DEVELOPING DIGITAL ECONOMY INDEX FOR THE CASE OF MALAYSIA

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ABSTRACT

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By

Anthony Foo Kim Long

The study of digital economy in the research has played an important role as the trends of evolution from traditional economy to the digital economy. In the recent years, there are many developed and developing countries had constructed their own indicators to measure the digital economy performance for their countries. However, there are less research is focusing on indicate the economy in Malaysia. Therefore, this study is focused to measure and predict the digital economy performance with the newly constructed Digital Economy Index (DEI) by using the publicly available database. The procedure used in this study to construct a composite indicator was the from the ideas that proposed by the Conference Board. The DEI was constructed from 4 component dimension and follow by more than 20 indicators. The construction of DEI is significant as it can use by the policymakers to predict and measure the digital economy performance for the country.

ABSTRAK

MEMBANGUNKAN INDEKS DIGITAL EKONOMI BAGI KES DI MALAYSIA

Oleh

Anthony Foo Kim Long

Kajian ekonomi digital dalam penyelidikan telah memainkan peranan penting sebagai trend evolusi dari ekonomi tradisional kepada ekonomi digital. Dalam tahun-tahun kebelakangan ini, terdapat banyak negara maju dan membangun telah membina penunjuk mereka sendiri untuk mengukur prestasi ekonomi digital untuk negara mereka. Walau bagaimanapun, terdapat penyelidikan yang kurang fokus untuk menunjukkan ekonomi di Malaysia. Oleh itu, kajian ini difokuskan untuk mengukur dan meramalkan prestasi ekonomi digital dengan Indeks Ekonomi Digital (DEI) yang baru dibina dengan menggunakan pangkalan data awam. Prosedur yang digunakan dalam kajian ini untuk membina penunjuk komposit adalah dari idea-idea yang dicadangkan oleh Lembaga Persidangan. DEI dibina dari 4 dimensi komponen dan diikuti oleh lebih daripada 20 petunjuk. Pembinaan DEI adalah penting kerana ia boleh digunakan oleh pembuat dasar untuk meramalkan dan mengukur prestasi ekonomi digital untuk negara.

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CHAPTER ONE

INTRODUCTION

1.0 Introduction

Digital economy was the economic term which identified that the economic was influenced by digital technologies included the activities of transactions and others economic processes. Tapscott (1995) was the first person mentioned this term which from the book “The Digital Economy: Promise and Peril in the Age of Networked Intelligence written by him. The book had discussed that how the internet would change and give impact for the business and the economic world. According to Negroponte (1995), the digital economy was the digital networking and communication infrastructures that serve as a worldwide platform for everyone to access, interact and collaborate between each other. The new economy allowed the people to get more information and faster the speed of business from the processing atoms to processing the bits.

The digital economy was play the very important role for the country developing process. It was played the role as the driver of innovation, competitiveness and growth. There were many trends had been highlighted by the new digital economy world which included the cloud computing, smart grids, mobile web services and social media. All of these trends had radically changed the landscape of business, reconstruct the nature work and globalize business scope. By an innovation from technology, all the knowledge and information can be transfer and access to the

international markets. By the statistical result showed that, there were only 2 billion of people was connected to the internet, but in 2019 showed that 4.39 billion internet users which was increase double versus the year 2016.

Besides that, the digital economy also important to create a new opportunity for business through the invention of new products and services, supply platform and allocation to the markets. By digital economy, the society well-being will also increase and reduced the inequity, imbalance and the unfairness in the term of knowledge and information sharing. Moreover, the digital economy also given the advantages and improvement to the environmental sustainability such as decreasing the fossil fuel emission via an increase of telework, smart public transport system and digital logistics. Furthermore, developing of digital economy by the improved of telecommunication such as the 5G internet can also boost up the whole economy. This was because the business can connect to various party within the short period of time. By this way, the competitiveness will be increased and given the contribution to the economy growth such as the GDP.

Although the digital technology had contributed a lot to the economy, but there was the problem to measure the contribution of digital economy. This was because the digital economy was abstract and virtual which we cannot count in unit and it is difficult to measure it from the traditional economy. So, this research is conducted to investigate the pattern of digital technology towards the economic in Malaysia and

developed the digital economy index as the benchmark for the digital economy in Malaysia.

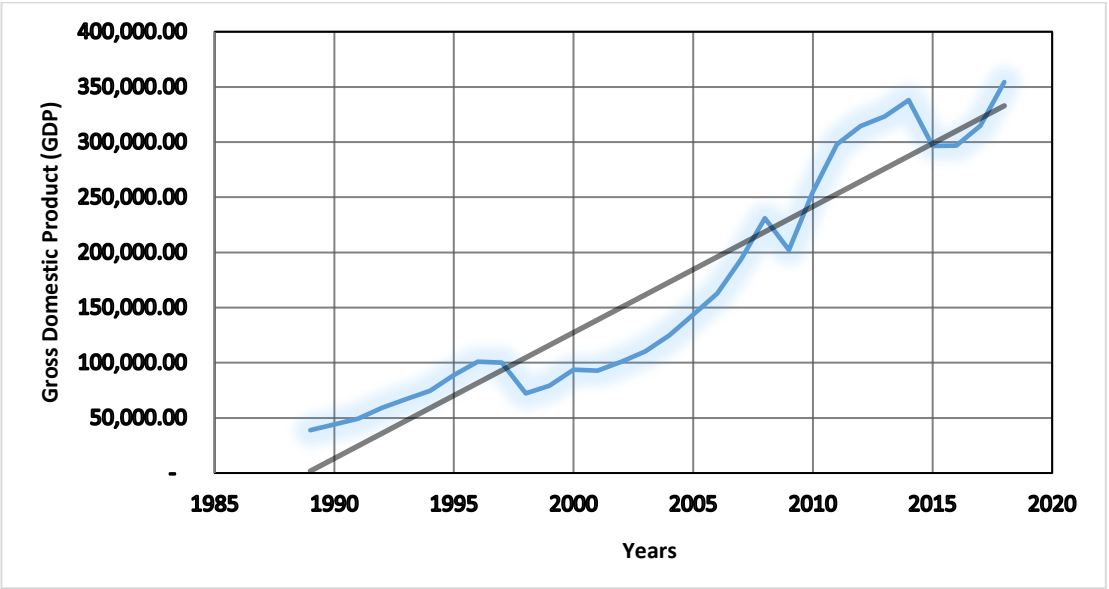
1.1 Background of the Study

Malaysia as the developing countries at the Asia region that involve applying the digital technology in the economy. Digital economy in Malaysia is supervise by the Malaysia Digital Economy Corporation Sdn. Bhd. which establish by Malaysia's government in year 1996. The initiative of this institution is to develop the concept of digital economy in Malaysia. This Malaysia Digital Economy is focus to the policy formulated and coordination of agencies to enable success, development of futureproof workforce to grow the Digital Economy ecosystem and contribute the digital technology to the growth of the Gross Domestic Product (GDP) in Malaysia.

According to Schumpeter (1934) and Solow (1956) had stated that there was positive relationship exist between ICT infrastructure and economic growth via their study. This is because the innovation and development of digital technology such as in communications and transactions has simplify the business process and boost the productivity. Thus, the people are more easily connected to others and exchange information and knowledge between each other. In Malaysia, there are increasingly for the development of ICT infrastructure from year to year. This is because the government of Malaysia has believed that the digital economy is the alternative way for the traditional economy to boost the economy for Malaysia. Therefore, there were

many policies had developed to encourages the participate of the business to join this platform in order to boost the economic growth especially the GDP.

Figure 1: Gross Domestic Product (GDP) of Malaysia from 1989 to 2018

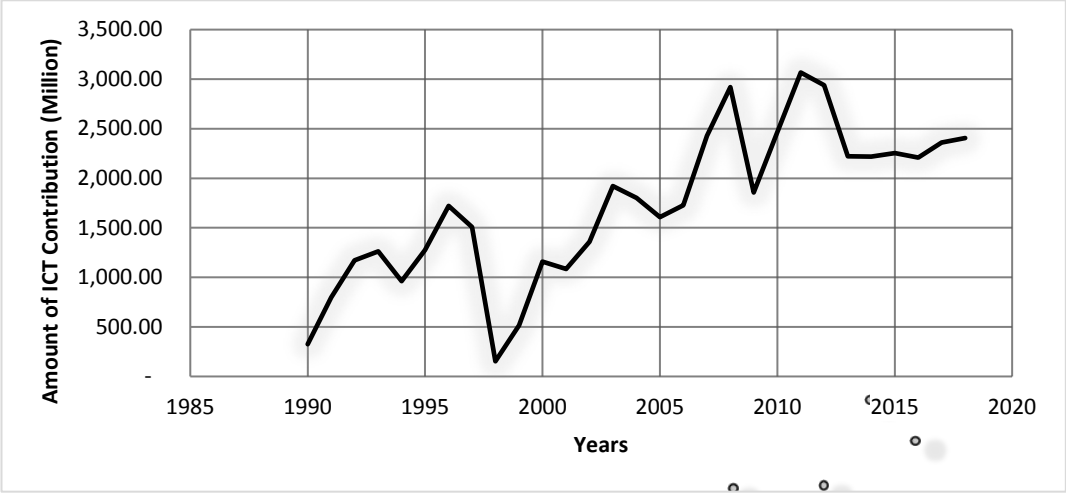


Source: The World Bank (2019)

Figure 1 depicts the data of Gross Domestic Product (GDP) over the 30 years period from year 1989 to year 2018, while the table 1 shows the Gross Domestic Product (GDP) and the changes between years to years. From this figure, the GDP is fluctuation year by year in the increasing pattern from year 1989 to year 2018. The biggest changes of the GDP were recorded by year 1998 which was only 72,167 million dollars as compare to the previous year 1997 which is 100,005 million dollars. There were 38.57% decrease of the GDP from year 1997 to 1998. This is because the year 1997 had recorded a serious crisis of financial according to (Khoo and Hui, 2010).

In year 1997, the financial crisis happened by the collapsed of currency market and stock market had cause the dramatically decrease in the GDP of Malaysia. However, the GDP had increase steadily after the year 1998 and recorded the highest GDP value in year 2018 which was 354,348 million dollars.

Figure 2: Contribution of ICT to Gross Domestic Product (GDP) of Malaysia from 1990 to 2018



Source: Conference Board (2019)

Figure 2 showed the data of the ICT contribution to the Gross Domestic Product (GDP) from 1990 to 2018. The data was retrieved from the Conference Board. From this figure 2, the highest ICT contribution was recorded in year 2011 which is 3,067 million dollars. However, the lowest ICT contribution to the GDP was recorded in year 1998 which only 153 million dollars. It was the dramatically drop of amount of ICT contribution from year 1997 to 1998 which is from 1,508 million dollars to 153

million dollars. There was 89.85% decrease of the ICT contribution. This is because the financial crisis in year 1997 give the impact to the investor and the not stable of money currency cause the investor to decrease their investment in this digital technology.

In short, the historical data had showed that the growth in ICT will leads to the growth in the GDP of Malaysia. Basically, the change in the ICT structure will also give the impact to the GDP growth such as the financial crisis in year 1997 which reduce in the ICT investment will also cause the drop in GDP. From this viewpoint, ICT can be one of the important factors that will affect economy growth for the countries. Therefore, the study needs conducted to identify the measurement for the digital technology to the economy growth of Malaysia.

In the Shared Prosperity Vision 2030 policy, the federal government has highlight that a goal for 10 years in order to change Malaysia from the low-skill labour-intensive economy to a knowledge-based economy which improve the standard living for the citizens Malaysia. Malaysia was aimed to become a nation that sustainable growth in various aspect which included the fair and equitable distribution without limit by different income groups, ethnicities and regions. Thus, main focus goal to achieve this vision is boost the economic growth within this 10 year. The dependency on export commodities that always fluctuate in price also be one of the reasons that cause the low economy growth for Malaysia as compare to others East Asia countries.

Moreover, the low adoption of high technology in Malaysia also cause the lagging for the growth of economic.

According to Murtada, S. (2019), the digital economy for Malaysia on average has shown that value added terms increase 9% per year from 2010 to 2016. Statistically, the grown of digital economy is greater than GDP growth in Malaysia. This has highlighted the country's digital economy as a growth source of expansion. Besides that, even as Malaysia has developed a strong base in ICT and digital technology that will eventually become a major force in the economy of Malaysia but that is not enough and more effort need to put it to boost it furthermore. From this viewpoint, digital economy has become an important source and leapfrog Malaysia achieves the Fourth Industrial Revolution. So, end-goal was established Malaysia as a regional digital powerhouse in the new era to the Fourth Industrial Revolution and ensure the digital economy become one of the forces drive shared prosperity for all Malaysians.

