role in the shift and subsequent contribution to the country's economic success. There are also services sub-sectors related to the non-service sector, such as the manufacturing and agriculture or other sectors. In Malaysia, the input-output table is one of the most widely used mediums for viewing and analysing the local economic structure. However, the analysis of the sub-sectoral relations derived from the input-output analysis is limited. This study examines the position and role of sub-sectors and inter-sectoral flows in the national economic system by combining input-output tables with network modelling. It also analyses the structure of the Malaysian economy of 2015 by using input-output data and network analysis to visualise the contribution of key sectors of the economy. Based on network analysis, it was found that seven sub-sectors are significant contributors of which four were from the manufacturing sector. A clear understanding of the economic position of the sectors is crucial because identifying the different roles of an industry in the complex economic network, policymakers can formulate and implement policies more objectively and effectively.

Keywords: Network analysis, input-output, economic structure, economic sector.

Introduction

Over the past 50 years, the country's economic performance has changed dramatically in line with its fiscal policies. According to a report from the Economic Planning Unit (2016), beginning in the 70s, the country's economic performance was driven by the agricultural sector (31.8%), which was followed closely by the services sector (29.2%), the mining sector (24.5%) and the rest from the manufacturing and construction sectors.

In the 80s, the agricultural sector (25.9%) was no longer the major contributor to gross domestic product (GDP) following the growth of the services sector (33.7%). Meanwhile from the early 2000s to date, the country's economic structure has continued to change with the services sector leading the way.

In 2016, the data showed that the major contributors to the gross domestic product of the country were from the services sector (53.7%), followed by the manufacturing (23%), mining (8.5%) and construction sectors (4.6%).

It concluded that Malaysia's economic structure has changed from agriculture to the service economy. For the past 50 years, the agriculture and mining sectors have declined while the services, manufacturing, and construction sectors continue to show promising performance growth. The continuity of the sectors' economic achievements was evaluated through the country's gross domestic product output.

Although the services sector is seen as a significant contributor to the gross domestic product, it is only a rough measure. Many sub-sectors in the services sector contribute to the economic growth of the country. There is no doubt that there are specific sub-sectors which play a larger role in the economic performance of the country than other sub-sectors, but these sub-sectors have links with non-service sectors, such as the manufacturing and agricultural sectors.

However, existing information does not indicate the relationship between the service sector and other sectors or sub-sectors. The lack of a detailed analysis on the existing sectors and sub-sectors that play a role in the economic growth may cause the country to deviate from its economic plan and be unable to make or implement a proper strategic decision.

Previously, any industrial policy intended to protect or stimulate specific sectors would start with the appropriate identification of the sector's importance to the Malaysian economy. Introduction to key sectors in the study of the economic structure has been highlighted in previous studies such as those from Dietzenbacher (1992), Hewings (1982), Rasmussen (1956) and Schultz (1977). The link between one key sector and another is essential, especially to show how the sectors are interconnected. For example, it can be seen that the services sector depends on the agricultural and other sectors.

In Malaysia, the input-output table is one of the most widely used medium for viewing and analysing the local economic structure. The input-output table is designed to provide an overview of the flow of goods and services purchased and sold by the various sub-sectors in the economy. This study aims to show the relationships between the sub-sectors, measure the interactions between sub-sectors in generating output and using intermediate inputs including backward and forward-looking connections.

Backward-looking connections or backward links reflect interactions between input suppliers to the sub-sector, while the forward-looking connections or forward links reflect interactions between the sub-sectors and output users.

In general, the input-output model shows the flow of input suppliers and output users and detects the relationships between the various sectors of the economy. However, the input-output analysis does not indicate the sector's position in the economic structure and the role that each sector and sub-sector plays in helping the nation grow.

Information about the key sectors and sub-sectors in economic growth is crucial for policymakers to have to help with formulating the appropriate policies to promote more efficient and faster economic growth. Therefore, this study aims to identify each of the economic sub-sectors, their respective positions in the economy, the roles that they play and analyse the sub-sectors' relationships with each other and the Malaysian economy as a whole by using network modelling.

The use of network modelling can provide a clear link between each sub-sector and give a clear picture of which sub-sector is connected to which. It also can show how changes in a sub-sector may affect other sectors in the economy. An analytical approach using network modelling has long been widely used in various other fields of study because of its potential to provide new insights into the understanding of complex phenomena. Fields that have used network modelling successfully include the fields of biology (Albert, 2005; Barabási & Oltvai, 2004), economics (Kitsak *et al.*, 2010; Pammolli & Riccaboni, 2002; Yu & Ma, 2020) and finance (Markose *et al.*, 2012; Ramadiah *et al.*, 2018; Said, 2016).

Network analysis can provide access to more complex information based on the data sources under review. Network visuals can help analysts understand the features of a structure, recognize their relevance and see each unit's role in the entire network.

However, network modelling studies on the sectors that play a crucial role in the economic growth of a country, especially in Malaysia are still limited. Therefore, this study aims to identify each of the economic sub-sectors positions and roles using a network modelling approach.

Given the current uncertain economic climate in both the domestic and international markets, it is difficult for policymakers to make informed decisions and implement effective policy measures. Nonetheless, the Malaysian economy needs to continue implementing policy initiatives that will contribute to its continued economic well-being and sustainability.

