LINKAGE BETWEEN THE ROLE OF KNOWLEDGE AND ECONOMIC GROWTH: A PANEL DATA ANALYSIS

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DECLARATION

We hereby declare that:

(1) This undergraduate research project is the end result of our own work and that due acknowledgement has been given in the references to ALL sources of information be they printed, electronic, or personal.

(2) No portion of this research project has been submitted in support of any application for any other degree or qualification of this or any other university, or other institutes of learning.

(3) Equal contribution has been made by each group member in completing the research project.

(4) The word count of this research report is 20,497.

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ABSTRACT

This paper seeks to investigate the linkage between the role of knowledge and economic growth using a panel data analysis ranging from the period of 2000 to 2012 across 55 countries as the sample of our studies. The use of knowledge to reduce the gap of unequal wealth distribution and drive up future economic growth has been a worldwide concern which is the main factor that urge us to choose this subject field for our paper. This study focused on the Knowledge Economy Framework which is well-developed by World Bank in year 1999. In other words, our main purpose is to identify whether each of the knowledge economy pillars within the framework can have impact on economic growth. The employment of Cobb-Douglas production function has been used to form our first standard growth model before further derive and extend it. Based on the finding of our empirical analysis using the best fitted Fixed Effect Model (FEM), 7 out of 12 independent variables is found to be statistically significant with economic growth. Next by using the Average Impact Index, the first pillar government incentives and institutional regime is estimated to be the most impactful pillar compared to the rest of three knowledge pillars. Finally, to compare impact across regions, our result for Fixed Effect Least Square Dummy Variable Model (FLSDV) based on average impact index suggested that all of the four pillars have stronger impact on the economic growth of G7 and developed nations as compared to non-G7 and developing nations respectively. While for Asia countries, it is found that both two pillars innovation system and information infrastructure have stronger impact on its economic growth. It is concluded that across different regions, the magnitude of knowledge contribution is different, hence the impact of knowledge pillar might alter too. Thus, designing policies on government incentives and institutional regime as well as respective impactful knowledge pillars according to regions are imperative for one’s economic growth.

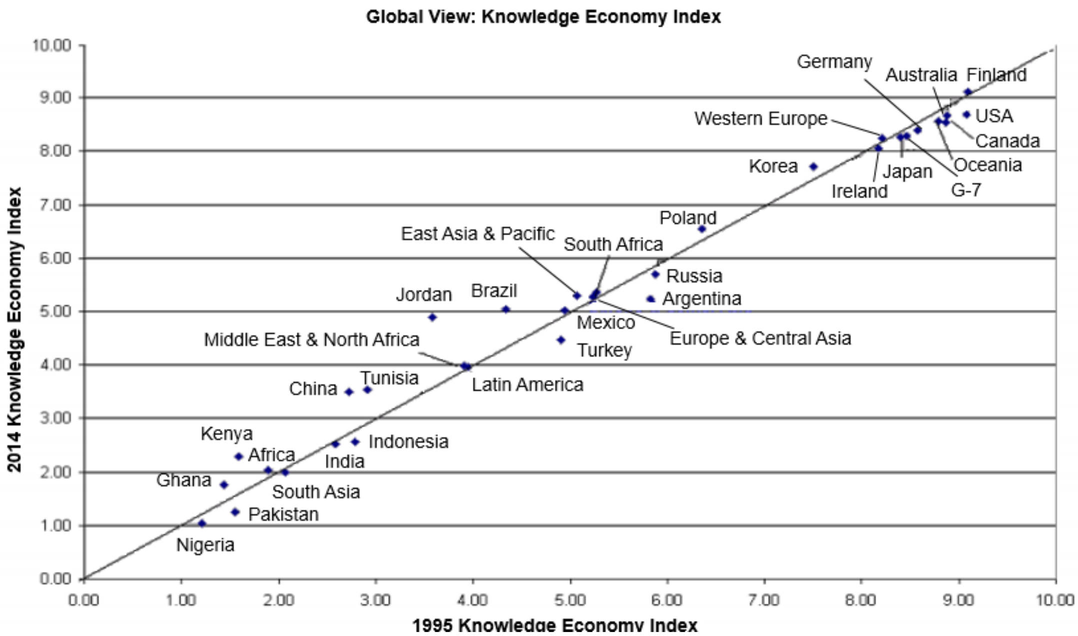
CHAPTER 1: RESEARCH OVERVIEW

1.0 Introduction

Over the years there has been growing tremendous attention and interest throughout the worldwide with the hotly debated topic of knowledge-based economy transition whereby the global economy is started moving out from the agricultural and labour based economies. Indeed, the global economy is transforming and entering into a new era of 'knowledge society' in which the growing realization of knowledge as a critical driver and core of economic development is undeniably driving countries into harnessing the advantages of a knowledge economy (Ogundeinde & Ejohwomu, 2016). Knowledge economy is a concept where both production and consumption that are based on intellectual capital which is considered an asset that provides economy with competitive advantage. As such, in a knowledge economy, a significant part of its economic value is consisted of intangible values, say knowledge.

Knowledge economy, is referring to the utilization of knowledge to create and produce innovative goods and services which indirectly spur and sustain long term economic growth of a country. It is an economy where knowledge is found, acquired, collected, produced, developed, diffused and used efficiently throughout every sector in order to promote economic growth. According to Chandra (2011), science and technological use are the main heart of knowledge-based economy development. The most common knowledge economy definition was developed by OECD (1996) whereby it is an economy that is meant to be directly based on creation, production, dissemination and use of knowledge as well as information. According to Shapira, Youtie, Yogeesvaran and Jaafar (2005), they defined knowledge content as "the combination of high qualified human capital resources, technology and information capital, leadership assets and experience, intellectual property, informational stocks, collaborative relationships, and capabilities for shared learning that is meant to enhance country wealth creation and foster economic competitiveness.” Furthermore, Powell and Snellman (2004) defined knowledge-based economy as an accumulation of knowledge-intensive activities that is based on production and services side in which it helps to contribute to a rapid pace of scientific and technological enhancement but at the same time creates equally rapid obsolescence.