1.2 Problem Statement

Digital economy was introduced early in year 1995 by Don Tapscott. Although there were various previous researchers had study on this topic, but there was not a specific study to the digital economy for the case of Malaysia. The study done by the previous researchers focused mostly on the impact of the ICT to the GDP. Therefore, in this study will be done on the measurement of digital economy to serve as a benchmark to measurement the economy performance of Malaysia.

Although the digital economy had contributed to the growth of economy, but we still cannot capture the progress and the improvement of economic from the contribution of digital economy. This is because the digital economy was invisible and cannot measure it directly. Thus, this digital economy index can serve as an alternative assessment tool indicate the progress. Moreover, there are not effectiveness for the measurement of the economic performance from the present indicator. This is because the existence indicator was not comprehensive and not cover every component of measurement indicator to measure the economy performance from digital perspective. Therefore, this developing of digital economy index might serve as a comprehensive forecasting tool to predict the change of the economy performance. Besides that, the digital economy index also can serve as a benchmark and tools for future development.

Furthermore, most of the variables used to measure the digital economy performance were ICT variables. In this sense, the ICT variables were not a good component to measure the digital economy because it is not comprehensive and only one of the driving forces behind the backbone. Thus, the ICT variables cannot represent the whole digital economy. ICT variables were only the tools to develop the economy, but it ignores the other factors such as the empowering society, jobs and growth and education. Therefore, ICT variables can only portray the general idea of digital progress but not represent the good indicator to measure the digital economy.

1.3 Objective of the Study

The objective of this study is to develop a Digital Economy Index (DEI) for the case of Malaysia to measure digital performance in Malaysia.

The specific objectives of this study are:

i. To construct a composite Digital Economy Index (DEI) in Malaysia.

ii. To identify the baseline (reference) chronology of digital economy in Malaysia.

iii. To identify the leading power of the constructed Digital Economy Index (DEI) in forecasting digital performance in Malaysia.

iv. To examine the directional accuracy of the constructed Digital Economy Index (DEI) in forecasting digital performance in Malaysia.

1.4 Significance of the Study

The study is conducted develop a digital economy index for the case of Malaysia. From the previous research, the researchers mostly focus to identify the impact of digital technology to the status of economic develop by using country approach which is study on developed country, developing country and the international organization countries. There are less focus and attention for the case in the single country such as Malaysia. Moreover, there are also no clear measurement for the digital economic.

Thus, this study is important and can be a reference and used by the different group of people such as government and society.

The first category of sector which can benefit from this study is the government. digital economy index can be the guideline and benchmark for the government to implement the plan such as the budget and policy. By this digital economy index, the government can forecast the trends of economic in the future and can imply different policy to solve different economic problems. Besides that, the digital economic index can also be the reference for government which indicate that the trend of economy changes for the future period. Apart from that, digital economy index can also become a benchmark to the government in order to measure the economy improvement progress.

Apart from that, the society will also get the advantages from this digital economy. This is because, the index will show the level development of economy and as a reference for the society to continue enhance this digital technology. Furthermore, the society can also gain the confidence by refer this index which show that the status of economy for Malaysia. By this index, the society will get and explore to all the information and data in clearly image without any confusing and misunderstand to the economy change. Thus, the comprehensive of digital economy index will serve as a forecasting tool to the trend of economy in the future.

1.5 Organization of the Study

This study was organized and presented into several sections to develop the digital economy index for the case of Malaysia. Chapter 1 was discussed the introduction, background of study, motivation, problem statement, objective and significant of the study. The chapter 2 reviews and summarized the past studies that similar to this topic. This chapter two will be divided by four parts which included theoretical review, empirical review, testing procedure and summary of the literature reviews. The chapter 3 will discuss the references series, selection series, data description, index construction method and empirical models. Next, all data result and analysis of finding are discussed in chapter 4. Lastly, the chapter 5 will make conclusion and recommendation of policy for the study conducted.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The goals of the study were conducted to develop the digital economic index as a benchmark of economic growth for the case of Malaysia. The Chapter two was discussing the literature review of past study that are similar to this study. However, previous have examine different results from various countries by using a different approach. From this chapter, the theoretical frameworks, methodology used and findings from the previous study will be discussed. This chapter will cover the introduction, theoretical review, empirical review, testing procedure and concluding remark for this chapter.

2.1 Theoretical Reviews

The digital economy concept was existed at the early stage of economic from the theory of post-industrial society (Bell, 1974). This theory explained that the shifts of society and economy from the producing and providing goods and products to the services. In this theory, the new technology was important to provide the services and information. Thus, this theory encouraged the evolution and development of technology such as the IT and cybersecurity. Information society has been the central element which can affect the production process by the advance production technology, marked as the beginning of information economy theory by Porat (1997)

at the later stage. Information economy theory was defined that economically valuable information were produce, process and transmit by the specific industries and occupations as their primary function.

Tapscott (1995) described that digital economy was allowed different people to free access of information and facilitate knowledge between each other without considered the limitation of geographic. Besides that, he depicted that the digital economy should have twelve characteristics. There was knowledge, digitization, virtualization, molecularization, integration or internetworking, disintermediation, convergence, innovation, prosumption, immediacy, globalization and discordance. Digital economy has played a role as a driver to transfer all the knowledge and information in digital form to different peoples in different places by the short time period. As the digital economy was possible to convert all the physical things into virtual things, the interaction for the business will be more flexible to connect with each other.

The definition of Negroponte (1995) is slightly different with Don Tapscott. The theory of atoms and bits from him has explained that the process of delivery change from the form of atoms to bits. In the world of traditional economy, the information was delivered in the form of atoms such as newspapers, magazines and book. However, by transformation the atoms to bits, the information was in form of no size, color and weight. When the problem and information was embodied as atoms, the middleman and huge corporation was needed to delivery such as FedEx. But, when

the atoms shift to bits, the traditional postman was no longer needed. This means that we can received and delivered any information instantly and represented in numerical information.

In addition, the production and distribution of knowledge Machlup (1996) had described that the formation of new knowledge is not over until it was transferred to the others person. By this process, the knowledge can be produced by the information. However, Thomas Mesenbourg (2001) had stated that digital economy concept can be identified into three main components. The three components were E-business infrastructure, E-business and E-commerce. The infrastructure of E-business was the used of all the electronic business process such as hardware, software and telecommunication networks to support the business. E-business was the business conducted based on the computer network and the digital technology while the goods and services sold by the network platform was defined as E-commerce.

According to Lane (1999), the people were allowed to exchange their knowledge without restriction by the information flow. Moreover, the flow of information and technology also increased the interaction between the people. Thus, the evolution of computer and communication technologies had stimulated electronic commerce which can change the organization structure. At the same year, Margherio et al. (1999) had first identified and categorized the digital economy into four drivers. There are building out the internet, electronic commerce among businesses, digital delivery of goods and services, retail sale of tangible goods. This segmentation of

digital economy was focused on foundations of digital economy more than the economy itself.

In the year 2000, Brynjolfsson and Kahin (2000) had emphasized that most of the sectors of economy were still unrealized the transformation of the computer-enabled digitization of information. The understanding was needed for the digital economy from various angles such as macroeconomics, competition, organizational change and labor. On top of that, Kling and Lamb (2000) had given the different definition from the Margherio et al. (1999) for the segmentation of digital economy. The new segmentation foe digital economy were digital goods and services, mixed digital goods and services, IT intensive services of goods production and IT industry. From this segmentation, there were focused on the goods and services development, production and sales from develop of digital technologies.

The term of ‘Digital Economy’ was first mentioned in year 1990. Concept and term of digital economy defined that evolution and changed of technology nature and the frequency applied from companies and consumers (Barefoot et al., 2018). When end of 1990s, most of the research were mainly concerned and focused for the internet adoption. Besides that, early thinking of impact from the internet to the economy also be considered which refer to the “Internet economy” [Brynjolfsson and Kahin, (2002); Tapscott, (1996)]. Expansion of internet usage has resulted in the emerge and steady growth of internet economy since the mid-2000s (OECD, 2012; 2014). Various policies and digital technology also be concerned and analysed by the evolution of

internet. Moreover, the develop of ICT and digitally oriented companies also become the important factors and give impact to others. By the pass of the time, internet connectivity had improved in developing countries and transform the firm into digital oriented in term of products and services. Thus, research on digital economy had pointed more focus analyses for the economic condition in developing country (UNCTAD, 2017; World Bank, 2016).

In addition, diffusion of digital technologies to the economies such as products, services and skill was referred to as digitalization which mean the transformation of business via the use of services, product and digital technologies (Brennen and Kreiss, 2014). According to Malecki and Moriset (2007), digital products and services can facilitate more rapid change and evolution to every sector to apply this high technology. Due to this change, the “digitalization” and “digital transformation” had become the focused of the economy and explore the digital trends to various sectors especially the developing countries (OECD, 2016 and 2017; UNCTAD, 2017). For instance, the develop of digital products and services will give impact and affecting the traditional sectors such as agricultural, transportation and tourism.

2.2 Empirical Reviews

This section will present the previous research about the digital economy index and the economic growth. There were three sub section will be demonstrated which include the review digital economy index for intergovernmental organization and cross country, developed country and developing country. Moreover, there were various content will be discussed from each of the past study. First of all, the purpose of each study will be stated and follow by the database used, time period for study and the country used as a sample in the study. Apart from that, the variables used for each study also included for each part. In addition, the review on the methodology used also recorded by each section. Last, the findings from each study will be showed clearly from the result tested.

2.2.1 Reviews on Related Studies from Region Perspectives

By the used of Generalized Method of Moments (GMM) with the framework of a dynamic panel data approach, Aghaei (2009) had investigated the effect of ICT on economic growth to the member countries of OPEC from 1990 to 2007. The data was mainly based on the World Bank tables (World bank, 2007). Moreover, the variable for ICT were ICT gadgets such as the wireless communication equipment, hardware and software of computer. The result for this research was showed that economic will grow positively by the ICT gross domestic investment. Thus, the outcome implied that these countries needed to implemented specific policies that facilitated the growth of economy by the ICT investment.

Besides that, study about the Information and Communication Technology (ICT) investment towards an economic growth in Newly Industrialized Countries (NICs) in Asia had examined by Kooshki and Ismail (2011). This research had estimated by the panel data for the endogenous production growth model of the four NICs in Asia, which is Singapore, South Korea, Hong Kong and Malaysia. Sample time period for the study was from 1990 to 2007. The variable in this study had divided into the ICT input and non-ICT inputs. The physical capital, human capital and labor were the non-ICT input. Data used to study were collected from World Development Indicator (WDI) and International Labour Organization (ILO). Method to conduct the study were Hausman specification test, Generalized Method of Moment (GMM) and Wald test. The finding showed economic growth will positively affected by the used of ICT.

Apart from that, Pradhan et al. (2018) had investigated how the economic growth and employment affect by the broadband infrastructure without considered the effect of causality. Therefore, the relationship of long term between the economic growth in G20 countries and the broadband infrastructure will be indicated by the panel data approach in this research. The data was collected from the World Bank for the selected G-20 countries from 2001 to 2012. The variable in this study were per capita economic growth (%), broadband users (%), internet users (%), gross domestic fixed capital formation (%), labor force participation rate (%) and Consumer Price Index (CPI). This research had applied the panel cointegration and Granger Causality in VECM to test the result. Outcome of the study indicated that economic in G20 countries will increase by the ICT infrastructure.

Another similar study for the G-20 countries was study by Pradhan et al. (2016). Main purpose in the research was to investigate correlation relationship between telecommunication infrastructure, gross capital formation and economic growth from period of 1961 to 2012. The database for this study from the source of World Bank, which is World Development Indicators. G-20 countries were used as a sample and breaks into two subgroup which is developed countries and developing countries in this study. Sample variables from the study were GDP, total population which connect to telephone line (TEL) and GCFs. There were two type of test used to perform the result which is panel cointegration test and panel Granger causality test. The result showed that the economic will growth by the used of TEL and GCF. Moreover, study result was not uniform and depended on the country and sample used.