The purpose of this study is therefore to provide policymakers with a different perspective of each sector's relationship with the Malaysian economy as a whole. By clearly understanding local economic sectors and recognising the different roles that each sector plays in the network system, a more strategic policy can be implemented.

Therefore, this study aims to analyse the local economic structure using input-output data and network modelling to help policymakers visualise the contributions of key sectors of the Malaysian economy.

The first part of this article is the introduction; the second part deals with the literature review and this is followed by a discussion of the methodology, empirical results, and conclusions.

Literature Review

It is vital to know and understand the sustainability of the various sectors in the economy of a country. Almost all of the sectors in the economy are linked together, and sustainable and as such the interactions between them needs to be well-protected. For example, the manufacturing sector draws on inputs from all sectors, while the services sector largely depends on inputs from other services (Saari *et al.*, 2018).

Even though there are linked together, the interactions between the various sectors of the economy are not widely known or understood. This study employed the use of a matrix model for its Input-Output table because that would indicate the relationship between the various industries in the economy by showing how the outputs of one industrial sector can be used as inputs in another.

This research paper adopted Leontief's methodology to study the flow on inputs and outputs between the various sectors of the domestic economic system. The approach used by (Leontief, 1936, 1951, 1974) through which input-output have been analysed has widely used to scrutinise various related cases.

As Saari and Rashid (2006) said in their research paper, that the advantages of domestic input-output tables were that the data used was more comprehensive and consistent. The input-output analysis involved both the direct and indirect relationships between various industries and the Malaysian economy, the sources and flow of the economic sectors change based on the input-output schedules, and the input-output analysis involved in balancing the economy.

Based on these advantages, input-output analysis and tables are one of the best techniques that researchers and economic planners can use to help them formulate national economic policies because of its ability to demonstrate the country's economic balance as a whole.

Even though the input-output analysis is a valuable tool for supporting the structural relationships among important sectors of a country or region's economy (Rasmussen, 1956; Tsekeris, 2015), this method relies only on the absolute or relative magnitude of the important sectors, without taking into account the heterogeneous characteristics such as a particular sectoral role and the interconnectivity or stability of the whole economic system (Tsekeris, 2015). Therefore the adoption of the method suggested by Boccaletti *et al.* (2006) and Newman (2003) which was adapted from graph theory, also known as a network modelling, is seen as a suitable tool to be used to overcome the lack of previous input-output analysis. This method can show each of the economic sub-sectors' relative positions and roles based on several analyses using graph theory or network modelling methods such as clustering, coreness and centrality measurement.

Many previous studies focused on using the input-output model to analyse the flow of products and services as it relates to the economic sector. However, this research paper aims to extend its research and use network analysis to visualise the complex systems in the Malaysian economy in a manner that previous researchers have not. There is a need to use network modelling to picture and visualise the link between one sector and another and to highlight the core and periphery sectors showing each sector's contribution to the economy as a whole.

Basically, in the economy, a chain of effects all take place all together at the same time. The effects can be seen in as a supply of outputs to meet the demand for inputs and vice-versa (Tsekeris, 2015). Using complex network modelling visualisation techniques can show how each sector in the economy is interconnected and chained together.

There are still no studies that use network analysis to look at the contribution of Malaysia's various economic sectors. Therefore, this study is the first research initiative that combines Malaysia's Input-Output tables with network modelling and analysis.

Network analysis or complex customisation systems as some authors define it, is one of the tools used to analyse intricate structures. In recent years, network analysis appears to have been widely used in the field of economics especially with regard to analysing relationships in international trade (Kitamura & Managi, 2017; Said & Fang, 2019; Yu & Ma, 2020) and those of financial networks (Markose *et al.*, 2012; Said, 2016).

Although international trade and financial networks are the most popular fields to employ the use of network analysis methods it can be used to establish relationships input-output networks as well.

There have been several studies on input-output analysis that have made use of existing network methodologies set down in the available literature (Blochl *et al.*, 2011; Chen *et al.*, 2018; Li *et al.*, 2018; Wang *et al.*, 2018). A study by Blochl *et al.* (2011) came up with two main steps that were viewed as compatible with input-output networks that contained strong self-loops that were found to be fully connected. From the perspective of sectoral centrality, the findings were supported by countries that were geographically distant and or were of a similar development status.

Based on the results of that study, Belgium and Spain appeared to have a similar centrality, with Turkey and India having similar central positions in their respective economic sectors.

Li *et al.* (2018) in their study developed a carbon emission metabolic network to explore emission reduction strategies by modelling carbon dioxide flow and identifying coherent relationships based on an input-output analysis. The study's results may provide a relevant and comprehensive reference point for decision-makers for the improvement of future mitigation policies.

Meanwhile, the study by Wang *et al.* (2018) showed that there was a direct and indirect link between the energy and water sectors in regional networks based on a study of the monetary flows using multiregional input-output analysis.

Four different types of networks were developed in that study; energy networks, water-related power networks, water networks, and energy-related water networks. Finally, an index set for ecological network analysis was used in that study to investigate these four networks' properties and connections.