Figure 1.1 Comparison of KEI in year 1995 and 2004



Source: World Bank Institute, 2014

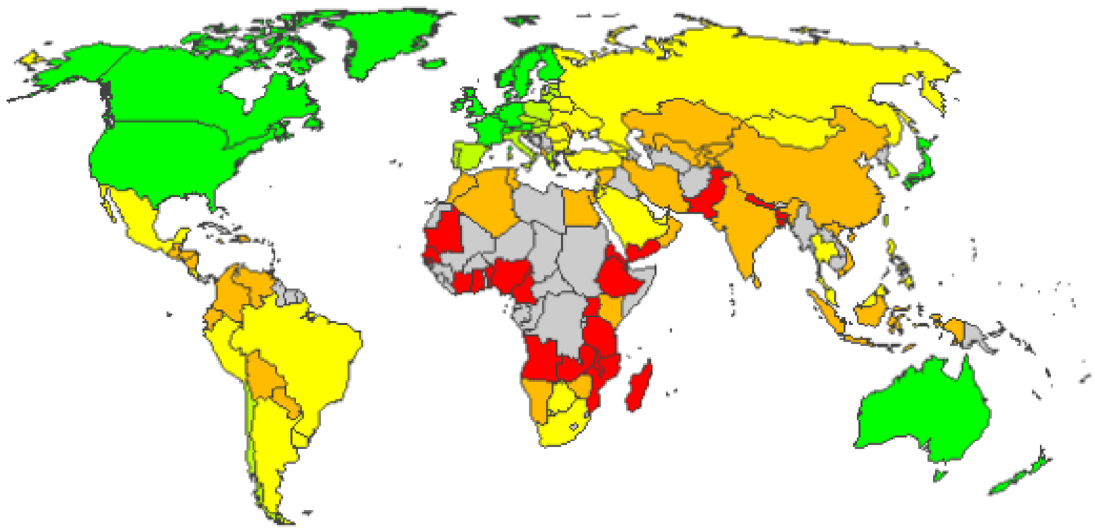
Figure 1.1 represents the comparison of knowledge economy index (KEI) derived from the World Bank’s Knowledge Assessment Methodology in year 1995 (plotted on horizontal axis) and the most recent year 2014 (plotted on vertical axis). KEI is a composite index developed by World Bank to act as the average performance scores of all the four knowledge pillars in a region or country. The index is a measurement or value that indicates the overall knowledge readiness of a region in relative to the world. Countries perform more knowledge economy is being plotted in the northeast area of the graph; whereas the weak performers being plotted in the southwest part. Besides, countries plotted below the line shows their knowledge performance in 1995 while for those plotted above line indicates an improvement in performance in 2014 compared to 1995. Lastly, countries plotted on the line meaning they remain the performance for these two periods. Apparently, those G7 and developed countries shown in northeast part do not have significant growth of knowledge performance as many of them still maintain the performance growth over the time. However, those like China, Kenya, Poland, Brazil and so on, shows a significant improvement of knowledge performance.

Today, much attention has been raised onto the new global stage of knowledge-based economy whereby it reflects the ability to achieve or invent something creatively and innovatively for an economy. As compared to traditional economy, the knowledge economy is not of scarcity anymore but abundance. This may be due to the depletion of resources in traditional economy, whereas for knowledge, it is something that can be shared and generated over and over again. (Tocan, 2012). In fact, the continuous use and generation of knowledge throughout the process of economic development serve as a foundation stone for an economy to become a knowledge economy eventually. A successful transition to the knowledge economy generally demands criteria such as enhancing innovation capability, investing in education sector, enlarging and modernizing the information infrastructure as well as building an economic environment that is beneficial and easy for economic transactions (Gorji & Alipourian, 2011). To be direct, the critical knowledge sources that used to generate both tangible and intangible values for the whole economy, are known as knowledge-based factor.

In a nutshell, knowledge which embodied in economy output has been identified as a primary source of wealth creation. It has been well acknowledged that the role of knowledge generated through advanced technological progress is said to be the long-term driver of one's prosperity. In this emerging global knowledge economy filled with the fast pace of human capital development by a means of education, it is vital for a nation to build a rigid foundation for self-capability construction in order to adopt knowledge. This would indirectly help one country to reap the opportunities of globalization and this society where information use and know-how is getting more critical to economic success (Chandra & Yokoyama, 2011).

1.1 Research Background

<u>Figure 1.2 World Knowledge Economy Map</u>



Source: World Bank Institute, 2014

Notation:

$0 \leq KEI \leq 2$

$2 < KEI \leq 4$

$4 < KEI \leq 6$

$6 < KEI \leq 8$

$8 < KEI \leq 10$

No data

Figure 1.2 represents the world knowledge economy map which demonstrates the KEI in different colours with different range across 121 countries. Apparently, the higher value of KEI (or higher range in our case) indicates higher preparedness or higher knowledge-related activities performed by that region. According to the Knowledge Assessment Methodology report from World Bank (2014), those countries like Australia, Sweden, Norway, Germany, Finland, United Kingdom, Japan, Korea, Canada and United States practiced the most of knowledge-based activities and hence they are coloured as light green, which exhibit the highest value of KEI among those range. While for countries like Poland, Spain and Portugal, the KEI is between 6 to 8; then for Russian Federation, Ukraine, Belarus, Romania, Saudi Arabia, Brazil, Argentina, Peru and Mexico have a KEI of between 4 to 6; followed by Egypt, Kenya, China, India and Columbia exhibits a KEI of between 2 to 4; lastly the least KEI range falls on Nigeria, Ethiopia and Pakistan.

Knowledge-based economy has been existed since early of human civilization. The evolution of knowledge economy started where knowledge was found to be the most powerful production engine in the late 19^{th} century and firms can help to facilitate knowledge growth, according to Marshall's studies (as cited in Cader, 2008). Then, knowledge was continuously incorporated as a part of firm's production function through a form of human capital in 20^{th} century and accumulated over the time (Cader, 2008). Besides, the worldwide national leaders also started to pay high attention and moving towards economic activities that were related to knowledge in which they inferred the future economy will be more prosperous by relying on the knowledge-based sectors. Then in the early 1990s, there has been growing demand for high skilled labour in the knowledge-intensive sector and the high demand was met with the heavy importation of China and India migrant workers.

According to Schumpeter (as cited in Cader, 2008), in early 20th century, the new combination of knowledge which includes innovation, entrepreneurship and technological change are the essential inputs for economic growth. Then, knowledge was passed on and benefited the society through the goods and services produced which made available for them to meet basic living needs. Ever since then, it is true where knowledge-based economy started to grow gradually with some countries dominate it as main economic activities.

World Bank and OECD have been cooperated in their activities to create knowledge-based economy and their effort was being helped by those transition countries too. Therefore in this paper, we will focus on the knowledge economy framework which had been developed by World Bank institute in year 1999. The primary function of this framework is to access and evaluate the adaptation and utilization of knowledge in domestic economic production, with the final purpose of producing higher value added goods and services in order to be able to stimulate one country's economy success as to become capable of competing in the current globalized economy. In this framework, it focuses on the four knowledge economy pillars which each pillar is constituted by some key knowledge-based proxies that provide and enable a better knowledgeable environment: (a) Government incentive and institutional regime: rule of law, regulatory quality, tariff and non-tariff barriers; (b) Educated and skilled populations: secondary enrolment, tertiary enrolment, adult literacy rate; (c) Innovation system: patent applications, royalty and license fees payments and receipts, scientific and technical journal article; (d) Information infrastructure: internet users, fixed broadband subscriptions, mobile cellular subscriptions (Gorji & Alipourian, 2011).

The first pillar is known as **government incentive and institutional regime** which essentially offers incentives to encourage the generation, diffusion and utilization of available knowledge efficiently. It is a regime that promotes and fosters favourable economic policies which helps to spur growth through efficient distribution of available knowledge and resources. Besides, the economic environment is also supported by favourable policies to the market transactions, say encourage trade openness and loosen regulations on foreign direct investment. Lee, Ricci and Rigobon (2004) found that openness to trade through increasing the frequency of import and export activities have a positive impact on economic growth due to knowledge spillovers. Furthermore, economic growth can also be promoted through encouraging foreign direct investment due to knowledge accumulation over time. (Silajdzic & Mehic, 2015).