By the panel data estimation techniques, Toader et al. (2018) had examined the relationship between the Information and Communication Technology (ICT) infrastructure and the economic growth in European Union (EU) from year 2000 to year 2017. This research included 12 indicators and obtained the data from various sources which were International Telecommunication Union (ITU), OECD, WDI and European Commission (Eurostat). The dependent variables in the econometric models were economic growth and proxied by GDP per capita. For explanatory variables were divided into two type, which were measure of ICT infrastructure and macroeconomic control variables. There was various test for the research which were F-test, Lagrange multiplier (LM) test, Hausman test and report the results by Driscoll and Kraay standard errors for linear panel models. The result finds that EU member states will

result the positive of economic growth by the used of ICT infrastructure, but the different type technology will be examined different magnitude of the effect.

Furthermore, an econometric approach had used by Spiezia (2013) to determine how the 26 industries in 18 OECD countries reflected by contribution of ICT investment especially the computer, communication and software. The time period from 1995 to 2007 was used in this study. The method used included growth accounting from parametric approach, GMM and econometric approach. The data collected from the EU KLEMS Growth and Productivity Accounts. The variables used in the research were services output, capital, labour, energy and material. 18 OECD countries involved for research were Australia, United States and Japan. Estimated result stated that 1% annually and 0.4% annually of value-added growth in the business from the ICT investment. The computing equipment showed the largest contribution (50%) towards most of the OECD countries except the Finland from the overall ICT contribution.

On top of that, Dewan and Kraemer (2000) had conducted the research by indicate relationship between the Information technology (IT) and the productivity from 36 countries. This study was concentrated how the demand of IT products and services from the global IT industry will reflect the returns for the IT investment. The study was conducted over the period from 1985 to 1993. Database were retrieved from International Data Corporation (IDC) and Penn World Tables (PWT). The dependent variable was GDP and the independent variables were IT capital stock, non-IT capital

stock and labor hours annually. Methodologies used in this study were F-test, Lagrange Multiplier test and SUR. The result examined that different return of IT investment for the developing and developed countries. In developed countries, there were positive and significant from the return of IT capital investment, but the reversed impact in the developing countries in the sample.

Another cross-country analysis about the telecommunications infrastructure and economic growth was examined by Torero et al. (2002). Purpose from this study were examined how economic performance will be affected by the communication technology in a country. There were 113 sample countries which covers the time period of 20 years from 1980 to 2000 used in this study. All the data sources were retrieved from WDI and ITU. There were two different variables used in the study which were economic variables and telecommunication variables. The methods applied in this study were Arellano and Bond's instrumentalization technique, Phillips Perron test and Hodrick Prescott Filter. Result for the study showed that telecommunications infrastructure and GDP had the positive causal relationship. Furthermore, non-linear appears as an effect and the telecom penetration rate pronounced for the countries was between 5 to 15 percent.

2.2.2 Reviews on Related Studies from Developed Countries Perspectives

Moroz (2017) had studied the digital economy development level in Poland and selected European countries from years 2002-2016. The purpose for this research was compared the digital economy development level in Poland with the others selected

European countries. Measurement used in the study were the degree of ICT use and growth of ICT use. For research methodology, analysis is do for the secondary sources and apply of statistical methods. Furthermore, two indexes were used as the benchmark to measure the development of E-economy were NRI (Networked Readiness Index) and DESI (Digital Economy and Society Index) to make countries comparison. The findings for this research are pointing out that Poland had lower level of digital economy development as compared to others European countries.

Moreover, Breitenbach et al. (2005) had examined how the South African economy had affected by the ICT sector. This study used 22 observations over the period 1975 to 2002. The explanatory variables for this studied were telephone mainlines (per 1000 people) and the gross domestic product at constant 2000 prices be the dependent variable. To determination the causal relationship between both variables, the study used the number of Telkom Mainlines as the Proxy for ICT. For the methodologies used in this research were Jarque-Bera (JB) test, CUSUM and unit root method. Outcome from the tested result was there are exists a positive relationship between the ICT and economic growth since a result was significant and stable through the test.

On top of that, Zuhdi (2012) had used decomposition analysis to indicate how the national economic structure of Indonesia and Japan will changed by the ICT sector. The time period for this studied was from 1990 to 2005 for Indonesia and from 1995 to 2005 for Japan. The methods used to conduct was decomposition analysis by the

input-output tables. There were 159 and 89 ICT sectors will used to examined for Indonesia and Japan respectively. The result showed that ICT sectors in Japan exist the significant effect of economy structural change. However, there was not significant affect for Indonesia for the year 1990s and 2000s. From the study concluded that the Indonesian government was not prioritized in ICT sectors during that period, but the government of Japan was played an important role in promoting ICT sectors for the same period.

2.2.3 Reviews on Related Studies from Developing Countries Perspectives

The similar study had conducted by Bahrini and Qaffas (2019) about the relationship between the ICT technology towards the GDP growth in the developing countries of Middle East and North Africa (MENA) region and Sub-Saharan Africa (SSA) region. Sample period to conduct the study was from 2007 to 2016. The database used was retrieved from the World Development Indicators (WDI) for 45 developing countries. The dependent variable for this study was GDP while the independent variables were financial development, general government final consumption expenditure, volume of country trade amont, INVEST (domestic investment) and INF (inflation rate). The result finds that the ICT except fixed telephone, other variables can cause the positive growth of economic in selected developing countries.

The study about of causal relationship between GDP and telecommunications had examined by Khaouani (2019). The sample period for the study was 53 years which was 1963 to 2015 in Algeria. The data source used to conduct the research was

from World Bank. The dependent variable was GDP per year while the independent variables were fixed telephone (Fixedtel) and mobile telephone (Mobiletel). There was various test used to determine the result such as the JJ test and VECM model. From tested result, variables of fixed telephone and mobile telephone had indicated long run relationship between each other from the ECT coefficient. Moreover, the test also indicated that two unidirectional causal relationship exist which were Fixedtel to GDP and Mobiletel to GDP.

In addition, Chaaben and Mansouri (2017) had conducted to evaluate the digital performance of Tunisia in comparison to the European countries. There are 44 countries including 28 ones of European Union (EU) had used to compared with the Tunisian digital performance for the year 2015. The data applied in the study was retrieved from the National Institute of Statistics, Ministry of Technology and the Digital Economy. Methodologies for this study was used the I-DESI index to calculate and test the result. Results for the research was indicated that Tunisia had a score of 0.39 and defined that Tunisia was digitally poor performed as compare to the average of the EU member states.

On the other hand, Etoundi et al. (2016) developed a study to indicated the level of readiness from Cameroon to develop their economy from digital perspectives, challenges and roadmap framework to ensure the Cameroon to be one of the successful developed digital economy country. There was 10 years of the time frame used in this study from year 2005 to year 2015. The data and sources from this study were

collected from both Cameroonian public and private institution. Variables for the study were ICT infrastructure and the supply of energy. The research methodology for the study was a descriptive research which analysed the impact of an implementation of the digital economy by the analytical framework. From the study, the roadmap was formulated as the guideline for the implementation of digital economy in Cameroon and become the references for others developing countries which included the socio-cultural context as the consideration.

Furthermore, Fong (2009) had conducted a research about the ICT impact to the Gross National Income for developing countries in year 2005. The methodology for this research is regression method. This method used to examine the relationship between Gross national income and ICT penetration index in 91 different lower-middle-income and low-income developing countries. Findings from this research was there are significant positive relationship between Gross National Income and the various ICT gadgets except the Internet technology.

2.3 Concluding Remarks

There are several theory and concept for the develop of digital economy to the growth of economy. All of this was related to the development and evolution of the technology, especially the Information and Communication Technology (ICT). However, the most study indicated that there was positive relationship between ICT and the economic development. There was various testing procedure used verified the correlation and impact between these two variables. The test mostly applied by previous researcher

were unit root test, cointegration test and Generalized Method of Moment (GMM) growth model. Different study will be indicated different result which was some researcher obtain the positive while some researcher determines the negative relationship between the digital technology towards the economic growth.

Table 1: Summary of Literature Review

Author	Variables	Country /Year	Methodology	Findings
Aghaei (2009)	• Computer hardware • Computer software • Computer services • Wire • Wireless communication equipment	OPEC member countries /1990-2007	• Generalized Method of moments (GMM)	• Significant positive effect of the ICT gross domestic investment on economic growth. • OPEC member countries needed to implemented specific policies that facilitated investment in ICT if they seek to enhance their economic growth.
Kooshki and Ismail (2011)	• ICT input • Non-ICT input (physical capital, human capital, labor)	NICs in Asia (Singapore, South Korea, Hong Kong and Malaysia)/1990-2007	• Hausman specification test • Generalized Method of moment (GMM) • Wald test	• ICT has a significant effect on the growth of NICs countries in Asia.
Pradhan et al. (2018)	• Per capita economic growth (%)	G-20 countries /2001-2012	• Panel cointegration test • Granger causality in a vector error correction models (VECM) framework	• ICT infrastructure increase the level of economic growth in G-20 countries.

Author	Variables	Country /Year	Methodology	Findings
Pradhan et al. (2016)	• Growth rates of real per capita income (GDP) • Percentage of the total population with telephone mainlines (TEI) • GCF as a percentage of gross domestic product	G-20 countries /1961-2012	• Panel cointegration test • Panel Granger causality	• Both TEI and GCF are drivers of economic growth. • Result was not uniform and depended on the country and sample used.
Toader et al. (2018)	**Dependent variable** • GDP per capita **Independent variables** • ICT infrastructure • Macroeconomic control variables	European Union (EU)/ 2000-2017	• F-test • Lagrange multiplier (LM) test • Hausman test • Driscoll and Kraay standard errors for linear panel models	• Positive and strongly effect of using ICT infrastructure on economic growth in the EU member states but the different type of technology will be examined different magnitude of the effect.

Author	Variables	Country /Year	Methodology	Findings
Spiezia (2013)	• Capital (K) • Labour (L) • Energy (E) • Material (M) • Services input (S)	18 OECD countries /1995-2007	• Parametric approach • Generalized Method of moments (GMM) • Econometric approach	• Contribution of ICT investment to value added growth in the business sector varies from 1% a year in Australia to 0.4 a year in Japan. • Most of the countries showed that computing equipment provided the largest contribution and accounted for over 50% of the overall ICT contribution except the Finland.
Dewan and Kraemer (2000)	• GDP • IT capital stock • Non-IT capital stock • Annual labors hours employed	Cross-countries (36 countries)/1985-1993	• F-test • Lagrange Multiplier test • Seemingly Unrelated Regression (SUR)	• Significant differences between developed and developing countries from the aspect of returns from capital investments. • For developed countries, there were positive and significant from the return of IT capital investment, but it is reversed for the developing countries in the sample.

Author	Variables	Country /Year	Methodology	Findings
Torero et al. (2002)	• Output • Labour force • Capital stock • Budget deficit (surplus) • Annual investment in telecommunications • Telephone density • Revenue per telephone line	Cross-countries (113 countries)/1980-2000	• Arellano and Bond's instrumentalization technique • Phillips Perron (PP) test • Hodrick Prescott Filter	• Positive causal link between telecommunications infrastructure and GDP. • The effect appears to be non-linear and the telecom penetration rate pronounced for the countries was between 5 to 15 percent.
Moroz (2017)	• Networked Readiness Index (NRI) component • Digital Economy and Society Index (DESI) component	Poland and selected European countries /2002-2016	• NRI index • DESI index	• Research are pointing out that disadvantage of Poland in terms of the development of the digital economy in comparing to analysed European countries.
Breitenbach et al. (2005)	• Telephone mainlines (per 1000 people) • Gross domestic product at constant 2000 prices	South Africa/ 1975-2002	• Jarque-Bera (JB) test • Unit root test • CUSUM test • Ramsey test	• There are exists a positive relationship between the ICT and economic growth.

Author	Variables	Country /Year	Methodology	Findings
Zuhdi (2012)	• Indonesia (159 sectors) • Japan (89 sectors)	Japan and Indonesia/Japan (1995-2005), Indonesia (1990-2005)	• Decomposition analysis (Input-output tables)	• ICT sectors have a significant effect in changing the structure of the national economy in Japan. • There was not affect in Indonesia during the 1990s and 2000s. • Indonesian government was not prioritized in ICT sectors during that period, but the government of Japan was played an important role in promoting ICT sectors for the same period.
Bahrini and Qaffas (2019)	• GDP per capita • FIND (financial development) • GOV (general government final consumption expenditure) • TRADE (country's trade volume) • INVEST (domestic investment) • INF (inflation rate)	45 developing countries in Middle east, North Africa (MENA) region and Sub-Saharan Africa (SSA) region/ 2007-2016	• Generalized Method of Moment (GMM) growth model	• The ICT except fixed telephone are the main drivers of economic growth in MENA and SSA developing countries.