To measure how well the economy has integrated over time, several other studies such as those by Kali and Reyes (2007), Kim and Shin (2002), Liang *et al.* (2016), Prell (2016), Su (1995) and Yu, Feng and Hubacek (2014) used network analysis to describe the entire network structure. Looking at network visualisation can help with understanding a structure's features and recognising each unit's role in the whole network structure.

A study by Chen and Chen (2013) worked on a multi-region input-output model for the global power flow network in 2007. The research paper developed an input-output network consisting of 6,834 global nodes. The research paper then found that almost 70% of the world's direct energy input was invested in the resources, heavy production, and transportation sectors that provide only 30% of energy content needed to meet the final demand.

The study by Chen and Chen (2013) showed that China was the largest exporter of energy, while the United States is the largest importer.

Grazzini and Spelta (2015) analysed the input-output network's evolution for intermediate goods and found that network fragility increased from 1995 to 2011. They found improvements in several new sectors with China becoming a major centre of global production. China's primary sector is the manufacturing sector, while in the West the primary sectors were the financial and or business services sectors.

Several other studies (Cerina *et al.,* 2015; Liang *et al.*, 2016; Soyyigit & Boz, 2017) have used global inputs as their focus. Soyyigit and Boz (2017) used a network approach to analyse global production outputs from between 1995 and 2011. This study aimed to look at sectoral connectivity and sector centres and see changes in these attributes through comparisons over the duration under review. The results of the study by Soyyigit and Boz (2017) provided information on how demand or supply shocks in the global input-output flow can impact the international production chain.

Finally, Chen *et al.* (2018) in their study applied a variety of tools to analyse the complex networks specifically to reveal the network structure of the global, regional and national energy sector based on an advanced input-output analysis for the environment. They argued that by identifying the different roles of the economy in complex flow systems, more targeted policies can be implemented accordingly.

The application network modelling methodologies to the analysis of key sectors of an economy has been used by several previous studies such as those by Alatriste-contreras (2015), Blochl *et al.* (2011), Giammetti *et al.* (2020) and Tsekeris (2015). The study by Alatriste-contreras (2015) used input-output data and complex network analysis to identify the most important European Union countries' and their most important sectors. The study found that as a whole the most important sectors in each country also become the most important sectors in the European Union.

Aside from that, they found the most central sectors had the best means of spreading the effects of a shock to the system and that they also had a high aggregate impact in the economy. Tsekeris (2015) implemented network tools to perform a multi-scale analysis of the Greek economy to identify inter-sectoral clusters and group interactions between the sectors of the Greek economy. The study's results may provide useful insights into the formulation of a national growth plan to achieve long-term economic growth goals and economic stability.

Realistically, the process of conducting an input-output analysis using a network approach is essential. The input-output model enables researchers to identify and measure resources directly and indirectly through the entire supply chain, whether forwards or backwards.

The use of input-output enables the determination of overall resources that need to be calculated systematically and helps to identify the sources geographical origin. By exploiting information from the input-output tables and the network model, it allows a more critical evolution of the data and can find more hidden information.

Such studies can help uncover potential weaknesses in the allocation of resources that may currently be exploited and provide new insights that can assist in the preparation and improvement of a policy.

Previous studies had different data sets, objectives and focuses; all of the previous studies had in common was their use and focus on a group input-output analysis with a network modelling approach. Therefore, to meet the aims of this study required combining of input-output data with network modelling to obtain a holistic assessment of input and output flows for all of the sectors in the Malaysian economy.

Methodology

Data

This study focuses on the specific analysis of the Malaysian economic structure in 2015 based on the Malaysian Input-Output table. Therefore, data from the Malaysian Input-Output table provided by the Statistics Department of Malaysia is required. This study uses the latest data, "Malaysia Input-Output Table 2015", which is published every five years.

The table comprises 124[1] economic sub-sectors, and each input or output transaction is in Ringgit Malaysia (RM).

The software used to complete the network visualisation and all the analyses involving network modelling were developed and performed using the UCINET (Borgatti *et al.*, 2002) and GEPHI software programs (Bastian & Heymann, 2009).

Network Modelling

Input-Output network modelling was derived from social network analysis and emerged as a set of social structure analysis methods, which allowed for the investigation of structural relationships. The use of these methods depends on the existence of the relationships or contact data.

According to Scott (2000), contact data on the other hand is related to people, relationships and connections, or joint and meeting groups that relate one agent to another and that they must be not less than two agents. The relationship between existing agents is not about the agent's nature, but rather about the agents' system. This relationship connects the agent's partner indirectly to the more extensive relationship system.

Network analysis or modelling consists of a set of qualitative measures of network or network structure. The data should be firstly organised in a matrix before conducting visualisation and network analysis. For the purposes of this study, the arrangement in the form of a matrix was used to show the actual relationship and the sub-sector's output value.

In the matrix, the row represents the input value, while the column represents the output value. Based on this study, the Malaysian input-output network matrix is defined by the matrix N x N (124 Malaysian domestic sub-sectors x 124 Malaysian domestic sub-sectors) with N being the sub-sector of Malaysia's 2015 domestic input-output table.