Education and training which can be invested to use and share available knowledge in a way more effective and efficient is the second pillar of the knowledge economy framework. The global economy is now demanding more on an educated society which is better equipped with skills and knowledge for significant economic production and to build a relatively strong competitive workforce that will lead to a rigid foundation for economic success (Tocan, 2012). Education is a form of lifelong learning which tends to prepare the society to generate higher level of demand in exploring knowledge. Undeniably, education improves one's thinking and behaviour, promotes social cohesion, narrows income gap and distribution as well as reduces one country's crime rate. Education can be divided into several categories such as formal education that come from proper schools, non-formal education that come from job training, and informal education that come from the skills taught by family members and society.

The third pillar under the knowledge economy framework is the development of **innovation system** by firms, universities, consultants, research centres and many other organizations which allocate, create, adapt and apply knowledge under the R&D environment that results in new innovative technologies and processes. The generation of new ideas and knowledge tend to spur productivity growth of one country. Indeed, there are many different individuals or social organizations play a pivotal role in this process: (a) Businesses: provides private capital to invest in newly innovative goods and services. Besides, they also do create business models which allow small to medium sized firms from different sectors to grow and succeed in the global economy; (b) Government: plays an important role in developing rigid system to protect one's patent and property. Also, working closely with businesses through R&D funding to strengthen innovation system by sharing knowledge, ideas and technology expertise; (c) University: is a place where most of the entrepreneurs born. More opportunities and support could be given to those who are interested in contributing ideas to the market and economic environment in order to promote talent growth (Tocan, 2012).

The fourth pillar is undeniably the **modern information infrastructure** that facilitates effective communication, processing and dissemination of information, knowledge and technology. The idea is to form a greater communication channel by allowing information added and productive economy. Shapiro and Varian (as cited in Cader, 2008) concluded that the fast pace of change and well-developed of information economy today are driven by the information technology and infrastructure advancement instead of the nature shift of the information itself. Indeed, information commons can be way more useful to the economy when it is codified and stored in a proper way to be made available for all users. Cader (2008) argued that knowledge storing can make information retrieval easier and be used in the economy production processes, which indirectly lead to update of current available knowledge as well as further generation of new knowledge. Other than speeding up information flow, it is crucial that government builds and provides basic infrastructure and relevant regulations aim to protect intellectual property rights of information users.

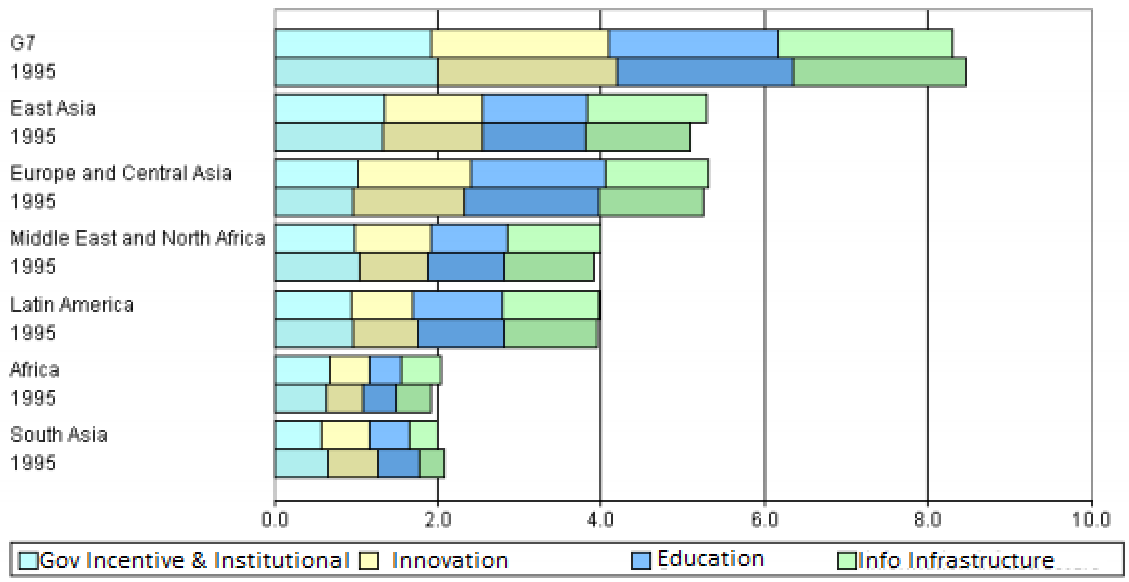
1.2 Problem Statement

With the rapid development and growing of worldwide economy, knowledge has attracted high volume of attention and become increasingly important as a result of being recognized as one of the core engine in determining the trend of economy growth. In other words, knowledge has led us to focus more on the role of technology, information and learning throughout the economy performance. Hence, it is undeniably that ensuring effective use of knowledge for both short-term and long-term economy growth is imperative for our 55 countries studied.

It is believed that to achieve an ideal state of global economy, every country should be in a 'good' economic situation whereby one country is utilizing its resources efficiently to prosper and achieve higher level of growth curve. However in reality, the current global economic situation is still in an unbalanced state as in those developed countries are enjoying better living standard compared to those developing; or even worse, rich people are getting richer and poor people getting poorer. The unequal distribution of wealth across the world or in one country is a serious matter that all of us need to concern and take note of. Indeed, here linked to the problem being addressed in this study- the most common economic problem- poverty, which is relatively difficult to be solved by traditional or resource-based economy even though it has developed to a certain high level. Poverty by definition, is referring to a state of living in extremely poor.

In between 1970s to 1990s, the resource-based economy has developed enormously across every country and with no worldwide war happen during that period. Many of the developed nations and those international non-profit organizations were trying to help the rest of undeveloped nations to reduce the gap between those poor and rich- the unequal distribution of wealth. Unfortunately, the situation in those nations did not undergo significant changes and the income gap was getting wider. During the development of knowledge economy in 20th century, some facts have been accounted where economic problems like poverty may not be solved under resource-driven economy but it is workable in knowledge-based economy in a long term view (Carayannis & Formica, 2008). The reason behind is that, with innovation, advanced technology, high education, rigid institutional framework and entrepreneurship under the knowledge R&D environment can definitely prepare the society in moving towards a better standard of living and thereby closing up the poverty gap in the long run.