Author	Variables	Country /Year	Methodology	Findings
Khaouani (2019)	• GDP per year • Fixed telephone (Fixedtel) • Mobile telephone (Mobiletel)	Algeria/ 1963-2015	• Phillips-Perron (PP) tests • Johansen cointegration test • Vector Error Correction model short-term (VECM) • Granger causality test	• The variables of fixed telephone and mobile telephone had showed that the coefficient is statistically significant for the VECM test. • The Granger causality test also showed that a unidirectional causal relationship between the fixed telephone and mobile telephone to the GDP.
Chaaben and Mansouri (2017)	• Connectivity • Human capital • Use of internet (citizens) • Integration of digital technology (business) • Digital public services	Tunisia and 44 European countries /2015	• I-DESI index	• Tunisia had a score of 0.39 and defined that Tunisia was digitally poor performed as compare to the average of the EU member states.

Author	Variables	Country /Year	Methodology	Findings
Etoundi et al. (2016)	• Energy (electricity) • Telecommunication and ICTs	Cameroon/2005-2015	• Descriptive research by Global Innovation-Mediated Paradigm Shift (GIMPS)	• The definition of a roadmap for the implementation of digital economy in Cameroon. • Guideline in the implementation of the digital economy in developing countries which included the consideration of socio-cultural context.
Fong (2009)	• GNI per capita (PPP international dollar) • Internet (Internet user index) • Mobile (Mobile phone index) • PC (Personal computer index) • Telephone (Telephone index)	91 lower-middle-income and low-income developing countries /2005	• Regression method	• The significant relationship between GNI per capita (in PPP international dollars) and adoption of each ICT (mobile phone, personal computer, and telephone) except for Internet technology.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

Chapter 3 focused on theoretical framework and procedure of indicator construction for the digital economy index in Malaysia. This chapter will discuss the theoretical framework from the previous study. Next, the indicator construction procedure will be illustrated which included the references series, selection series, data description and the construction of Digital Economy Index. Lastly, this chapter will be end by the concluding remarks.

3.1 Theoretical Framework

Based on Digital Economy Task Force (DETF), member countries of G20 had developed a few goals to achieve the economy by the digital technology. The develop of digital economy such as use of knowledge and information, apply of information networks and innovation of information and communication technology (ICT) had given an impact to the growth of economy among the G20 countries. Thus, one of the objectives to achieve by G20 DETF is summarizes the different methodological approaches and indicators used to identify the digital economy. From the various methodologies and indicators, the G20 toolkit had used and highlight the key indicators that can measurement the digital economy. These highlighted indicators were important to be the subject for the further work by others G20 countries and the

International Organisations (IOs) that involved to measure the digital economy performance.

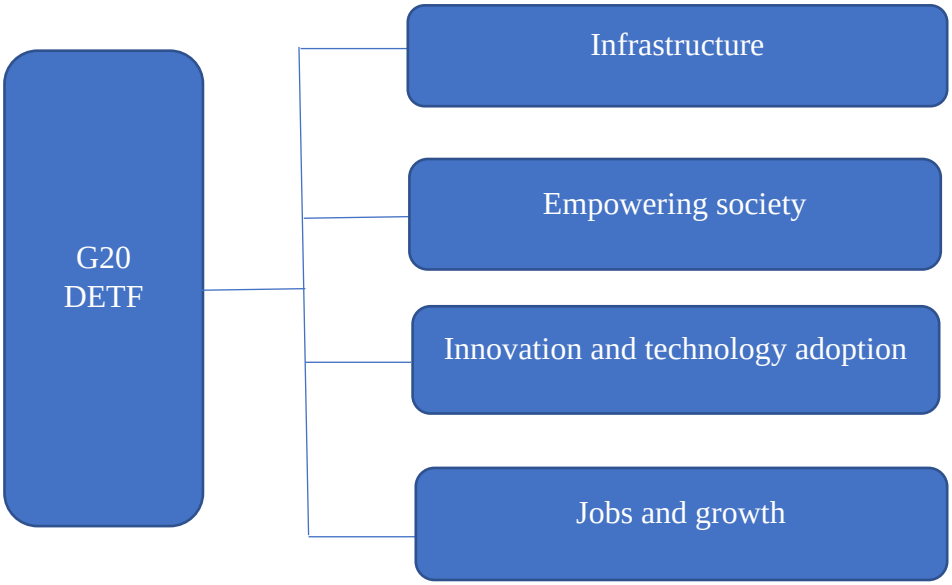


Figure 3: Theoretical framework for G20 DETF

There were four dimensions from this digital economy index framework and brings together 35 key existing indicators and methodologies in order to measure the digital economy. The first dimensions were infrastructure and measure by 8 indicators. This component was covered the indicators that involved in the development of physical, service and security of the infrastructure for the digital economy. Next, the empowering society is the second dimension for the index and measure by 7 indicators. This component focused on how the people use, access and interact by the digital technologies. Moreover, innovation and technology adoption also be an important component for this digital economy index. By this section, the indicators were used to identify and measure the innovation and development of digital technologies and how

it contributed to the economy growth. The last dimension for the index is jobs and growth. The indicators under this component were focused on how the innovation and development of digital technologies contributed to the jobs market and the employment creation.

For the methodology to collected and developed the digital economy index, G20 toolkit had used both primary and secondary sources. The methodologies used to collect the primary data included the survey by questionnaire to the respondent and computer-assisted telephone interview (CATI) technique. All of this method was used to collect the quality data such as the people use of internet and the accessibility to the digital platforms. On top of that, G20 toolkit also collected some data from the secondary sources. For instances, the data were directly collected and acquired from the official institution which included EITO, WEF, ITU, World Bank, European Patent Office, OECD, Eurostat and others. Besides that, G20 toolkit also develop estimation method to forecast the data due to unavailable data from some of the G20 countries for the selected sample period.

3.2 Digital Economy Index (DEI) Indicator Construction

By OECD (2004), composite indicator is formulated by each of the individual indicators are compiled into a single index to measure the multi-dimensional concept. This composite indicator was easier for the general public used to identify the trends and useful in benchmarking country performance as compare to interpret by each separate indicator (Saltelli, 2007). Thus, this section will be discussed the selection of

reference series, component series, data description and the construction of digital economy index.

The three categories can be classified by the cyclical indicators which are leading, coincident and lagging. All of these indicators are categories based on their timing movement. To construct an indicator, a broad group of component series which included infrastructure, empowering society, innovation and technology, jobs and growth will be compiled. This is because to develop a leading indicator that reflects the digital economy for Malaysia, only the component series with the leading characteristics will be chosen. Then, after the component series have been determined, the systematic compilation procedure that proposed by the Conference Board (2001) will be used to construct the DEI. The five-step procedure and formula were shown as below:

(1): Month-to-month changes, $r_{i,t}$, is calculate for each component, $X_{i,t}$ where i = 1,…,n. for the components that are in percent form, simple arithmetic differences are calculated: $r_{i,t} = X_{i,t} – X_{i,t-1}$.

$$r_{i,t} = \frac{X_{i,t} - X_{i,t-1}}{X_{i,t} + X_{i,t-1}} * 200$$

(2): The month-to-month changes are adjusted by multiplying them with the component's standardization factor (w_i). The results of this step are the monthly contributions of each component $c_{i,t} = w_i * r_{i,t}$.

(3): The adjusted month-to-month changes are added (across the components for each month). This step results in the sum of the adjusted contributions,

$$S_t = \sum_{i=1}^{n} c_{i,t}$$

(4): The preliminary levels of the index are computed recursively using the symmetry percent changes. It is calculated by letting the initial value for the first quarter, I_1 = 100 and the following month to be:

$$I_2 = \frac{200 + S_2}{200 - S_1} * I_1$$

(5): Finally, rebase the base year of 2010 on the preliminary index.

3.2.1 Selection of Reference Series

The reference series to be chosen must be a long time and uninterrupted series as well it has a strong correlation to the digital economic growth (Zhang & Zhuang, 2002). Thus, the chosen reference series must indicate a trend of economy in the digital world and reflect the situation for the particular country. Normally, the ICT variables will be represented as the reference series which included the internet, cell phone, computer, fixed broadband, mobile broadband and intranet. For this study, the contribution of ICT to the national economy (ICTE) will be chosen as one of the best measurement tools to reflect the trend of economy affect by the digital world. All the series collected annually will be interpolated by using the Gandolfo (1981) interpolation method into its quarterly basics.

3.2.2 Selection of Component Series and Data Description

For the selection of component series, the component series chosen should result in conformity, consistent timing, economic significance, statistical adequacy, smoothness and currency. Thus, component series chosen in the study must fulfil those criteria and present the constant timing pattern to serve as good leading indicator. Furthermore, the correlation analysis will be applied in the study to detect the co-movement of each potential component series with the business cycle. There were more than 20 series of data will be collected from different sources such as World Bank, Department of Statistics Malaysia (DOSM), CEIC database and Malaysian Communications and Multimedia Commission (MCMC). The sample period for the database is 10 year from year 2009 to 2018. The data was collected and measured by the period of quarterly and yearly.

3.3 Correlation Analysis

This method is applied to determine the relationship between the variables. Correlation analysis is adopted to examine the degree of association between the component series and the references series in this study. The Pearson's correlation coefficient is used to measure the strength of the relationship between both variables. The used of correlation coefficient was suitable for the quantitative variables such as measure in ratio or interval scale variables. The formula for the correlation coefficient is showed in the equation below:

$$r = \frac{n \sum xy - \sum x \sum y}{\sqrt{(n \sum x^2 - (\sum x)^2)(n \sum y^2 - (\sum y)^2}}$$

In this equation, the value of r is usually lying between -1 and 1. There are no relationship between both variables when the r is 0. If the r is above 0.8, it means that there is strong relationship between both variables; while there is poor relationship occur when the value of r is below 0.5. Both of the variables will move in the same direction when the coefficient is positive, while moving in the opposite direction when the coefficient showing negative.

3.4 Detrending Procedure

This method is used to identify the cyclical patterns in a particular data set. A detrend procedure is purpose to remove the effects of accumulating data sets from a trend and showed only the absolute changes and identifies the cyclical patterns. The filter used in this study was Christiano-Fitzgerlas (CF) Filter.

The Christiano-Fitzgerlas (CF) filter was a band pass filter developed by Christiano and Fitzgerald (2003) that was built on same principles as the Baxter and King (BK) filter. The de-trending will be formulated in this filter and the problem in the frequency domain will be smoothing. The CF filter is better than BK filter due to it can work well on a larger class of time series and converges in the long run to the optimal filter.

The Christiano-Fitzgerlas (CF) filter can be calculate as follows:

$$c_t = B_0 y_t + B_1 Y_{t+1} + .. + B_{T-1-t} y_{T-1} + \tilde{B}_{T-1} y_T + B_1 y_{t-1} + .. + \tilde{B}_{t-1} y_1$$

$$B_j = \frac{\sin(jb) - \sin(ja)}{\pi_j}, j \geq 1$$

$$B_0 = \frac{b-a}{\pi}, a = \frac{2\pi}{P_u}, b = \frac{2\pi}{P_1}$$

$$\tilde{B}_k = -\frac{1}{2} B_0 - \sum_{j=1}^{k-1} B_j$$

The parameter p_u and p_i are the cut off cycle length in month. The cycles longer than pi and shorter than p_u are preserved in the cyclical term c_r.

3.5 Turning Point Dating Procedures

Bry-Boscham Quarterly (BBQ) algorithm (2001) that proposed by Harding and Pagan was used to identify the turning points of the business cycle start from the steps of deseasonalized, detrending and smoothing the reference series. This BBQ algorithm test was used to determine the critical episodes of the business cycle. In order to translates the ocular judgements, there are three steps needed to perform:

1. Determination of possible turning points which is the peaks and troughs in a series.

2. A procedure for alternating peaks and troughs.

3. A set of rules that re-combine the turning points established after steps one and two in order to satisfy predetermined criteria concerning the duration and amplitudes of phases and complete cycles.