The network matric structure can be viewed from two different perspectives which are binary matrix and weighted value matrix. This study will use the weighted value matrix as proposed by Fagiolo *et al.* (2010) because of its advantages when compared with the binary matrix form.

The binary matrix only determines whether any relationship exists by setting the cut value (Said & Fang, 2019). While the weighted value matrix shows the relationship and proves its existence, the information represents the flow between them. In other words, the weighted value matrix can reveal the character of the network perfectly.

Fagiolo *et al.* (2008, 2009) managed to show a difference between the results of a weighted network analysis and a no-power network analysis. The intensity of the weighted world trade network shifts it to the right.

For this matrix, Xij will represent the actual value of input from sub-sector i to sub-sector j with a row representing the input values, while the columns represent the output values such as the following matrix:

[1] The full list of sub-sectors in the Malaysian Input-Output Table 2015 can be found in Appendix 1

$$X = \begin{bmatrix} 0 & X_{12} & X_{13} & X_{14} & \dots & \dots & \dots & X_{1j} & X_{1n} \\ X_{21} & 0 & \dots & \dots & \dots & \dots & \dots & \dots & X_{2n} \\ X_{31} & \dots & 0 & \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & 0 & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & 0 & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & 0 & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots & 0 & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots & 0 & \dots \\ X_{n1} & \dots & \dots & \dots & \dots & \dots & \dots & \dots & 0 \end{bmatrix} \quad (1)$$

Next, matrix X is changed to its weighted matrix form. In the weighted matrix form W, based on the Fagiolo *et al.* (2010) study, aims to make all the values of ∈ [0,1], all the values in the matrix W need to be divided by the maximum value, while this does not affect the final analysis results.

$$W = \begin{bmatrix} 0 & w_{12} & w_{13} & w_{14} & \dots & \dots & \dots & w_{1j} & w_{1n} \\ w_{21} & 0 & \dots & \dots & \dots & \dots & \dots & \dots & w_{2n} \\ w_{31} & \dots & 0 & \dots & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & 0 & \dots & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & 0 & \dots & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & 0 & \dots & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots & 0 & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots & 0 & \dots \\ w_{n1} & \dots & \dots & \dots & \dots & \dots & \dots & \dots & 0 \end{bmatrix} \quad (2)$$

Network Visual Construction

In this study, the economic networks used input-output data as R = (N, M) where R is the network, N is the number of nodes, and M is the number of links. In this study, the nodes represent the 124 economic sub-sectors in the Malaysian Input-Output table, and the links define the relationships between each sub-sector. The link direction can also be called the input-output flows. The goal of the visualisation as a starting point for this analysis is to get a full picture of the entire network, focusing on key sectors that play an important role in Malaysia's economic activities.

Density

Density in a network model measures how many links are in a network compared with the maximum number of connections between the nodes. Density measures tightness or compactness among all sub-sectors in the Malaysian economic network. The greater the density value, the more integrated the relationships between sub-sectors within the network.

The following equations show the density network (Kitamura & Managi, 2017):

$$Density = m/n(n-1) \quad (3)$$

where n is the number of nodes and m is the number of actual links or connections within the network.

Core and Periphery Structure

In network terminology (Prell, 2016), the primary structure refers to two subdivisions. The core structure consists of nodes or sub-sectors that are interconnected and are the focal point of the whole network structure. The core structure forms an integrated block and shares the same network with other nodes in the network.

On the other hand, a periphery structure refers to a more or less isolated nodes associated with the rest of the network mainly through its relationship with the core structure. Among the core-periphery systems, the core structure is seen to be more likely to benefit, primarily in the form of economic growth (Clark, 2010; Prell, 2016).

Distance (Route Length)

The average path length represents the average number of steps for each sub-sector pair that uses inputs or outputs in the Malaysian economic sector. The longest shortcut is the diameter of the network. Therefore, the average path length can be defined based on Watts and Strogatz (1998) study as follows:

$$l = 1/n(n-1)\sum_{i,j} d_{i,j} \quad (4)$$

Dij represents the shortest distance between nodes *i* and *j*, if nodes *i* and *j* are not able to link or reach each other or $i = j$, then the shortest distance *dij* is equal to 0.

Degree

The node's degree is the number of links per node or sub-sectors in a network, and it's showing network features. Direct networks have two types of degrees that are an in-degree and out-degree. The out-degree represents the value of outputs or a link exit, while the in-degree represents the value of inputs or link that enters one sub-sector. Analysing the degrees of a node or sub-sector can further explore the sub-sectors significance to the Malaysian economy based on its in-degree and out-degree position. The in-degree and out-degree can be defined based on the following equation (Kitamura & Managi, 2017):

$$k_{in}i = \sum_{j=1}^{n} a_{ji} \quad (5)$$

$$k_{out}i = \sum_{j=1}^{n} a_{ij} \quad (6)$$

Aij is the value of the input link, and *aij* is the output link's value. While k_{in} is the degree of entry and k_{out} is the degree of exit.

Empirical Results

Descriptive Analysis

Table 1 shows a descriptive analysis of the overall pattern of Malaysia's 2015 input-output data. The 124 nodes that comprise the 124 economic sub-sectors in the national economy that are included in the 2015 Malaysian input-output table. The links represent the weighted value of input or output for the sector, and here the first minimum score value is 0 to a maximum of 1.