Figure 1.3 Knowledge Economy: Regional Performance in 1995 and 2004

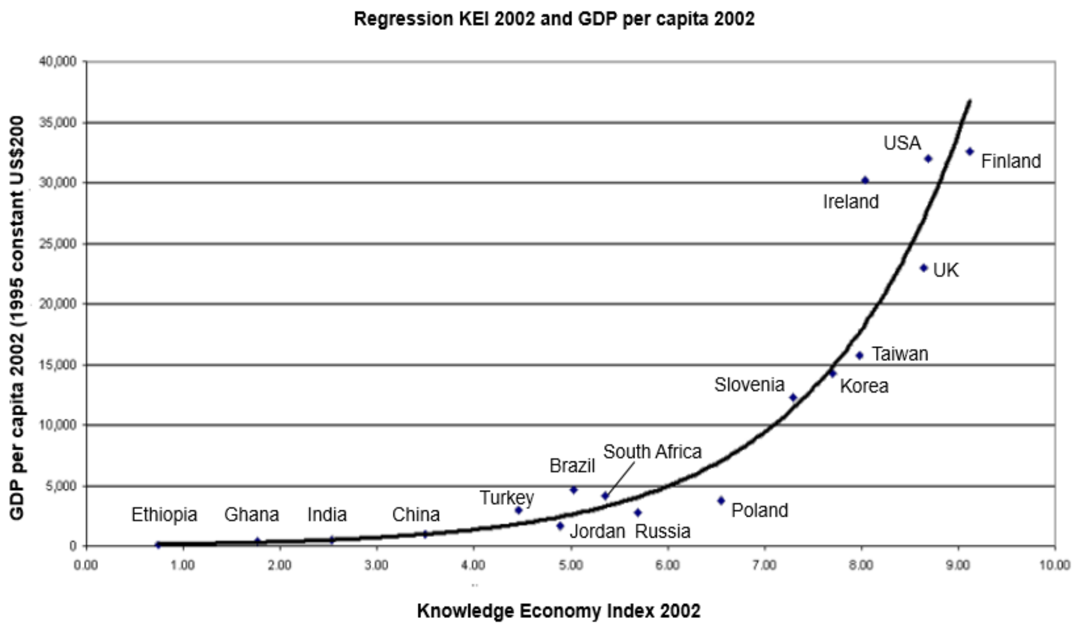


Source: World Bank Institute, 2014

The bar chart above represents the aggregate KEI score performance for four knowledge pillars across selected country and region in 1995 (lower bar) versus 2004 (upper bar). Each colour bar represents each country or region's knowledge readiness on each particular pillar. In 2004, G7 has the highest knowledge performance among those regions and countries, followed by East Asia, Europe and Central Asia. The least knowledge score is illustrated by South Asia and Africa. Therefore, it is obvious where the knowledge performance differs across different regions. The purpose of examining cross region in knowledge economy growth is to allow us able to assess to what extent developed countries' economic growth rely on nationally or internationally produced knowledge. As much of the knowledge generated in one economy can be enjoyed by other countries with similar characteristics, the capacity to increase growth will be determined not only by the country's stock of knowledge but also by other countries' knowledge (Leon-Ledesma, 2005).

In addition, in the past decade or so, most of the researchers have been investigating on many other factors that contributed to economy growth over a period of time in particular countries. However, many of the economic-related inputs are believed to have unsustainable effect due to diminishing returns. For instance, other than those common factor like foreign direct investment which can have significant impact on economic growth, the role of knowledge-related activities can be one of the contributor too as it seems to be the key to overcome diminishing marginal returns effect because of its valuable characteristic where it can be passed down from users to users without losing its usefulness over the time (Karagiannis, 2007).

Figure 1.4 Relationship between KEI and Economic Growth in 2002



Source: World Bank Institute, 2014

The graph above illustrates the positive and significant correlation (R^2=0.66) between KEI and economic growth, according to World Bank (2014). This simply implies that, although the KEI is derived by World Bank using its own knowledge assessment methodology, nevertheless it is positively related with economic growth. In other words, KEI is part of the economic growth and whenever we want to talk about knowledge growth, country's economic growth can be used as one of the indicator other than KEI, by a means of adopting proper model to regress the relationship between knowledge components or knowledge-based variables with economic growth.

For instance, Palickova (2014) has studied on the relationship between role of knowledge and economic growth of studied countries. It is found that there exist significant and positive impact of knowledge towards economic growth. When a country has more investment in knowledge, the more advanced a country will be. This may be due to knowledge creation and knowledge accumulation over time which contribute to a country's development. According to Utku-Ismihan (2012), it is suggested that higher level of knowledge is proven to have positive impact on the growth of Turkish economy from year 1963 to 2010 by applying a production function approach. Hence, it is important to form an economic environment that is conducive to promote the knowledge level which indirectly spurs economic growth. On the other hand, Perret (2015) also showed that Russian's growth is no doubt driven by the exploitation of vast natural resources, such as gas and oil. However, their study concluded that there is a significant part of Russian growth is contributed by its innovation system, which is claimed as one of the knowledge-based component. As a result, this proves that innovation oriented growth is a solid foundation to be built for further knowledge growth generation.

Much has been mentioned about the impact and importance of knowledge towards achieving high productivity of a nation's economy. Furious debate on this topic has been carried out from different researchers on examining the relationship between knowledge economy framework and economic growth. However, different studies contributed to different results. Besides, many of the researchers mainly focus on the study of four knowledge pillars and discuss more on how they can relate to economy growth. Instead, very rare of the studies quantify the relationship between knowledge economy framework and economic growth research. Other than that, a broad range of studies have reported the empirical results on the contribution of knowledge economy pillars, however they mostly focus on one particular country or some region area such as USA, Western Europe, European Union or those high income countries; whereas only a smaller range of studies show comparison among regions.

Furthermore, as mentioned earlier the knowledge-based variables extracted from each pillars in the knowledge economy framework are created and well-developed by World Bank. In fact, many of the researchers only discussed the impact of one particular pillar, say whether they are significant or so. In that sense, it leaves a question whereby we do not know which knowledge pillar out of the four is the most impactful one in influencing economic growth for future research or contribution. Lastly, these problem statements lead us to a way as in what we can contribute for the gap of past research.

1.3 Research Objectives

1.3.1 General Objective

The problem statement stated above provided us a clearer insight, guidelines and better motivation to analyze the relationship of knowledge economy framework on economic growth using a panel data analysis. Our research could be able to serve as a major contributor to foster policy change by emphasizing more on upgrading education system, innovative system and technology infrastructure in order to further stimulate and generate new knowledge in the economy.

1.3.2 Specific Objective

i. To investigate the linkage between knowledge economy framework and economic growth across 55 countries from year 2000 to 2012.
ii. To identify the most impactful knowledge economy pillar in affecting the economic growth.
iii. To compare the impact of knowledge economy framework on economic growth across different regions.

1.4 Research Questions

i. What is the relationship between each knowledge economy pillar with economic growth using a panel data analysis?

ii. Which is the most impactful knowledge economy pillar in influencing economic growth?

iii. Which knowledge economy pillar has stronger impact across different economic regions?

1.5 Significance of the Study

After carrying out the studies, we found that most of the journal articles and researchers devoted enormous energy to study on how the knowledge economy framework in affecting the economy growth. However, their findings are mainly based on the collection of results from different other sources and they mainly focused on some region in their study. Hence, it gave us a deeper insight and motivation to contribute to our research by quantifying the results for 55 countries across 13 years, which is a view from panel data analysis.