The core step of the algorithm to determine for the local peak or trough as happening at time t is shown as:

$$\{a_{t-n} < a_t > a_{t+n}\}, \text{n} = 1, \ldots, N$$

$$\{b_{t-n} > b_t < b_{t+n}\}, \text{n} = 1, \ldots, N$$

From this equation, a_t is the peak, b_t is the trough and n are generally set to five. The phase must last at least six months and the complete cycle should have the minimum duration of fifteen months. For the data that measures at the quarterly frequency, the first step of the BB algorithm should put n = 2 while a_t is a local maximum relative to two quarters.

$$\{\Delta_2 a_t > 0, \Delta_{a_t} > 0, \Delta_{a_{t-1}} < 0, \Delta_2 a_{t+2} < 0\}$$

3.6 Directional Accuracy Test

This test is the formal statistical approach to analysis the predictive accuracy of the indicator is particularly meaningful for a more credible study in the field of forecasting. From a forecasting perspective, renewed interest in direction accuracy of macroeconomics forecasts clearly indicates that unreliable forecast will make no sense to the users. Thus, if forecasting model comprises predicted changes that are not adequately significant to reflect the underlying impact of the real shock, then the

forecasting result will be susceptible. According to Greer (2003), the indicators will be subjected to directional accuracy testing and complemented the findings with binomial testing. The cyclical change will break into three trichotomous scenarios; specifically, a large predicted increase, no significant change and a large predicted decrease. The directional accuracy rate is calculated by the formula below:

$$\text{Directional Accuracy Rate (DAR)} = \frac{C_s}{N_s} \text{ x } 100$$

where C_s is the number of correct predictions for significant large changes and N_s refers to the total number of significant large changes in the business cycle.

In addition, the binomial test with the directional accuracy result will be applied to know that whether the success of the prediction is owing to the predictive power of the forecasting model (indicator) or to mere chance. The verification is important to portray that the indicator itself has compelling predictive power and is robust over time. The null hypothesis of binomial test is the probability of correct prediction to direction of change in the forecasting model is 50 percent. The rejection for the null hypothesis will lead to two distinct conclusions, depending on the result of direction accuracy testing (DAR). If the DAR is over 50 percent, then show that the forecasting model is independent of wild guess. However, if the DAR is below 50 percent, then we can expect that wild guess possibly dominates the source for obtaining correct predictions. The failure in beating the wild guess again implies that the indicator is less likely to be robust forecasting tool.

3.7 Data Interpolation Techniques

The interpolation is the process of producing a time series at a higher frequency from a lower frequency. The converting of annul data to quarterly and a monthly series from quarterly data is the interpolation process.

The observation of the continuous flow variables can write as $y_{t-1}, y_{t-2}, y_{t-3}$. y_t is the current value at period t. The polynomial function describes the variable of interest rate with degree of 2, it shows at following:

$$F(t) = at^2 + bt + c$$

Where the coefficients are a, b and c to be determined.

To estimate the observation for three period which are y_{t-1}, y_t, y_{t+1}, definite integrals from initial (0) to period three (3) are show below:

$$Y_{t-1} = \int_0^1 (at^2 + bt + c)\, dt$$

$$Y_t = \int_1^2 (at^2 + bt + c)\, dt$$

$$Y_{t+1} = \int_2^3 (at^2 + bt + c)\, dt$$

The coefficients a, b and c are showed as the integration equations:

$$a = \frac{1}{2}\, y_{t-1} - \, y_t + \, \frac{1}{2}\, y_{t+1}$$

$$b = -2y_{t-1} + \, 3y_t - \, y_{t-1}$$

$$c = \frac{11}{6} y_{t-1} - \, \frac{7}{6} y_t + \, \frac{1}{3} y_{t+1}$$

The condition of the sub period figures within any period, t can be obtained by using the Order Statistic theory.

$$y_y^{(i)} = \frac{\int_{\frac{p+i-1}{i}}^{\frac{p+1}{i}}}{p} (at^2 + bt + c)\, dt$$

Where i = 1,2,3, …, p and p ≥ 2

$$y_t = \sum_{i=1}^{p} y_t^{(i)}$$

The algorithm for interpolating monthly values from quarterly can be obtained by setting p=3 in the equation above.

$$y_t^{(1)} = \frac{10}{162} y_{t-1} + \frac{52}{162} y_t - \frac{8}{162} y_{t-1}$$

$$y_t^{(2)} = \frac{-2}{162} y_{t-1} + \frac{58}{162} y_t - \frac{2}{162} y_{t+1}$$

$$y_t^{(3)} = \frac{-8}{162} y_{t-1} + \frac{52}{162} y_t - \frac{10}{162} y_{t+1}$$

Where y_{t-1}, y_t, y_{t+1}, are the quarterly observations of a continuous flow variable y_t.

Cubic Spline Interpolation

This method can use to estimating the quarterly series from the annual data. A piecewise seamless curve is obtained, and it passes through each of the observations of the underlying series over the sample period. From this method, there are not require any observed from higher-frequency indicator variable related to low-frequency series and it fits a series. Thus, this procedure correlates each of the data points efficiently and effectively even the data may appear randomly. The data is show as follow:

$$S(y) = \begin{cases} s_1(y), & if\ y_1 \leq y < y_2 \\ s_2(y), & if\ y_2 \leq y < y_3 \\ s_{n-1}(y), & if\ y_{n-1} \leq y < y_n \end{cases}$$

In order to define the S(y) splines, total 4(n) parameters had to be estimated, as there are n evenly spaced intervals and four coefficients are required for each interval. These coefficients twist the curve to let it pass through each of the observations without any interruption. This indicate that the curve does not show any breaks in continuity. $S_i(y)$ serve as a third-degree polynomial function and defined by,

$$S_i(y) = \beta_{3i}(y-y_i)^3 + \beta_{2i}(y-y_i)^2 + \beta_{1i}(y-y_i)^1 + \beta_{0i} \qquad \text{for } y \in [y_i, y_{i+1}]$$

where x_i can be obtained from the equation above. These conditions produce a piecewise continuous function, indicating that each of sub-functions must joint at the data point at both ends of the interval. To making the curve seamless and smooth across the interval points it required to impose the assumption of the continuity of the first and second derivatives:

$$S'_{i-1}(y_i) = S'_{i-1}(y_i),\ S''_{i-1}(y_i) = S''_{i-1}(y_i) \qquad \forall\ i = 1,2,\dots,n-1$$

3.8 Concluding Remarks

In this chapter was discussed on how to construct the DEI. First of all, the theoretical framework was selected as the reference to build the DEI. Next, the reference series and component series will be chosen based on their characteristic with the good leading indicators. The data use for the study was retrieved from reliable sources and sample time period was 10 years from 2009 to year 2018. The last part to construct the DEI was applied based on Conference Board (2001) to build the index. Firstly, the

Christiano Fitzgerald (CF) was used to smooth the inconsistent parameter for the detrending procedure. Next, the BBQ technique that proposed by Harding and Pagan (2001) will be used to date the turning points and determine the critical episodes of digital economic in Malaysia. Then, the directional accuracy test was applied to investigate the performance of constructed DEI with the selected reference series. In short, the digital economy index was built from various quality indicators that can reflect the digital economy performance in Malaysia.

CHAPTER FOUR

EMPIRICAL FINDINGS AND INTERPRETATION

4.0 Introduction

The main objective of this study is to develop a Digital Economy Index (DEI) in order to measure the digital performance in Malaysia using quarterly data from year 2009 to 2018. The DEEI has been developed via the indicator construction procedure outlined in the previous chapter. In this chapter, interpretation of the DEI along with relevant discussion on the turning point analysis and directional accuracy will be presented. Specifically, Section 4.1 will illustrate the results of the selection of component series based on correlation analysis, followed by the result of reference series selection in Section 4.2. Subsequently, Section 4.3 will present the visualization of the constructed DEI together with the justification of selected component series, while the cyclical movement of the reference series and the constructed DEI will be reported in Section 4.4. Thereafter, Section 4.5 will discuss the results of turning point analysis, followed by finding on directional accuracy test, while the final section concludes.

4.1 Results of the Selection of Reference Series

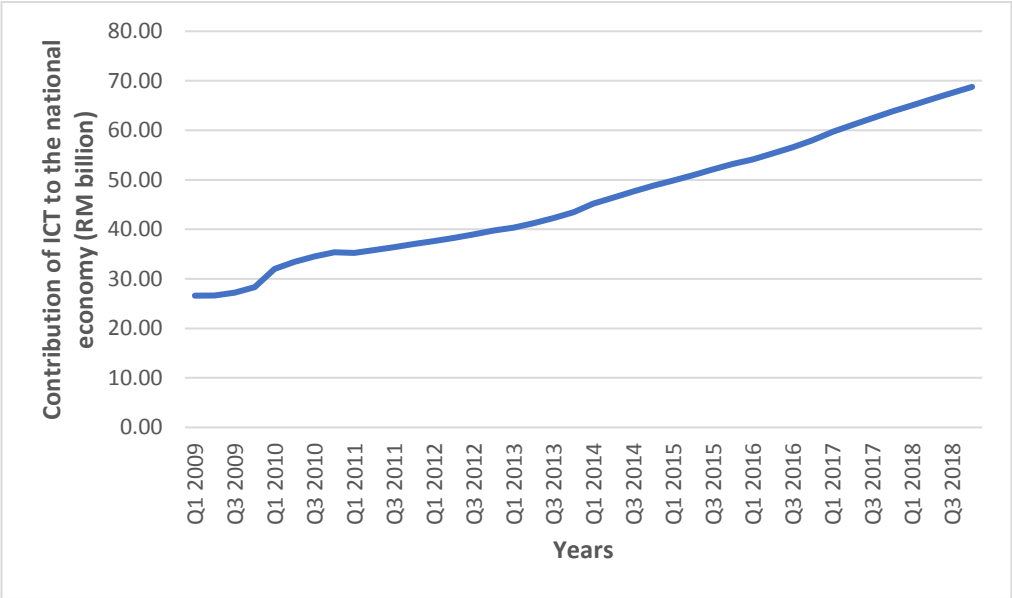
To measure the digital economy performance in Malaysia, Department of Statistics Malaysia (DOSM) had taken an initiative to measure it by using satellite accounts approach through ICTE compilation. Therefore, we have selected the contribution of ICT to the economy (ICTE) of Malaysia as the references series from year 2009 to

2018 in this study. The coverage of ICTE is consisting of the ICT sector which based on recommendation from OECD Guide to Measuring Information Society 2011 (OECD, 2011) and e-commerce by the OECD Internet Economy Outlook 2012 (OECD, 2012). The ICTE has a more complete measure in most ICT sectors such as ICT manufacturing industry, ICT trade industry, ICT services industry and e-commerce which included the value added of wholesale and retail sectors. Thus, it is most suitable and acceptable to choose ICTE as the reference series of this study.

The data of ICTE are obtain in the yearly basis from year 2009 to 2018. After we complete collect the ICTE data, then the interpolation technique from Gandolfo (1981) will be applied to interpolate the yearly ICTE series into its quarterly basis. All the ICTE data are calculated in the unit of RM billion and shown in the Figure 4 from the period of 2009 Q1 to 2018 Q4 by applied of interpolation techniques to the data. Based on the Figure 4, there are significant increase in the trend of ICTE from year 2009 Q1 to 2018 Q4 especially the increase significantly in year 2010. The launched of Economic Transformation Program (ETP) on 21 September 2010 had given a positive sign to the digital economy. By this programme, the government had focus to stimulate the creativity of human with new technologies and create more opportunity. Thus, there are more jobs opportunity and transform the nation into information and knowledge age. The limited of data transparency due to the license and rights protection by the laws had hold the growth of digital economy in the year 2013. Thus, this barrier has restricted the growth of the digital entrepreneurship especially those digital entrepreneurs who needs the open data in the development of mobile applications or other products.

However, the investment by the government in year 2014 had boosted the ICT sectors which included funding infrastructure expansion, providing support for both research and development (R&D), and private sector training. On the other hand, the slumped that captured in 2016 had indicated that lags in coverage and adoption of fixed broadband services, especially compared the level of economic development in Malaysia and the global.

Figure 4: Contribution of ICT to the National Economy (ICTE)



4.2 Results of the Selection of Component Series

To construct a good indicator in this study, we only choose the component series that showing leading characteristics to build the DEI. All the selected component series must fulfil those criteria such as result in conformity, consistent timing and economic significance. Thus, there was more than 20 series of data were obtained from different sources which include CEIC database, World Bank, Department of Statistics Malaysia

and ITU. Next, all the collected data will be compiled and examined the degree of association between reference series and selected component series by the correlation analysis.