Table 1: Results of descriptive analysis for Malaysia input-output network 2015 using weighted value

Item	Value
Edges	15,252
Clustering Coefficient	0.645
Mean	0.001
Standard Deviation	0.013
Sum	21.005
Variance	0
Minimum	0
Maximum	1
Eigenvalue	0.525
Density	0.5847

The total link value is 21, with the average link value being 0.001. While the total possible edges are 15,252 shows the total number of all possible directed or connected links between the counterparties. The clustering coefficient is 0.645, which has established a highly clustering connection between one sector and another sector.

The eigen value is 0.525. According to May (1972), the stability of the network can be shown by the eigenvalue. The network is determined to be stable if its maximum eigenvalue is smaller than 1.

Network Visualisation

Figure 1 shows the Malaysian economic structure as a network visualisation based on data from the Malaysian Input-output table 2015. The purpose of the visualisation is as a starting point is to get an overview of the network (Lovrić *et al.*, 2018) focusing on the sectors that play a significant role in the Malaysian economy.

According to the 2015 Malaysian input-output table, the local economic structure comprises 124 (S-1 to S -124) economic sub-sectors. Out of 124 economic sub-sectors, these sub-sectors divided into 12 major sectors in Malaysia: manufacturing, utilities, construction, finance and others.

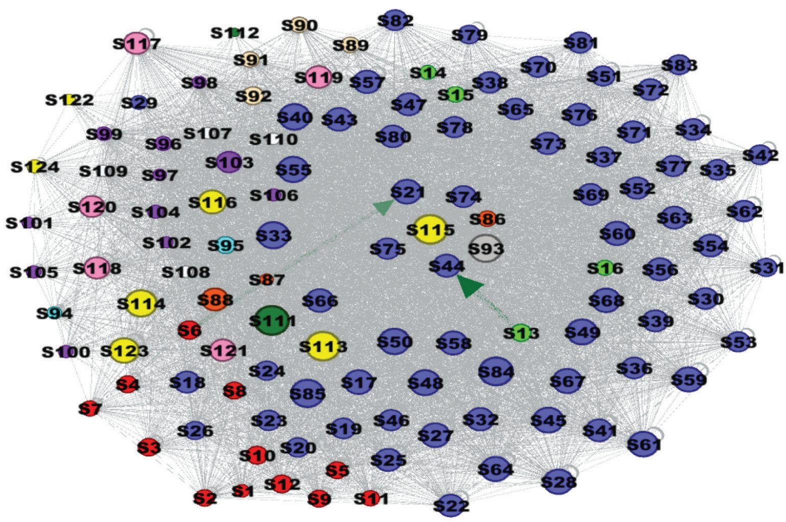

Figure 1: Malaysian Economic Structure 2015
Source: Data from the Malaysian Input-Output Table 2015 visualised by the author using Gephi

Diagram Indicator[2]

	Sector
1	Agriculture, forestry & fisheries
2	Mining & quarrying
3	Manufacturing
4	Utility
5	Construction
6	Wholesale & retail trade
7	Accommodation, food & beverage
8	Transportation, storage & communication information
9	Finance & insurance
10	Real estate & homeownership
11	Business & private services
12	Government service

[2] Each colour represents different sector

The core of Malaysia's economic structure concentrated on the manufacturing and agriculture, forestry, and fisheries sectors. It showed that the core sectors are highly interconnected to other sectors, whereas other sectors have less interconnectedness. Based on the flow of input-output networks above, the Malaysian economy is interconnected across its sectors. Each of the sectors is linked to one another showing that they are interconnected. The high degree of interconnection indicates manufacturing, utilities, wholesale, retail trade and both the business and the private services sectors are connected with other sectors in the economy.

Most of the core sectors are highly interconnected, indicating how vital these sectors are to other sectors. For example, the manufacturing sector has a high interconnection with the agriculture, retail, business, and other sectors.

Density

In this study, the number of nodes is equal to the total sub-sector, 124 sub-sectors, and the total number of links or actual links in the network is 8,918. Based on the total number of nodes and the number of actual links, the density obtained is 0.5847 (Table 1).

Density in the network model is used to measure the closedness of compactness among all sectors of the Malaysian economic network. The greater the density value, the more integration between sub-sectors within the network.

Thus, based on density measurement, almost 58% of the economic sub-sectors in Malaysia are integrated. In other words, the density value also represents the degree of network efficiency (Hou *et al.*, 2018), the larger the value, the closer the relationship between all nodes.

The density value can be ranked in three basic levels which are high value (70% and above), low value (40% and below), and median values (between 40% to 70%) (Alatriste-contreras, 2015). Based on the perspective posited by Alatriste-contreras (2015), the high-density value is the value that reflects high connectivity of the economic system where sectors are highly dependent on almost all other sectors and vice-versa. Based on this ranking, this research paper concludes that Malaysia has a middle density value. That value reflects a midlevel connectivity between members of the economic system where the sectors are moderately dependent on each other in the Malaysian economy. Other countries that have middle density value levels are Austria, Finland, Poland, Netherlands, Slovenia, Spain and Sweden (Alatriste-contreras, 2015).