In addition, the knowledge economy framework early developed by World Bank is the main model we want to test in our studies. Other than to prove whether which pillar has significant impact to economic growth, we also keen to identify the most impactful pillar in influencing economic growth. Furthermore, since we have 55 countries data on hand, other than to discussing the result as a whole, we will compare the results region by region. For instance, the effects of knowledge pillar towards economic growth in G7 and non-G7 countries, Asia and non-Asia countries, and lastly developing and developed nations. Through this, the research can have a clearer comparison in overall view.

This research paper is important to see how economic growth can be enhanced by knowledge in order to foster policy change. If our studies proven insignificant, those unnecessary funding can be relocated to other sectors for better economic balance. On the other hand, if results proven significant in certain pillars, more upgrading development can be done to further enhance its impact on countries' growth.

1.6 Chapter Layout

Our paper will be divided into five chapters in which the sections are organized as follows: Chapter 1 covers our research overview; Chapter 2 provides a brief review on the relevant literature studies whereas Chapter 3 discusses our data descriptions and methodology used in our paper then followed by Chapter 4 which presents our result findings and interpretation. In the final section, a summary of our research conclusion and policy implications will be elaborated at Chapter 5.

1.7 Chapter Summary

In this Chapter 1 of research overview, we had introduced on the definition of knowledge economy and its importance in affecting worldwide economic development. Besides, we also introduced the knowledge economy framework formed up by World Bank. Then, it followed by the description of background and history of our research topic with some graphical presentation to illustrates a clearer overview.

Indeed there do not have much researchers quantify the knowledge economy studies and most of them probably only focus on either one of the four pillars which had been well-developed by World Bank. Also, most of the researchers carried out their research on knowledge economy towards particular countries or region only. These problem statements lead to our research objectives where we want to quantify the 'knowledge growth' and compare the results among regions.

Other than that, a few research questions have been brainstormed and proposed by us as they provided us a clearer direction to find out the answers. Lastly, the significance of the study will illustrate our contribution for this paper.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

In this chapter, we will be reviewing those previous published studies that are relevant to our research topic- the knowledge-based economy. This is especially useful for us to brainstorm about developing hypothesis for our study and establishing a relevant theoretical or methodological framework to make our research solid and meaningful. Thus under this section, we will divide the writing into several parts. For the first part, we will focus on the labour and capital in affecting economic growth. Then, it will be followed by the relationship between our independent variables, which are the four main knowledge pillars towards economic growth.

2.1 Relationship between Government Incentives and Institutional Regime and Economic Growth

In this part, we will review on the first pillar of knowledge economy framework which is government incentives and institutional regime. This pillar is compiled of few proxies such as trade, government effectiveness and regulatory quality. It is no doubt to say the complete process of knowledge generation and dissemination in a knowledge economy is strongly tied to the application of government policies (Chandra, 2011). Thus, in this section, we will be reviewing previous studies on how this pillar can affect economic growth, say whether positively or negatively.

The ability of government to provide effective regulatory framework can be a benchmark or determinant of how well an economy and market transaction perform. Thus, the effect of institutional regime on economic development depends on the quality of governance process, regulatory policies adopted and incentives applied. The process of structural change towards knowledge-based economy and its relationship together with institutional regime is increasingly important. This is because of the interaction relationship between players and institutions such as firm production system, public authorities, businesses, universities and education sector as a whole – addressed to developing technology and scientific knowledge, which indirectly impact on the innovative performance of organizations, firms, and economies (OECD, 1996; Mokyr, 2002).

According to the studies from Jalilian, Kirkpatrick and Parker (2007), they tested on the efficiency and regulation quality with economic performance using both cross-sectional and panel data analysis. The result confirmed that the regulation standard matters for economic growth. The result and finding are consistent with the support by Kauffman, Kraay and Mastruzzi (2005); Olson, Sarna and Swamy (2000) who showed that there is a strong relationship between government regulation quality and economic productivity government regulation quality has significant impact on income growth.

Other than that, the work of Petrovic and Stanisic (2015) has proven that government incentive and institutional regime gives unique and statistically significant contribution to the economic growth. Also, based on their beta values, it was shown that this pillar has the second highest impact on economic growth. This is due to the economic growth depends on whether the state has a well-established and transparent macroeconomic and competitive policies, as well as the legal framework that provides a way for different individuals to generate and use knowledge freely, efficiently and effectively. From the journal of Sepehrdoust and Shabkhaneh (2015), they also found that government incentives and institutional regime have the highest impact on the economic growth of the factors of production. It also showed a better economy performance for production factors and a significant increase in total factor productivity (TFP). Besides, they argued that institutional regime of a country should be planned efficiently so as to encourage businesses to utilise knowledge given that favourable environment and condition for economic activity are delivered.

In order to promote a knowledge-based economy, the existence of institutions alone is not enough but a strong, credible and stable regulatory quality for these institutions is equally important. This is further supported by the work done of David and Foray (2003), they found a highly significant impact of institutional regime on knowledge economic growth. The reason behind is that the development of a knowledge-based society is specifically based on the institutional regime, thus the creation of credible institution framework becomes a prerequisite. Besides, they also argued that the relation is very complex although institutions and knowledge are highly interrelated with each other. This is because institutions often act as a framework of reference which constitutes the 'environment', an independent reality that exists from individual considerations. Nevertheless, they provide stability for firms, business individuals and organizations while reducing uncertainty at the same time. Therefore, their relationship is said to be positive as it guides the process of knowledge economic growth.

In addition, Bosworth and Collins (2003) declared that a country's institutional regime plays a crucial role in fostering knowledge-conducive environment for economic development, provided the criteria of stable inflation, sustainable government spending and budget deficits are fulfilled. This statement is further supported by Levine, Loayza and Beck (2000), in which they found that the exogenous element of financial intermediary development has a significant positive impact with economic growth. They argued that a rigid financial system should have the ability to make use of resources to meet sound investment opportunities and reallocate those unnecessary funding from failed organizations to more promising ones who in better needs. Therefore it is no doubt that a strong and credible regulatory quality from policy makers is increasingly important and necessary.

An institutional regime that is conducive comprise features such as accountability and corrupt-free legal framework as well as effective regulatory system that provides support to the basic commerce rules and protection against intellectual property rights. Among various indicators of institution, Knack and Keefer (1995) found that patent offered a more powerful explanation and significantly affect knowledge economic growth. They also stated that intellectual property rights should be well protected by a means of regulating and enforcing laws in order to achieve knowledge economy growth. The result is further supported by the findings from Kaufmann, Kraay and Zoido-Lobaton (2002) which investigate on the growth of knowledge economy using cross-sectional data analysis. They found that property rights is the most significant proxy in affecting economic growth as if intellectual property rights is not being protected adequately, those researchers, entrepreneurs or scientists will find relatively less incentive to generate new technological knowledge because the lack of protection will hamper the knowledge to be transmitted everywhere.

Last but not least, Debnath (2011) found that openness to international trade that provides large investment opportunities, allows minimal price distortions and creates competitive business environments is significantly and positively related to the knowledge economic growth. It was concluded that appropriate application of economy incentives is a very important determinant to economic growth. Without incentives, the growth is relatively difficult to be fostered in a knowledge-based community. This relationship is also supported by another group of researchers, however with mixed results. Huchet-Bourdon, Le Mouel and Vijil (2013) suggested that there is a negative impact between trade and growth when countries' product traded are mainly low quality products; whereas there found a positive impact on growth once countries specialized in higher quality products for trading. This indicated the higher quality of one's country export basket, the greater the effect of export ratio on economic growth or in another words, trade only enhance growth for countries who trade high quality of goods and services.