Then, the correlation analysis will be used to test the compiled data that we gathered, and the results are show in Table 2. For this study, the component series will only choose by showing the strong correlation with our reference series. We are only choosing the component series that had the value of greater than 0.5 which are usually referred as positive and strong correlation. In contrast, any component series that had the value lower than 0.5 will be automatic eliminated and rejected as they may not bring the significant impact to construct a good leading indicator.

Based on the Table 2, the results show that the list of components that had the high correlation with the reference series and each them are category into the respective pillar. There are four pillars formed by respective component series which is Infrastructure (INF), Empowering Society (ES), Jobs and Growth (JG), Innovation and Technology adoption (ITA). By the development of digital technology, the basic digital infrastructure had play an important role to maintain the stable connectivity. According to the Internet User Survey (IUS) by the MCMC in year 2018, there are showing the increase of people connect to the internet by using the smartphone which is from 89.4% in year 2016 to 93.1% in year 2017. Thus, the subscription for various devices to the internet such as cellular and fixed telephone line are important and able

to give a significant impact to the digital economy. Therefore, the fixed broadband subscription had category in this pillar.

Besides that, the empowering society also been chosen as one of the pillars because of the perception of people to use the internet can give the impact to the digital economy. By the advance of technology, there are increase of people willing to replace the traditional platform by the convenient way. One of the good examples is people are preferring to use the online banking services compare to physical present in the bank. By access the internet, various tasks such as online banking and payment can be complete within the short time and save cost. Therefore, the internet usage, electronic payment by E-money, payment systems by Interbank GIRO, payment channels by mobile banking, number of subscribers for mobile banking, mobile banking penetration rate to population and mobile banking penetration rate to mobile subscribers were category in this pillar.

On top of that, pillar of jobs and growth are represented by employee in ICT manufacturing, percentage of commercial services imports, percentage of ICT service exports and employee in ICT trade. The adoption of e-commerce and ICT technology in the business can also break the barrier to trade from each other. As the result of stable connectivity and penetration of internet, Malaysia had recorded a high rate of e-Commerce usage. There are recorded 16.53 million online shoppers and involve 62 percent of mobile users in year 2018 by the MCMC report. Nowadays, people are preferring to make the online shopping because of the price advantage and available

of shipping. Thus, the increase of e-Commerce usage by various sector will give the huge impact to the trend of digital economy.

On the other hand, the innovation and technology adoption are relatively important to boost the growth of digital economy. By the continuous research and development, new technology and innovation are crucial to bring the Malaysia into the Industrial 4.0 which is increase the productivity by the high skilled workers, collaboration between the industry and improve the performance and efficiency. Moreover, the support and encourage of government for the business to invest in knowledge also help them to accelerate the transformation of market and industry. Hence, in this study, the number of researchers and patent applications are important to influence the growth and develop of high technology.

Table 2: Results of Correlation Analysis between Selected Component Series and the ICTE

INF		ES		JG		ITA	
FBSP	0.55	EPEM	0.98	EICTT	0.96	RRD	0.98
		MBPMS	0.98	CSI	0.69	PA	0.76
		MBPP	0.98	EICTM	0.6		
		NSMB	0.98	PICTEX	0.66		
		PSGIRO	0.98				
		PCMB	0.84				
		U	0.86				

Table 3: List of Selected Component Series

List of Component Series

INF	**Infrastructure**
FBSP	Fixed broadband subscriptions (people)
ES	**Empowering Society**
EPEM	Electronic Payment by E-money (RM billion)
PSGIRO	Payment Systems by Interbank GIRO (RM billion)
PCMB	Payment Channels by Mobile banking (RM billion)
NSMB	Number of Subscribers for Mobile Banking
MBPP	Mobile banking penetration rate to population (%)
MBPMS	Mobile banking penetration rate to mobile subscribers (%)
U	Internet usage
JG	**Jobs and Growth**
EICTT	Employee in ICT Trade ('000)
CSI	Computer, communications and other services (% of commercial service imports)
EICTM	Employee in ICT Manufacturing ('000)
PICTEX	ICT service exports (% of service exports)
ITA	**Innovation and Technology adoption**
RRD	Researchers in R&D: per Million people
PA	Patent applications

4.3 Visualization of the Constructed DEI

The DEI are built by the selected component series which is aggregated into the composite form by the Conference Board (2001) method. There are five chronological steps that mentioned in the previous chapter will be applied to the selected component series which included the procedure of aggregation. Hence, the computed DEI is shown in Figure 5 and Figure 6. From the Figure 6, it demonstrated that the DEI increase significantly and depicts the upward trend from the period of 2009 Q1 to 2018 Q4. However, there are few declines of the trend which happened in year 2013 and 2016 are due to the impact of limited data transparency and lags in digital infrastructure.

Figure 5: Digital Economy Index (DEI)

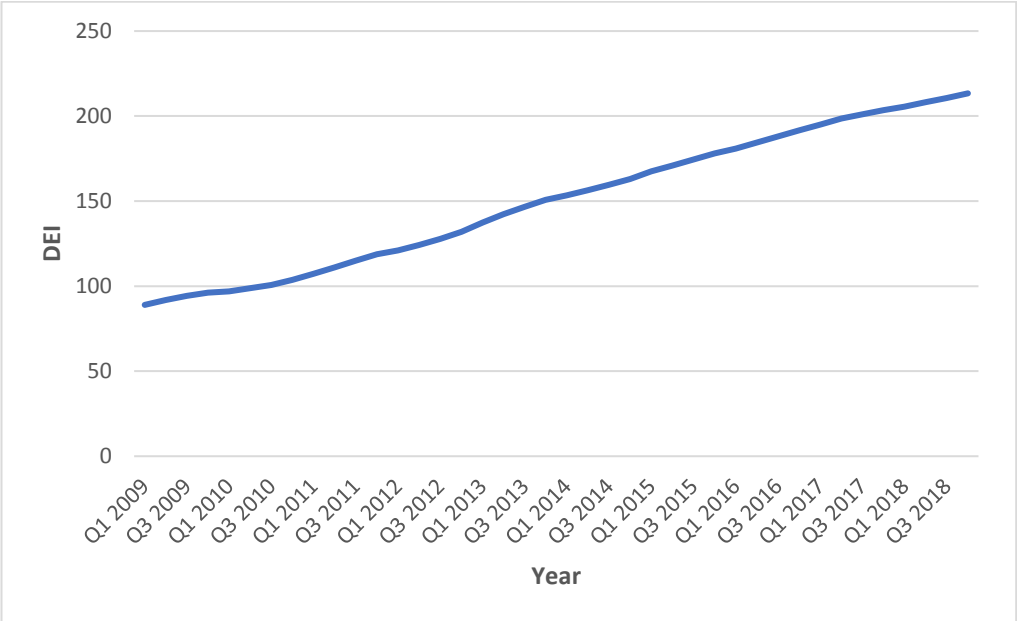
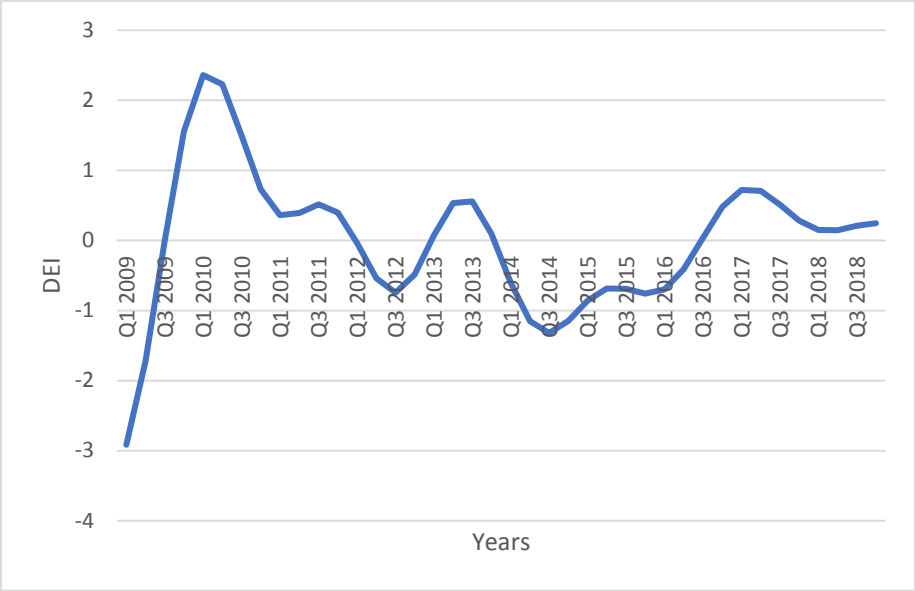


Figure 6: Cyclical Movement of Digital Economy Index (DEI)



4.4 Cyclical Movement of the Reference Series and the Constructed DEI

In this study, the main objective is to develop a Digital Economy Index (DEI) with the leading power in order to forecasting as well as to detect the turning point of digital economy performance in Malaysia. Thus, there are few method and techniques that proposed by Moore and Zarnowitz (1986) had been done and the result of cyclical movement of the ICTE and DEI has been shown in Figure 7. All of the steps were included detrending, smoothing and detecting the turning points of both DEI and references series.

The first method had been done before detecting the turning point is detrending procedure. In order to identify the cyclical patterns in a particular data set, detrending is important to remove the effects of accumulating data sets from a trend and only

show the absolute changes to identifies the cyclical patterns. For this study, the CF filter that proposed by Christiano and Fitzgerald (2003) had been applied to measure detrend and cycle extraction. By this CF filter, the problem of variation can be reduced and smoothing the trend component. Therefore, the cyclical movement of the ICTE and DEI can be analysed and visualised after smoothened of both series.

From the Figure 7, there are few economic precariousness can be observed which happened in year 2010, 2013, 2014 and 2016. In year 2010, there are one economic program named Economic Transformation Program (ETP) had implement by government to help Malaysia to achieve high-income nation by 2020. From this program, one of the focus is sector information and communications technology (ICT) which can stimulate and boost the digital economy growth. The target of the government in this program is to transform the nation into the digital and knowledgeable by encourage more innovation on the product and boost up the competitive level in the global. As ICT became the key factor in digital economy, Prime Minister Datuk Seri Najib Tun Razak also give the investment allowance for broadband service and remove the import duty and sale tax of broadband as the initiative to boost the digital economy.

In the year 2013, the formulation of Personal Data Protection Act (PDPA) had cause the ongoing tensions between data protection and its legitimate use for commercial purposes. Thus, the limitation of open data had become the barrier for the digital development especially the digital entrepreneurs which need it in the

development of mobile applications or other products. Besides, the difficult to access government data also cause the lagging in Big data analytics. This is because most of the datasets on the portal do not specify a data license and government always reserve the rights for the datasets that hosted on agency websites. Thus, the lacked capacity and freedom to engage with the data especially the private sector will leave the potential digital entrepreneurs without the social connections, guideline and role model they need to succeed.

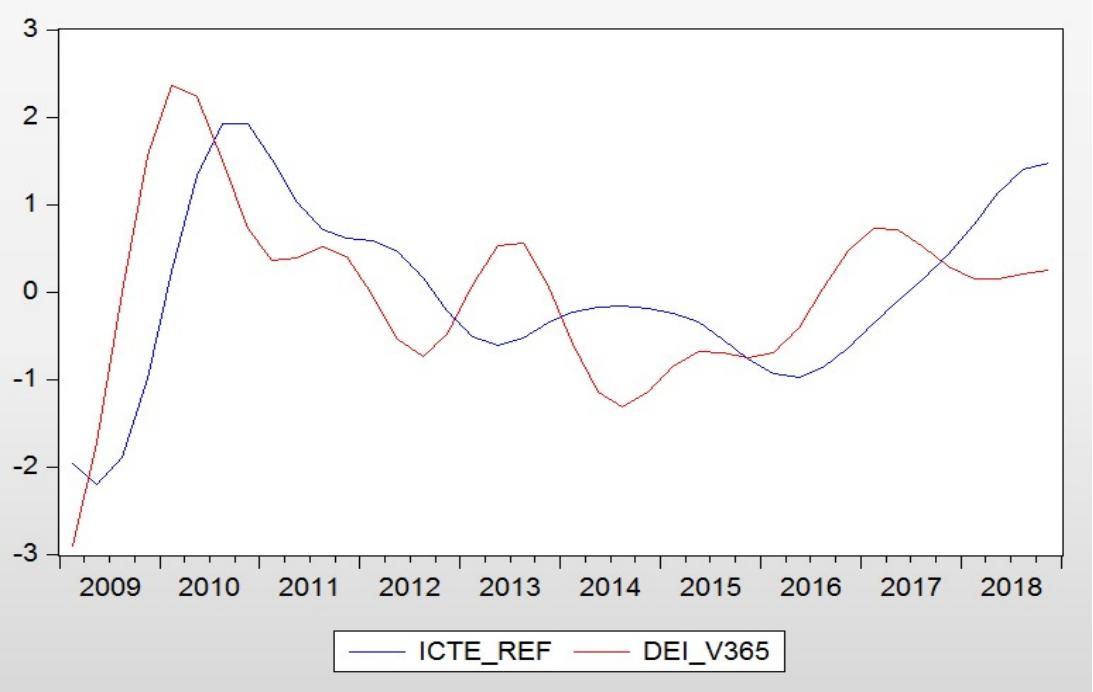
On the other hand, the increase of expenditure by government that focus to strengthen the ICT sector had given the influenced to boost the digital economy in year 2014. All of this expenditure included funding infrastructure expansion and support in research and development (R&D). The allocated of RM 2.7 billion for the construction of 1000 telecommunications towers and the laying undersea cables had speed up the connectivity and coverage. Besides the infrastructure spending, the allocated of RM 200 million to development of digital content and RM 1.3 billion in development of innovative and commercially viable technology by the government also give a great impact to the growth of digital economy. In addition, the allocated of RM 80 million to promote the use of new technology, automation and innovation by small and medium-sized enterprises (SMEs) also available to encourage more sector involve in digital economy.