Core and Periphery Structure

Based on Figure 1 and Table 2, it shows that seven sub-sectors, S-21 (Vegetable & Animal Oils & Fats), S-44 (Coke & Refined Petroleum Products), S-74 (Electronic Components & Boards), S-75 (Communication Equipment & Consumer Electronics), S-86 (Electricity & Gas), S-93 (Wholesale & Retail Trade, Repair of Motor Vehicles & Motorcycles) and S-115 (Professional) were the "core sub-sectors" of Malaysia's economic structure in 2015, while the remaining 117 sub-sectors were "periphery sub-sectors".

The core sub-sectors were from the manufacturing, services, and trade sectors. The core sub-sectors were nodes with many links and high integration levels with other sub-sectors within the network.

Based on Malaysia's 2015 input-output data, the total production for the seven significant sub-sectors amounted to almost RM500 billion and accounted for 40.62% of the total output in 2015.

The remaining 59% of the total output came from 117 periphery sub-sectors. Periphery sub-sectors comprise a set of sub-sectors with a little linkage and lower integration levels than the core sub-sectors within these input-output networks.

Based on network analysis, it shows that seven sub-sectors are core sub-sectors. Four of

Table 2: Result for core-periphery

Structure	Sub-sector
Core	S-21 S-44 S-74 S-75 S-86 S-93 S-115
Periphery	S-1 S-2 S-3 S-4 S-5 S-6 S-7 S-8 S-9 S-10 S-11 S-12 S-13 S-14 S-15 S-16 S-17 S-18 S-19 S-20 S-22 S-23 S-24 S-25 S-26 S-27 S-28 S-29 S-30 S-31 S-32 S-33 S-34 S-35 S-36 S-37 S-38 S-39 S-40 S-41 S-42 S-43 S-45 S-46 S-47 S-48 S-49 S-50 S-51 S-52 S-53 S-54 S-55 S-56 S-57 S-58 S-59 S-60 S-61 S-62 S-63 S-64 S-65 S-66 S-67 S-68 S-69 S-70 S-71 S-72 S-73 S-76 S-77 S-78 S-79 S-80 S-81 S-82 S-83 S-84 S-85 S-87 S-88 S-89 S-90 S-91 S-92 S-94 S-95 S-96 S-97 S-98 S-99 S-100 S-101 S-102 S-103 S-104 S-105 S-106 S-107 S-108 S-109 S-110 S-111 S-112 S-113 S-114 S-116 S-117 S-118 S-119 S-120 S-121 S-122 S-123 S-124
Correlation Core/Periphery	0.4749

Source: Data from the Malaysian Input-Output Table 2015 visualised by the author using UCINET 6

these sub-sectors were from the manufacturing sector: the utilities, wholesale and retail trade, as well as the business and private services sectors.

As anticipated by the study of Vandermarliere, Standaert, and Ronsse (2016), if the theory of core-periphery structure occurs, network structure can be separated into the core structure of highly integrated or connected nodes. The periphery structure is highly integrated or connected with the core structured nodes but not periphery (side structure) and this can be seen through visualisation in Figure 1.

As the core structure has highly integrated or connected nodes, if a shock hits one of the country's core sectors, it will have a strong impact on the whole economic structure and vice-versa (Alatriste-contreras, 2015). The high integration or connectivity of core sub-sectors allows for targeted shocks to propagate from one sub-sector to another, thus making the economy fragile.

If core sub-sectors are intentionally targeted or accidentally affected, the effects can ripple rapidly across the entire system. Therefore, this paper concludes that core sub-sectors are good sub-sectors for selective promotion and are vulnerable points in the economy for negative shocks or hits.

Distance

Table 3 shows the calculation of path length between economic sub-sectors using data from the Malaysian Input-Output Table 2015.

It shows that a sub-sector's length to another sub-sector is either between one sub-sector, two sub-sectors, three sub-sectors, and over three sub-sectors.

Table 3: Results for the distance between the sub-sectors of the economy

Distance (sub-sector)	Frequency	Ratio (%)
1	8631	0.566
2	5634	0.369
3	3	0.000
>3	984	0.065
Average Path Length	1.4	

According to Table 3, 8631, sets of relationships between sub-sectors or 56.6% of the real connections between sub-sectors require only one step to reach one sub-sector. Besides that, 36.9% of all sub-sector relationships need only two steps to get the other sub-sectors, and 6.5% or 984 of the sub-sectors relationships require more than three sub-sectors to reach another sub-sector.

The distance or path length of this study in other words (Hou *et al.*, 2018), each sub-sector may have indirect relations with other sub-sectors if there is a mediator between them. The mediators act as a "bridge" indirectly, linking any sub-sector and its input or output to another sub-sector.

In this study, the average overall path length was 1.4 steps between sub-sectors. It showed that the average shortest path length inferred that most of the sub-sectors in the Malaysian economy have substantial relationships with each other.

The event of a systemic shock to any one of the economic sub-sectors will directly impact all the other sub-sectors involved with the input or output.