2.2 Relationship between Education and Training and Economic Growth

In this part, we will review on the second pillar of knowledge economy framework which is education and training. This pillar is compiled of few proxies such as general government expenditure on education and operating expenditures on education which included salaries and wages. Education is a process of learning and acquiring knowledge which enriches one's thinking in understanding better of the world. Quality of one's lifestyle can be improved through education and indirectly lead to huge social benefits (Ozturk, 2001). Therefore, in this section, we will be reviewing on previous studies and discuss how this pillar can affect economic growth, say whether positively or negatively.

It is generally known that education acts as an important determinant variable in economic growth as it secures social progress while at the same time closing the gap of income distributions (Chandra, 2011). World Bank (n.d.) has dispute about the education quality and distribution in labour force together with the economy structure is very much influencing the human capital and economic development. However, an increase in better education investment among labour force can only promote productivity but it is insufficient to enhance economic growth. Thus, more educated labour in an economy is believed to increase the ability to translate human capital into higher economic growth. In that sense, there quite a number of literature proven that education brings significant and positive impact to economic growth and some of the empirical studies concern on the impact of education levels towards economic growth (Owusu-Nantwi, 2015; Idenyi & Ogbanna, 2016; Babatunde & Adefabi, 2005; Urhie, 2014).

For instance, Aqil, Aziz, Dilshad and Qadeer (2014) have proved in their studies where the education expenditures showed a significant impact on economic growth in Pakistan. This result is supported by Idress and Siddiqi (2013) whereby they examined the long run relationship between education expenditures and economic growth.

According to their results, it also showed that the two variables have positive relationship in which a 1 dollar increase in education spending, it will lead to roughly 20.85 dollar gain of GDP. The reason behind is that, labour productivity is being enhanced through an investment to labour by means of funding injection and therefore, spur economic growth indirectly.

Moreover, Mekdad, Dahmani and Louaj (2014) also obtained the same long run positive result between education spending and economic growth when they study the linkage between them from year 1974 to 2012 in Algeria. The empirical result revealed that public spending on education serves as a crucial input in affecting Algeria's economic development while comparing to other variables. The statement is further confirmed by the findings from Mercan and Sezer (2014), in which the result showed a statistically significant relationship between education and economic growth in Turkey from year 1970 to 2012. They also concluded that when more resources being allocated to education sector, particularly on higher education, it is able to enhance transfer opportunities of knowledge production and strengthen Turkey's economic performance.

In the work of Mallick, Das and Pradhan (2016), they also confirmed the existence of long run equilibrium relationship between expenditure on education and economic growth using panel data analysis in 14 Asian countries from 1973 to 2012. According to their findings, it revealed that 0.84 percent of economic growth is stimulated by one percent increase on education investment. As higher quality of human capital created through education spending on the aspect of skills training in operating advanced technology tools, resources can be fully utilised and simultaneously minimize operating cost throughout the production process. Furthermore, it also enables those skilled labours to engage in diverse sector and contributes to one country's development process.

However on the contrary, in Permani (2009), he studied the relationship between education and economic growth in East Asia. He found that there are insufficient criteria to conclude that education is important for economic growth. Whereas according to the findings from Michaelowa (2000), there is also an ambiguous result obtained in which for the low income country like Africa, it has a clear indication that shows significant impact of education on growth. However, when comes to interpretation of overall studies, it produces a 'ripple effect' whereby it is relatively difficult to prove and explain the relationship between that two variables. This can be explained by the imperfectness of data set (extremely finite) for human capital stock, which is a drawback of low income country. Lastly, the ambiguity of political and institutional framework cause large portion of education investment to have non-productive effect.

2.3 Relationship between Innovation System and Economic Growth

In this section, we will review on the third pillar of knowledge economy framework which is innovation system. This pillar is compiled of few proxies such as patent applications by resident and number of scientific and engineering articles being published. Innovation is defined as a process of research and development in which different individuals play different role in inventing something creatively, say firm master in new product practice and manufacturing design that are new to them, whether or not they are new to universe (Nelson, 1996). Thus, in this section, we will be reviewing on previous studies to see whether this pillar affects economic positively or negatively.

Innovation and creative ideas has increasingly become indispensable driver to promote long term economic growth in a knowledge society. Gerguri and Ramadani (2010) stated that innovation provides the best way for an organization or a business to achieve competitive advantage among other existing rivals as it serves as an underlying fundamental on sustainable development for one country's growth. According to the studies from Abazi-Alili and Gerguri-Rashiti (2014), the importance of innovation cannot be neglected as it has played a crucial role in helping firms to increase their output productivity and production efficiency. However, it is difficult to measure and study the performance of innovation as it heavily depends on the economic situation, governance, education and infrastructure (World Bank, 2010). Thus, there are various types of innovation indicators such as research and development (R&D), number of patterns, trademark, as well as scientific and technical journal articles.

From the recent work of Sachwald (2015), it was revealed that in the innovation process, R&D acts as an important variable in enhancing productivity, particularly in business field. However, it was being claimed as an indirect policy factor as it depends on the sector allocation of one's economy. Therefore, it was suggested that more R&D and innovation should have combined and mix together in both existing sectors and newly exploited sectors, in order to achieve the objective of generating dynamic knowledge-intensive growth. Besides, Wu (2015) claimed that innovation leads to productivity growth and continuously brings uptrend impact towards economic growth. This is due to the R&D funding and scientific articles which allow researchers and scientists to invent, create and explore those new technologies, techniques as well as knowledge. With the knowledge being passed on later in the production side, it enables people to produce more output by using lesser resources.

On the other hand, according to the findings from AliAshrafiPour and Amirabbasi (2012), it has shown a positive relationship between knowledge economy indexes and innovation measured in terms of number of patents. They also proved that knowledge economy indexes together with innovation system bring a strongly significant impact on total factor productivity in those selected group of countries with middle income. Furthermore, Wang (2013) also studied on the same relation and concluded that taking into the considerations of long term effect, innovation can drive economic growth positively for some countries like Australia, Japan and Frances.

Nevertheless, there are also researchers who showed a negative or ambiguous result in their studies, such as the relationship between innovation system and economic growth is inconformity in all literature (Terziovski & Guerrero, 2014; Rosenbusch, Brinckmann & Bausch, 2011). According to the findings from Rosenbusch et al. (2011), they proved that there is circumstance dependent on the relationship between the innovation and economic growth. The impact if innovation on the economic growth can be large degree being influenced by the factors such as type of innovation and cultural circumstance. Hence, whether innovation can stimulate the economic growth or not it needs to be deeply identified.

On the contrary, in some countries like German and United State, innovation may no longer be positively driving the economy growth either in patterns or trademarks statistic concluded from the work of Wang (2013). Lastly, according to the journal of Vuckovic (2016), he studied the relationship of innovation activities and economic growth for the emerging markets within the period of 1991 to 2013. It was found that innovation and economic growth are not statistically significant when measures on the number of patent per million citizens, GDP growth rate and innovation.