However, the slumped of the trend that indicated in year 2016 had showed that Malaysia still lags in digital infrastructure. Although there are nearly 80 percent of the

population has connected to the network, but the country still lags in the coverage and adoption of fixed broadband services when compare to its level of economic development. This is because there were only 9 fixed broadband subscriptions per 100 inhabitants in 2016 which less than the prediction. Furthermore, Malaysia also recorded as one of the countries that has slow download speeds and high prices. This is because the domination Telekom Malaysia (TM) had controls 92 percent of fixed broadband subscriptions and cause the Malaysia's fixed broadband market are concentrated and lack of market competition. Therefore, the lags in digital infrastructure and domination of market will affected the digital economy in Malaysia.

Generally, Figure 7 had showed the result of cyclical movement for ICTE and DEI. By this Figure 7, the observation can be recorded that constructed DEI is moving ahead of ICTE in most of the time which it means that the turning point of DEI is leading a few quarter ahead as compare to the turning point of the ICTE. Hence, we can indicate that there are 4 turning points of digital economy index from the period 2009 Q1 to 2018 Q4. However, these 4 of the turning points are only the observation depicts from the graph. Thus, we need to applied the BBQ technique that proposed by Harding and Pagan (2001) to date the turning points more accurately in this period and the result of the dating turning points will be discussed in the next section.

Figure 7: ICTE versus DEI (2009Q1 – 2018Q4)



4.5 Results of the Turning Point Analysis

By using the Bry and Boschan Quarterly (BBQ) technique that proposed by Harding and Pagan (2001), we can identify the turning points of the reference series and DEI and presented it in the Table 4. All the quarterly basis data of the references series and DEI were obtained from the period of 2009 quarter 1 until 2018 quarter 4. From this Table 4, there are 3 peaks and 3 troughs presented for digital economy in Malaysia from the year 2009 to 2018. Although there are not all the peaks and troughs points of DEI leading the references series consistently, but the DEI are able to capture all the significant event in Malaysia and lead averagely 2.8 quarter which presented in the Table 4.

From the Table 4, all the significant events had been presented and all of them had discussed in the previous section. The first peak that happened in year 2010 was influenced by the launched of Economic Transformation Program (ETP) while the first trough was affected by the limited data transparency and data protection laws in year 2013. Besides that, the big portion of expenditure allocation for ICT sector and R&D had boost the digital economy and caused the second peak in year 2014. However, the problem of lags in digital infrastructure had exists the second trough which occurred in year 2016. In addition, this constructed DEI can capture the additional peak and trough for the year 2017 and 2018 respectively which there are undetectable by the ICTE. For the year 2017, the launch of Digital Free Trade Zone (DFTZ) had given the positive sign to improve the growth of digital economy while there are rise of cybercrime cases and cause the trough to happen in year 2018.

In short, the constructed DEI can capture and forecast all the short-term digital economic significant events in Malaysia. This DEI are constructed by 14 component which included fixed broadband subscription (FBSP), internet usage (U), electronic payment by E-money (EPEM), payment systems by Interbank GIRO (PSGIRO), payment channels by mobile banking (PCMB), number of subscribers for mobile banking (NSMB), mobile banking penetration rate to population (MBPP), mobile banking penetration rate to mobile subscribers (MBPMS), employee in ICT manufacturing (EICTM), percentage of commercial services imports (CSI), percentage of ICT service exports (PICTEX), employee in ICT trade (EICTT), number of researchers (RRD) and patent applications (PA).

Table 4: Results of turning point analysis (CF filter)

	ICTE	DEI	Amount of Lead/Lag (quarterly)	Important Events
Peak	2010 quarter 3	2010 quarter 1	+2	Economic Transformation Program (ETP)
Trough	2013 quarter 2	2012 quarter 3	+3	
Peak	2014 quarter 3	2013 quarter 3	+4	Expansion on ICT Expenditure
Trough	2016 quarter 2	2015 quarter 4	+2	
Peak	-	2017 quarter 1	-	Launch of Digital Free Trade Zone (DFTZ)
Trough	-	2018 quarter 2	-	Rise of Cybercrime
Amount of Lead/Lag (quarterly)			**+2.8**	

4.6 Results of Directional Accuracy Test

In this section, the Directional Accuracy Test is applied to predicting the directional of the digital economy performance in Malaysia. The results of the directional accuracy analysis between the reference series ICTE and the constructed DEI are shown in Table 5. The purpose of this test is to identify whether the DEI can be the dependable estimating indicator to outperforming capability against the ICTE. The null hypothesis of the ICTE is that the estimating indicator is a dependable estimating indicator.

Based on the result, it is shown that the first 4 lags are exceeding 70% which presents that the DEI has more than 70% probability to make a prediction of the directional change. Next, the DAR also indicates that there are more than 60% for the

fifth lag and 50% for the sixth lag for the DEI to predict the directional change. For the binomial testing results, it is shown that the binomial value is smaller than the 1% from the first lag to the third lag while smaller than 5% for the fifth lag and 10% for the sixth lag. Thus, the results show that we do not reject the null hypothesis for all the six lags because their binomial value are less than 1%, 5% and 10% significant level respectively. Therefore, it can be said that DEI can be the good estimating indicator for the digital economy in Malaysia.

Table 5: Result of Directional Accuracy and Binomial Testing

DAR between Reference Series (ICTE) and DEI		
Lag (Quarter)	**Directional Accuracy Rate (%)**	**P(Binomial)**
1	74.36%	0.001***
2	78.95%	0.000***
3	78.38%	0.000***
4	72.22%	0.004***
5	65.71%	0.024**
6	58.82%	0.081*

Note: Asterisks (***), (**) and (*) denotes rejection at 1%, 5% and 10% significance level respectively.

4.7 Concluding Remarks

In this chapter, we had achieved our objective by develop a Digital Economy Index (DEI) for the case of Malaysia as a tool to predict and forecast for the significant economic events in the future. In this study, the contribution of contribution of ICT to the national economy (ICTE) had been selected as our reference series due to it can reflect the contribution from each ICT sector and e-commerce to the national economy. Next, the component series were only selected for those component series that showing high correlation to the reference series in the correlation analysis. After that,

the selected component series had been aggregated into the composite form by the Conference Board (2001) method. Then, a few method and techniques that proposed by Moore and Zarnowitz (1986) had used to detect the cyclical movement and date the turning point of the ICTE and DEI. CF filter that proposed by Christiano and Fitzgerald (2003) had been applied to measure detrend and cycle extraction. Moreover, the Bry and Boschan Quarterly (BBQ) technique that proposed by Harding and Pagan (2001) were used to date the turning points of both reference series and DEI. From the results of BBQ test, we can identify that there are 3 peaks and 3 troughs presented and DEI can lead the reference series averagely by 2.8 quarter for the digital economy in Malaysia. In addition, the constructed DEI are able to predict the directional change from the result of DAR test.

There are 14 component was selected to build the DEI which included fixed broadband subscription (FBSP), internet usage (U), electronic payment by E-money (EPEM), payment systems by Interbank GIRO (PSGIRO), payment channels by mobile banking (PCMB), number of subscribers for mobile banking (NSMB), mobile banking penetration rate to population (MBPP), mobile banking penetration rate to mobile subscribers (MBPMS), employee in ICT manufacturing (EICTM), percentage of commercial services imports (CSI), percentage of ICT service exports (PICTEX), employee in ICT trade (EICTT), number of researchers (RRD) and patent applications (PA).

CHAPTER FIVE

POLICY RECOMMENDATIONS AND CONCLUSIONS

5.0 Introduction

This study is conducted to develop a Digital Economy Index (DEI) for the case of Malaysia. This index is important as a tool to predict and forecast the short-term digital economic precariousness that is expected to happen in the future. In this chapter, the summary of the empirical findings will be discussed in Section 5.1. Then, some of the relevant policy implications and recommendation will be presented in Section 5.2. On top of that, the limitation of the study and the direction of the future study will also be highlighted in Section 5.3 and Section 5.4 before the closing remarks make in the Section 5.5.

5.1 Summary of the Empirical Findings

The purpose of this study is constructing an indicator that can use to predict and forecast for the digital economy in Malaysia. Thus, DEI is important as the tool and reference for all the policymakers, investors and other entrepreneurs to prevent the economic vulnerability and make the effectively and efficiency decision for the economy of Malaysia in the future. In this study, the DEI was constructed by the procedure that proposed by the Conference Board (2001). Moreover, there are some method had applied as the empirical guidance to select and choose the component series before the construction of DEI.

The data of component series was collected from the various sources such as Department of Statistic Malaysia (DOSM), World Bank and CEIC from the period year 2009 to 2018. Besides that, we had selected the ICTE as the reference series due to it can capture most of the digital economy activity from ICT sector and e-commerce in Malaysia. Then, both the reference series and component series were transformed from the yearly basis data into the quarterly basis data by the method of interpolation from Gandolfo (1981). After that, the correlation analysis had applied to all component series and only those high correlation component series towards the reference series will be selected for this study.

Next, the five chronological steps that present in chapter 3 had used to compute the composite index by the selected component series and the result of computed index was shown in chapter 4. After that, the few procedure that proposed by Moore and Zarnowitz (1986) had used to detect the cyclical movement of both ICTE and DEI which consist of detrending, smoothing and detecting the turning points. The first step was applied the CF filter that proposed by Christiano and Fitzgerald (2003) for detrending and cycle extraction. Then, the Bry and Boschan Quarterly (BBQ) technique that proposed by Harding and Pagan (2001) were used to date the turning points of both reference series and DEI. In addition, the directional accuracy test was applied to predicting the directional change of the digital economy performance in Malaysia. As the result, we can indicate that there were 3 peaks and 3 troughs presented and the computed DEI can lead the reference series on average of 2.8 quarter. In short, we can conclude that the developed DEI had the function to indicate the significant economic events happened and it can give the early signal than the

reference series. Therefore, this DEI was very useful to reduce the economic precariousness in the short-term for the future in Malaysia.

5.2 Policy Implications and Recommendations

Currently, the change of economic structure has become the hot issues to concern by most of the policymakers, investors and the public. The adopted of digital technologies has transformed the manner in business, work and service into the new generation. By the development of digital economy, transaction cost can be reduced, productivity will be increase and boost the economy growth. Besides that, evolution of digital economy also boosts the globalization which the product and service can provide cross broader with the low cost and shorten time consume. Thus, digital platforms have become important in the world economy and key factor to growth the economy.

The new platform of digital economy can make the collaboration and competition across public, private and others sector. This rapid change of economy also caused the existing government policy outdated and the policy makers needed to try and prepare new policy for the change. By the past of ten years, there are various research had been done on the constructing the digital economy indicator for both developed and developing countries. However, there is only few researches on develop the digital economy index for the case of Malaysia. Hence, the DEI in this study are very useful to give the awareness to the policymakers to make the short-term forecasting and implement the suitable policy. By applying this DEI, the policymakers can forecast the short-term economy precariousness and against the economic

uncertainty. Therefore, the DEI can act as a short-term forecasting tool for the investors and policymakers to make the effectively policy and avoid the unpredictable risk.