Degree

Table 4 lists input and output degrees of the top 10 sub-sectors and the lowest ten sub-sectors of Malaysia's economic structure 2015. The node

Table 4: Results for In-degrees and Out-degrees for the top 10 Sub-sectors and the lower 10 sub-sectors

No.	Sub-sector	In-degree	No.	Sub-sector	Out-degree
1	S-93	1.747	1	S-93	2.916
2	S-21	1.584	2	S-44	1.849
3	S-44	1.437	3	S-115	1.337
4	S-74	0.820	4	S-13	1.098
5	S-95 0.646		5	S-6	0.784
6	S-91	0.540	6	S-86	0.740
7	S-90	0.530	7	S-74	0.638
8	S-89	0.503	8	S-92	0.611
9	S-115	0.500	9	S-75	0.538
10	S-45	0.484	10	S-45	0.524
N_i	-	-	N_i	-	-
115	S-19	0.012	115	S-119	0.000
116	S-8	0.012	116	S-42	0.000
117	S-79	0.011	117	S-81	0.000
118	S-35	0.010	118	S-89	0.000
119	S-122	0.010	119	S-90	0.000
120	S-2	0.009	120	S-112	0.000
121	S-34	0.009	121	S-114	0.000
122	S-16	0.008	122	S-120	0.000
123	S-1	0.004	123	S-121	0.000
124	S-42	0.001	124	S-122	0.000

Source: Data from the Malaysian Input-Output Table 2015 visualised by the author using UCINET 6 degree is the link value of each node within a network representing its essential characteristics.

As described earlier, directed networks have two types of degrees, which are in-degree and out-degree. The out-degree represents the output value of the outbound link sub-sector, while the in-degree represents the input link value of a sub-sector. Analysing all the sub-sectors' degrees helps to explore further the important sectors of the Malaysian economy based on each sub-sector's input and output values .

According to Table 4, out of the ten sub-sectors with the highest in-degree value, four sub-sectors are from the manufacturing sector, three sub-sectors from the construction sector, while the rest, were from the wholesale and retail trade sectors, accommodations, food and beverage sector, and the business and private services sector.

Meanwhile with regards to the highest out-degree value, out of the 10 sub-sectors, four sub-sectors were from the manufacturing sector. The remaining sub-sectors with the highest out-degrees were from the agriculture, forestry and fisheries sector, the mining and quarrying sector, utilities sector, construction sector, wholesale and retail trade sector, and the business and private services sectors, which accounted for one sub-sector each. The sectors with the highest in and out-degrees were from the manufacturing sector.

These findings are in line with the findings of Saari *et al.* (2018) where the manufacturing sector uses the most inputs from across all sectors compared with other sub-sectors.

Sub-sectors with high input and output degrees are potentially vital to generating demand and indirectly distributing growth across the economic system. Identifying the sub-sectors that exhibit the highest input and output levels is essential because each sub-sector will influence the other sub-sectors of the economy differently based on the links and values.

For example, negative demand shocks impact or positive demand shocks impact from one sub-sector to another varies based on outputs taken from the sub-sectors affected by demand shocks' impact. Analysing the degree will provide a clearer picture of the changes in other sectors of the Malaysian economy.

It is essential to know the position of the sectors based on their degrees. In the event of a systemic shock, whether the reduction/increase in production in the Malaysian economy will have a small or large effect is based on the degree value of the sub-sector. By analysing all the nodes' and degrees, researchers can further explore the relationships between the nodes or sub-sectors, input or output statuses, and identify changes in network structure over time (Hou *et al.*, 2018).

Conclusion

The result of this study provides in-depth knowledge of the dominant sectors in the Malaysian economy. The relationships between these sectors and how other sectors can benefit from linking with one another are addressed by merging the Input-Output tables and analysis with network modelling.

The findings show that the government can promote to maximise growth based on the core structure such as the manufacturing, utilities, wholesale and retail trade, and business and private services sectors are the core sectors that are most influenced by others.

Findings also found that the sectors with the potential for further development were based on sub-sectors with high in-degree and out-degree. As each, sector in the economy is interconnected and chained to one another, sectors with high degree values are vital in generating demand and indirectly distributing growth throughout the economic system.

Therefore, this study contributes to the policymakers by suggesting structural economic policies that are more efficient and effective by understanding each sector's importance. Policymakers can design initiatives to link one sector to another to contribute to both sector's economic growth. The manufacturing sector is the most core sector based on the analysis of the sample.

Therefore, this core sector can help other periphery sectors expand and grow based on how interconnected the sector is, how it is linked and where its edges are.

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Appendix 1: 124 Sub-Sector in Malaysia Input-Output Table 2015