2.4 Relationship between Information Infrastructure and Economic Growth

In this section, we will review on the last pillar of knowledge economy framework which is information infrastructure. This pillar is compiled of few proxies such as fixed broadband subscriptions, number of internet users, and mobile cellular subscriptions. Information and communications technologies (ICT) infrastructure in an economy means the reliability, accessibility, and efficiency of phones, computers, radio sets, television, and the numerous networks that connect them. From the definition of the World Bank Group, ICT entails of software, hardware, media and networks for storage, collection, presentation of information and processing transmission in the form of voice, data, text, and images from the telephone, television and radio to the Internet (World Bank, 2003). It is undeniably that technology breakthroughs play an important character in affecting our living standard in many different ways. Thus, in this section, we will be reviewing previous studies on how this pillar can affect economic growth, say whether positively or negatively.

There have been various studies over the past decade shown that both the production of ICT and the usage of ICT have led to economic growth (Pilat & Lee, 2001). Sectors which involve ICT producing have been through major technological progressions, which have contributed to huge expansions in total factor productivity at the level of the economy. While for the sectors of non-ICT producing, investment in ICT has led to capital deepening, and thus growths in labour productivity. More importantly, many studies have shown empirical evidence proposing that significant productivity gains have been experienced from ICT usage (Oliner & Sichel, 2000).

According to the studies from Broersma, McGuckin and Timmer (2003), it was concluded that investment in ICT, specifically in IT equipment, shown a significantly positive impact on economic growth. This was due to the revolutionary changes in ICT accompanied by organisational change and higher labour skills had a striking impact on the overall countries' productivity performance, particularly in manufacturing and services sector. This positive result is also supported by another study from Karagiannis (2007), where knowledge, by means of ICT, has positively affect economic growth through huge investment in information technologies and frequent use of computers. At the same time, his finding also proven that there exist a positive consensus relationship regarding the relation between ICT investment, their utilisation and productivity growth.

In more recent studies, there is one done by Mohammad and Gow (2016) on the long run and short run relationship between economic growth and internet usage in South Africa from the period 1991 to 2013. The result shown it has significant and positive long run relationship between economic growth and internet usage but not in short run. The information also reveal that the internet usage have future potential significant effect through creation of knowledge spill-over in shaping South Africa economy. For example, ICT able to help developing countries overcome inefficiencies in trade promotion, customs services and logistics and customs services to become more competitive and integrated in the international trading system (World Bank, 2003).

On the other hand, Rooney (2005) stated that in order to have a solid information society, early completion of information infrastructure is a must. In year 2002, the knowledge-based industry's proportion in Korea measured in GDP was found quite similar to OECD members and Korea became one of the top ten developed information societies globally. Korea's speed of Internet services became faster than before ever since they pursue the global standard. Korea also tried to give opportunities of computer classes to all members of society in order to achieve the sophisticated computer users globally. They further mention that knowledge of social and culture is the fundamentals to process the economic benefits.

On the contrary, quite a number of researchers found that investment in information infrastructure or say technology, might not be as economy beneficial as it seems to be, due to the increase in energy consumption which might in turn cause scarcity for future needs (Ropke, Christensen & Jensen, 2010; Jorgenson & Fraumeni, 1983). This is supported by the work done from Mohammad and Khorshed (2016), which they found unidirectional causal link come from mobile and internet use to electricity consumption and economic growth in the OECD countries. This indicates that although internet use brings positive impact for economic growth, but OECD countries yet to reduce the carbon dioxide emissions that produce from the electricity use for ICT products. Therefore, green IT is recommended. Moreover, Sundac and Krmpotic (2011) also found that the impact of ICT on economic growth was less significant than expected because ICT works in synergy with those complementary factors like availability of high skilled technician and human capital as well as political environment.

Last but not least, some researchers also found the relationship between information infrastructure and economic growth to be ambiguous and debatable. For instance, in the journal of Abdul and Deb (2016), they studied the impact of ICT on economic growth in Indian economy. The result shown that ICT played an important role in driving the economic growth but largely limited to service sector, such as IT services, engineering services and so on. Therefore, ICT is leading them towards fast growing service economy. However, Indian's manufacturing sectors lags quite behind. From this, we are able to observe although ICT has positive impact in economy growth, but some sectors might yet to apply ICT effectively. The other research done by Maryam, Rahmah and Masood (2012) also share part of the same idea, it mentioned that ICT use is vital for economic growth but the density in developed countries is stronger than developing countries.

Lastly, in the study of Vu (2013), the researcher agrees ICT bring a positive impact toward economic growth but the effect will becomes worse overtime. The reasons are intensifying global competition, rapid progress of ICT technology and so forth. This study further mentioned that effectiveness of government is important to eliminate such worries. Other than that, due to resources constraints on developing countries, fostering ICT adaption is much more important than keep pump in ICT production. One of the examples from Ramlee and Abu (2004), stated that Malaysia has put massive effort in enhancing its ICT infrastructure, however, there are still inadequate in educational institutions in producing ICT literacy experts.

2.5 Relationship between Labour and Capital and Economic Growth

Indeed, when focusing at what reasons enable an economy increase in the long run, it is vital to start by investigating how output can be created. Labour and capital is the most basic and common factor that people will always relate to when comes to economic growth. There is no doubt a firm incorporate a combination of labour and capital into their production function to produce output, which in turn promotes economic growth. Labour can be called as manpower, which compiled of every level of workers and employees who involve in production process by handle, manage, process, and produce output. Whereas capital basically explains both the ideas and knowledge required for production, plus the machinery used throughout production process. Generally, capital can be categorized into few groups such as: (i) human capital is referring to ideas and other intellectual property; (ii) physical capital is referring to machinery, tools and equipment. Indeed both labour and capital seems equally important, however both factors are subject to diminishing marginal return; (iii) capital market such as stock and bond. Therefore is this part, we will review on how both labour and capital can affect economic growth.

Many researchers have found evidence in proving that labour has significant positive impact on economic growth (Umar, 2016; Jajri & Ismail, 2010). For instance, Maia and Menezes (2014) aim to analyse the relationship between labour market dynamics comparing Brazil with United States from year 1981 to 2009. According to their findings, a significant economic growth in Brazil is caused by the massive incorporation of labour force in labour-intensive sector, say agricultural and transport. Whereas in United States, a huge part of economic growth is proven to be contributed by a substantial improvement of labour productivity in high-tech activities. Other than that, Auzina-Emsina (2014) has studied on the relationship of labour productivity on economic growth in European Union countries during pre-crisis and crisis period. It has argued that increase in labour productivity has very weak relation with economic growth in the pre-crisis period. However, the rise of labour productivity in the midst of crisis period shows a significant impact on economic growth.