On top of that, DEI can also very useful for the business and economy sector. By apply this DEI, the business and organization able to look for the market change and to grab the opportunity. For example, the change of habits by the customer to prefer access the information of product by the e-platform can be an opportunity for the business to advertise and promote their product on the website. Moreover, the business can also identify their weakness by apply this forecasting tools to clarify the problem. Thus, the business can also make improvement based on the prediction of DEI and increase their competitiveness.

5.3 Limitation of the Study

In this study, the incomplete dataset has become the biggest challenge for the study. This is because most of the data from the Department of Statistic Malaysia (DOSM) is incomplete and missing for the specific year. Then, it is very hard for us to collect the complete data accurately and specifically. Moreover, most of the data for component series is very difficult to obtained due to its data protection and privacy concerns. Limitation of data transparency will restrict this study to obtain the complete time series data especially to access the government data. Besides that, most of the data collected were only present in yearly basis and very limit to obtain the accurate data for every quarter that needed for this study.

On top of that, there are big portion of potential leading time series data is lacking in Malaysia. This potential data is useful to improve the composite index to become more effective in forecasting the digital economy in Malaysia if the data is available and sufficient. Furthermore, lack of universal definition for the digital economy had make this constructed DEI difficult to distinguish its measurement scope whether core, narrow or broader. Therefore, this DEI can only be the short-term forecasting tool and use by the policymakers to make the short-term decision. By the limitation to obtain the complete dataset for the long time period, this constructed indicator may not suitable for the long-term decision making due to it cannot capture the economy precariousness accurately in the long-term. However, this DEI still can be very effectively to assists the policy maker to capture most of the significant economic events in the short-term time period and prevent for the uncertainty that may give impact for the digital economy in Malaysia.

5.4 Direction of Future Study

In generally, this study can be further study to construct the better leading indicator and provide more accurate turning point to predict the digital economy in Malaysia. The study of DEI can be extending by other researchers who are interested to build the better forecasting tool for the digital economy in Malaysia. A better leading indicator can be constructed by added more potential component series that can capture an accurate significant economic event. Thus, others component series that has the high correlation with the reference series can included for the study to detect more turning point of the digital economy. Besides that, this study can also be

extending to build the indicator which can forecast the digital economy in the long-term period. If the future researchers can collect and obtain the complete dataset for the long period of time in quarterly basis or monthly basis, then the more specific and accurate indicator can be developed as the long-term forecasting tools. In addition, the future researchers can also use others high level technique to further analyse and construct this indicator to better predict for the digital economy in Malaysia.

5.5 Closing Remarks

The main objective of this study had been achieved by develop a Digital Economy Index (DEI) for the case of Malaysia. This composite DEI is constructed by the high correlation component series with the various methods and procedures that proposed by the previous researchers. The result from this study shown that the DEI has the leading power which can lead the reference series (ICTE) on averagely for 2.8 quarter. Thus, DEI can be the short-term forecasting tool to make the decision due to it can give the early signal than the ICTE for the significant economic events. In conclude, the DEI is the very useful forecasting tool to predict the change and movement of digital economy. So, the policymakers can make the effective policy and prevent the impacts from the economic downturns.

REFERENCES

Bahrini, R., & Qaffas, A. A. (2019). Impact of information and communication technology on economic growth: Evidence from developing countries. Economies, 7(1), 21.

Barefoot K., Curtis D., Jolliff W., Nicholson JR., and Omohundro R. (2018). Defining and measuring the digital economy. Working paper. Bureau of Economic Analysis, United States Department of Commerce, Washington, DC. Retrieved from https://www.bea.gov/system/files/papers/WP2018-4.pdf.

Baxter, M., & King, R. G. (1999). Measuring business cycles: Approximation Band pass filters for economic time series. *Review of Economics and Statistics, 81*(4), 575-593.

Bell, Daniel. (1974). The Coming of Post-Industrial Society. New York: Harper Colophon Books.

Breitenbach, M., Aderibigbe, O., & Muzungu, D. (2005). The Impact of Information and Communication Technology (ICT) on Economic Growth in South Africa: Analysis of Evidence. Retrieved from http://www.essa.org.za/download/ 2005Conference /Breitenbach.pdf.

Brennen, S., and Kreiss D. (2014). Digitalization and digitization. Culture Digitally, 8. Retrieved from http://culturedigitally.org/2014/09/digitalization-and-digitization/.

Brynjolfsson E., and Kahin, B, eds. (2002). Understanding the Digital Economy. Massachusetts Institute of Technology, Cambridge, MA.

Brynjolfsson, E., & Kahin, B. (2000). Introduction, in Understanding the Digital Economy, E. Brynjolfsson & B. Kahin (eds), MIT Press, Cambridge, MA, 1-10.

Chaaben, N., & Mansouri, F. (2017). Digital Economic and Social Evolution of Tunisia.

Christiano, L. J., & Fitzgerald, T. J. (2003). *The Band Pass filter*. NBER Working Paper No. W7257.

Conference Board (2019). Contribution of ICT to Gross Domestic Product (GDP) 1990-2018

Dewan, S., and K.L. Kraemer, (2000). Information technology and productivity: Preliminary evidence from country-level data. Management Science, 46(4): 548–562.

Etoundi, R.A., Onana., F.S.M., Olle, G.D.O., and Eteme, A.A. (2016). Development of the Digital Economy in Cameroon: Challenges and Perspectives. Electronic Journal of Information Systems in Developing Countries, 76(7), 1-24. Retrieved from http://onlinelibrary.wiley.com/doi/10.1002/j.1681-4835.2016.tb00558.x/pdf

Fong, M. (2009). Digital Divide: The Case of Developing Countries. Issues in Informing Science and Information Technology, 6, 471-478. Retrieved from http://iisit.org/Vol6/IISITv6p471-478Fong597.pdf

G20 Repository of Digital Policies. Retrieved December 6, 2019, from https://g20digitalrepo.org/detf/.

Gandolfo, G. (1981). *Qualitative Analysis and Econometric Estimation of Continuous Time Dynamic Models.* Amsterdam: North-Holland Publishing Company.

Greer, M. (2003). Directional Accuracy Test of Long-Term Interest Rate Forecast. *Journal of Forecasting*, 19(2), 291-298.

Harding, D. and Pagan, A. (2001), Dissecting the cycle: A methodological investigation, journal of monetary economics, Forthcoming.

Hodrick, R. J., & Prescott, E. C. (1980). *Postwar U.S. Business Cycles: An Empirical Investigation.* Carnegie Mellon University Discussion Paper Series 2233.

Johansen, S., & Jelius, K. (1990). Maximum likelihood estimation and inference on cointegration with application to money demand. *Oxford Bulletin of Economics and Statistics,* 52, 169-210.

Khaouani, Leila. (2019). The impact of fixed and mobile telephones on economic growth in Algeria during the period from 1963 to 2015.

Khoo, G. S., & Hui, M. L. M. (2010). The Impact of Global of Financial Crisis: The Malaysia Case. Retrieved November 10, 2019, Retrieved from https://www. twn.my/ title2/ge/ge26.pdf.

Kling, R., & Lamb, R. (2000). IT and organizational change in digital economies, in Understanding the Digital Economy, E. Brynjolfsson & B. Kahin (eds), MIT Press, Cambridge, MA, 295-324.

Kooshki, M.F., & R. Ismail (2011) The impact of information and communication technology investment on economic growth in newly industrialized countries in Asia. Australian Journal of Basic and Applied Sciences, 5 (9) (2011), pp. 508-516

Kwiatkowski, D., Phillips, P. C., Schmidt, P., & Shin, Y. (1992). Testing the null hypothesis of stationary against the alternative of a unit root. *Journal of Econometrics*, 54, 159-178.

Lane, N. (1999). Advancing the digital economy into the 21st century, Information Systems Frontiers, 1(3), 317-320.

Machlup, F. (1996). The Production and Distribution of Knowledge in the United State, Moscow, Progress.

Malecki, EJ., and Moriset, B. (2007). The Digital Economy: Business Organization, Production Processes and Regional Developments. Routledge, London.

Margherio, L. et al. (1999). The Emerging Digital Economy, Department of Commerce, Washington, DC. Retrieved from http://www.esa.doc.gov/sites /default/files/ emergingdig_0.pdf

MOROZ, M. (2017). The level of development of the digital economy in Poland and selected European countries: A comparative analysis. doi: 10.1515/fman-2017-0014

Murtada, S. (2019). Speech: Unlocking The Potential of The Digital Economy. Retrieved December 7, 2019, from https://www.treasury.gov.my/index.php/ en/galleryactivities/speech/item/5105-speech-unlocking-the-potential-of-the-digital-economy.html.

Nasab, E. H., & Aghaei, M. (2009). The effect of ICT on economic growth: Further evidence. International Bulletin of Business Administration, 5, 46–56.

Negroponte, N. (1995). BEING DIGITAL, 1–243.

OECD (2004) "The OECD-JRC Handbook on Practices for Developing Composite Indicators", paper presented at the OECD Committee on Statistics, 7-8 June 2004, OECD, Paris.

OECD (2011). OECD Guide to Measuring the Information Society. OECD Publishing. http:// dx.doi.org/10.1787/10.1787/9789264113541-en.

OECD (2012). OECD Internet Economy Outlook 2012. OECD Publishing, Paris

OECD (2014). Measuring the Digital Economy: A New Perspective. OECD Publishing, Paris.

OECD (2016). Ministerial Declaration on the Digital Economy ("Cancún Declaration") from the Meeting on The Digital Economy: Innovation, Growth and Social Prosperity, Cancun, 21–23 June 2016. Retrieved from https://www.oecd. org/internet/Digital-Economy-Ministerial-Declaration-2016.pdf

OECD (2017). OECD Digital Economy Outlook 2017. OECD Publishing, Paris.

Phelps, E.S. (2006), 'Toward a Model of Innovation and Performance along the Lines of Knight, Keynes, Hayek and M. Polanyí', paper prepared for the conference on Entrepreneurship and Economic Growth, Max Planck Institute and the Kauffman Foundation, Tegernsee (Munich), 8–9 May

Porat, Marc Uri. (1997). The Information Economy: Definition and Measurement. Retrieved October 2019

Pradhan, R.P., Arvin, M.B., Mittal, J. and Bahmani, S. (2016) 'Relationships between telecommunications infrastructure, capital formation, and economic growth', Int. J. Technology Management, Vol. 70, Nos. 2/3, pp.157–176.

Pradhan, R.P., Mallik, G., Bagchi, T.P. (2019) Information communication technology (ICT) infrastructure and economic growth: A causality evinced by cross-country panel data. IIMB Manag. Rev. 2019, 30, 91–103

Saltelli, A. (2007) Composite indicators between analysis and advocacy, Social Indicators Research, 81: 65-77.

Spiezia, V. (2013). ICT investments and productivity: Measuring the contribution of ICTS to growth. OECD Journal: Economic Studies, 199–211.

Tapscott, Don. (1997). *The digital economy: promise and peril in the age of networked intelligence*. New York: McGraw-Hill.

The Conference Board. (2001). *Business Cycle Indicators handbook.* New York, NY: The Conference Board.

Toader, E., Firtescu, B., Roman, A., & Anton, S. (2018). Impact of information and communication technology infrastructure on economic growth: An empirical assessment for the EU countries. Sustainability, 10(10), 3750.

Torero, M., Chowdhury, S., and Bedi, Arjun S. (2002). Telecommunications Infrastructure and Economic Growth: A cross-country analysis.

UNCTAD (2017). Information Economy Report 2017: Digitalization, Trade and Development. (United Nations publication, Sales No. Sales No. E.17.II.D.8, New York and Geneva).

World Bank (2016). World Development Report 2016: Digital Dividends. Washington, DC.

World Bank (2019). Gross Domestic Product of Malaysia from 1989 to 2018.

Zarnowitz, V., & Moore, G. H. (1986). Major changes in cyclical behavior. In *The American Business Cycle: Continuity and Change* (pp. 519-582). London: University of Chicago Press.

Zuhdi, U., Mori, S., and Kamegai, K. (2012). Analyzing the role of ICT sector to the national economic structural changes by decomposition analysis: the case of Indonesia and Japan Procedia-Social and Behavioral Sciences 65 749–54

Zhang, W., & Zhuang, J. (2002). *Leading Indicators of Business cycles in Malaysia and the Philippines.* Asian Development Bank, Economics and Research Department, Working paper Series, No. 32.