No.	Code	Sub-Sector
1	S-1	Paddy
2	S-2	Food Crops
3	S-3	Vegetables
4	S-4	Fruits
5	S-5	Rubber
6	S-6	Oil Palm
7	S-7	Flower Plants
8	S-8	Other Agriculture
9	S-9	Poultry Farming
10	S-10	Other Livestock
11	S-11	Forestry and Logging
12	S-12	Fishing and Aquaculture
13	S-13	Crude Oil and Natural Gas
14	S-14	Mining of Metal Ores
15	S-15	Quarrying of Stone, Sand and Clay
16	S-16	Other Mining and Quarrying
17	S-17	Processing and Preserving of Meat
18	S-18	Processing and Preserving of Seafood
19	S-19	Processing and Preserving of Fruits & Vegetables
20	S-20	Dairy Products
21	S-21	Vegetable & Animal Oils and Fats
22	S-22	Grain Mill Products, Starches and Starch Products
23	S-23	Bakery Products
24	S-24	Confectionery
25	S-25	Other Food Processing
26	S-26	Prepared Animal Feeds
27	S-27	Spirits, Wines and Liquors
28	S-28	Soft Drinks, Mineral Waters and Other Bottled Waters
29	S-29	Tobacco Products
30	S-30	Preparation, Spinning and Weaving of Textiles
31	S-31	Finishing of Textiles
32	S-32	Other Textiles
33	S-33	Wearing Apparel
34	S-34	Leather Products
35	S-35	Footwear
36	S-36	Sawmilling and Planning of Wood
37	S-37	Veneer Sheets and Wood-based Panels
38	S-38	Builders' Carpentry and Joinery
39	S-39	Wooden Containers and Other Wood Products
40	S-40	Paper and Paper Products
41	S-41	Furniture
42	S-42	Reproduction of Recorded Media

43	S-43	Printing
44	S-44	Coke and Refined Petroleum Products
45	S-45	Basic Chemicals
46	S-46	Fertilisers and Nitrogen Compounds
47	S-47	Paints and Varnishes
48	S-48	Pharmaceuticals, Medicinal Chemical & Botanical Products
49	S-49	Soaps & Detergents, Cleaning & Polishing, Perfumes and Toilet Preparations
50	S-50	Other Chemicals Products
51	S-51	Rubber Tyres and Tubes
52	S-52	Rubber Processing
53	S-53	Rubber Gloves
54	S-54	Other Rubber Products
55	S-55	Plastic Products
56	S-56	Glass and Glass Products
57	S-57	Refractory, Clay, Porcelain and Ceramic Products
58	S-58	Cement, Lime and Plaster
59	S-59	Non-Metallic Mineral Products
60	S-60	Basic Iron and Steel
61	S-61	Basic Precious and Other Non-Ferrous Metals
62	S-62	Casting of Metals
63	S-63	Structural Metal Products, Tanks, Reservoirs and Steam Generators
64	S-64	Other Fabricated Metal Products
65	S-65	Engines & Turbines, Fluid Power Equipment, Other Pumps & others
66	S-66	Other General Purpose Machinery
67	S-67	Weapons, Ammunition and Special Purpose Machinery
68	S-68	Domestic Appliances
69	S-69	Computers, Peripheral, Office Equipment and Machinery
70	S-70	Electric Motors, Generators and Transformers
71	S-71	Electricity Distribution & Control Apparatus, Batteries and Accumulators
72	S-72	Fibre Optic, Electronic and Other Electric Cables
73	S-73	Wiring Devices, Electric Lighting Equipment and Other Electrical
74	S-74	Electronic Components and Boards
75	S-75	Communication Equipment and Consumer Electronics
76	S-76	Irradiation Equipment, Electro Medical and Electrotherapeutic
77	S-77	Measuring Equipment, Testing, Navigating and Control
78	S-78	Optical Instruments, Photographic Equipment, Magnetic and Optical Media
79	S-79	Watches and Clocks
80	S-80	Motor Vehicles, Trailers and Semi Trailers
81	S-81	Motorcycles
82	S-82	Ships, Boats, Bicycles and Invalid Carriages
83	S-83	Other Transport Equipment
84	S-84	Other Manufacturing
85	S-85	Repair & Installation of Machinery and Equipment
86	S-86	Electricity and Gas

87	S-87	Water
88	S-88	Sewerage, Waste Management & Remediation Activities
89	S-89	Residential Buildings
90	S-90	Non-Residential Buildings
91	S-91	Civil Engineering
92	S-92	Specialized Construction Activities
93	S-93	Wholesale & Retail Trade, Repair of Motor Vehicles and Motorcycles
94	S-94	Accommodation
95	S-95	Food and Beverage
96	S-96	Land Transport
97	S-97	Water Transport
98	S-98	Air Transport
99	S-99	Warehousing and Support Activities for Transportation
100	S-100	Services Incidental to Water and Air Transportation
101	S-101	Highway Operation Services, Bridge and Tunnel
102	S-102	Postal and Courier Activities
103	S-103	Publishing Activities
104	S-104	Telecommunications
105	S-105	Motion Picture, Programming and Broadcasting Activities
106	S-106	Computer and Information Services
107	S-107	Monetary Intermediation
108	S-108	Other Financial Service
109	S-109	Insurance/Takaful and Pension Funding
110	S-110	Activities Auxiliary to Financial Service and Insurance/Takaful
111	S-111	Real Estate
112	S-112	Ownership of Dwellings
113	S-113	Rental and Leasing
114	S-114	Scientific Research and Development
115	S-115	Professional
116	S-116	Business Services
117	S-117	Public Administration
118	S-118	Education
119	S-119	Health
120	S-120	Public Order and Safety
121	S-121	Other Public Administration
122	S-122	Non-Profit Institutions Serving Households
123	S-123	Arts, Entertainment and Recreation
124	S-124	Other Private Services