Based on the review of previous studies, many researchers had proven a positive significant relationship between economic growth and capital (Barro, 2001; Mankiw, Romer & Weil 1992). It is believed that as more capital is being injected to a production process, higher level of output can be obtained and caused economic growth. This relationship theory is concluded from the findings of Becker (1962), Mincer (1958) and Schultz (1961), which suggested that human capital is something that can be invested through health quality and education training to create output which in turn promote economic growth. The finding is also supported by Freire-Seren (2001) where accumulation of human capital through direct participation in production process would generate economic growth, and it is called as level effect. Then, human capital can also affect growth through contributing to technical progress, which promote adoption and innovation of new technology, is called as rate effect. Furthermore, it is also found that physical capital like machinery shows a statistically significant and positively related to economic growth in Malaysia from year 1981 to 2007 when Jajri and Ismail (2010) did their research on labour-capital productivity growth.

When looking at the relationship between economic growth and human capital, education level is often being used as an indicator of it. Other proxies such as government spending on education and training, literacy rate as well as health are quite often being used to represent human capital for economic development. Whereas some researchers also show how capital market and trade policy can influence human capital in determining the growth of economy (see Lee & Barro, 1998; Tallman & Wang, 1994). For instance, Ketenci (2015) studied on the relationship between capital flow and economic growth in European countries during pre and post crisis period. The empirical result concluded that international capital flows can have more obvious impact on economic growth after global financial crisis period. This may due to the increased awareness in which government reconsidered the advantages of capital account liberalization after crisis.

It is undeniably that the role of human capital and physical capital is getting increasingly crucial in this era of knowledge-based economy. However, there also exist study that shows negative relationship between human capital and economic growth. This statement is supported by the findings from Teixeira and Queiros (2016) who used a dynamic panel data analysis in Mediterranean countries from year 1990 to 2011 concluded that the specialization effect on human capital through knowledge-intensive activities has disappointed impact on growth. This may probably due to the lack of proper industrial structures which can incorporate highly educated individuals into production function.

2.6 Chapter Summary

After reviewing these past researches, inconclusive results are obtained from the studies of the relationships among the variables. The results are especially ambiguous for the studies of relationship between training and education and economic growth because some journals we conclude that there is significance of relationship between economic growth and education expenditure, some says the contrast. The Innovation system provides the same ambiguous results too as different countries have different effect and results. Government Incentives and Institutional Regime and the Information Infrastructure have the more direct and clear results that both variables can positively enhance the economic growth. Thus, we will develop the model based on the knowledge economy framework, which will be further discussing in Chapter 3.

CHAPTER 3: METHODOLOGY

3.0 Introduction

In this chapter, we are going to introduce the econometric model and theoretical framework that we will use to estimate the relationship for our data set. First of all, we will be introducing the whole data set to be used for our research analysis, such as the dependent variable- real GDP and the independent variables- labour and capital for Cobb-Douglas production function as well as all those proxies from four pillars of knowledge economy framework. Then, in conjunction with the theoretical framework, we originated 4 models in this research for our data analysis which will be discussed further later in this chapter. In the first model, we employed Cobb-Douglas production function to identify the relationship between labour and capital with economy growth. Then, by using the conventional Cobb-Douglas production function, we modified and developed our second and third model by adding in the knowledge economy framework. Last but not least, we incorporated all of the variables introduced in the previous models and transformed them into our fourth model to test their relationship with economic growth. We have obtained proxies for all of our data ranging from year 2000 to 2012 which provides us a full data of 13 years across 55 countries which we will discuss later on.

In the end part of chapter 3, econometric frameworks will be introduced. At first, Augmented Dickey-Fuller test will be used to test stationarity of our data in order to avoid spurious problem. Next, we will employ the Likelihood Ratio (LR) test and Lagrange Multiplier (LM) test to compare FEM and REM to POLS. The suitability between FEM and REM will be tested using Hausman Test. Lastly, In order to study the impact of the knowledge economy framework on economic growth across different regions, we employed fixed effect LSDV model to show how large the degree of impact on economic growth can be affected.

3.1 Theoretical Framework

3.1.1 Cobb-Douglas Production Function

Cobb-Douglas production function is a form of production function used to represent the relationship between labour, capital, and the production output that is produced by the two inputs, say economic growth. Paul Douglas and his colleague Charles Cobb developed their first formulation of Cobb-Douglas production function in year 1927. They modelled a simplified view of an economy by assuming that an increase in economy output is resulted from either increase in the amount of labour or capital stock invested.

According to Palickova (2014), knowledge of a country measured by the four knowledge economy pillars is proved to have significant impact towards economic growth. Their hypothesis is confirmed as the result showed positive relationship between the country's knowledge- as indicated by Knowledge Economy Index (KEI from now on) and its GDP growth. Whereas from the findings of Gyekye and Oseifuah (2015), they used three sub-regions of Saharam Africa as sample and the statistical analysis proved that KEI had significantly impact GDP per capital. Besides, they also concluded that larger gap of knowledge will result to a lower level of GDP. Therefore, the KEI of the four knowledge pillars should be taken into consideration as they have a significant relationship with economic growth or in other words, total output of the economy.

In order to study the relationship and impact of the knowledge economy framework on economic growth, we employed this Cobb-Douglas production function as a medium and bridge to show how the economic growth can be affected. The reason we applied this function is due to the effect of diminishing marginal return of factor of production is taken into account which makes the model relatively reliable as it is close to actual production. The function stated as follows:

$$Y = AL_{it}^{\alpha 0}K_{it}^{\alpha 1} \text{ , where } \alpha_0 + \alpha_1 = 1 \quad (1)$$

Where L denotes total labour force, K denotes capital stock and A denotes total factor of productivity. In order to standardize the data measurements and improve the result accuracy (Shahbaz, 2012), logarithms will be applied to the equation (1) and rearrange to a new equation:

$$lnY_{it} = lnA + \alpha_0 lnL_{it} + \alpha_1 lnK_{it} + \varepsilon_{it} \quad (2)$$

3.1.2 Knowledge Economy Framework in Total Factor of Productivity Function

Undeniably, there is a mainstream that labour and capital have long been taken as a primary factor of production in which more attention was paid only on the role of labour and capital and pay less focus to other variables when comes to the theory of economic growth (Stern, 2004). This can be explained by a truth where owner of primary inputs benefited the most as prices paid for different inputs will be routed to them eventually. In growth theory, the so-called Solow residual that is unexplained through increased labour and capital accumulation attributed to the growth of total factor productivity.

Based on the endogenous growth model, investment in knowledge, innovation and human capital play a very significant role in economic growth. This theory mainly focuses on the spillover effect and positive externalities of a knowledge-based economy which further enhance the economic development. A previous researcher, Abdulai

(2004), claimed that endogenous growth model is the best theoretical grounding for measuring the shift in knowledge-based economy. Moreover, knowledge has been pinpointed as part of the growth that is not accounted for by other production factors, namely labour and capital (Prajogo & Ahmed, 2006). According to Gorji and Alipourian (2011), the sustained investments in the four knowledge economy pillars (indicated by KEI) will tend to increase the growth rate of total factor productivity and eventually promote the economic growth. From the research of AliAshrafiPour and Amirabbasi (2012), they claimed that there is a positive and significant impact on the total factor of production. In this sense, we replace the total factor productivity in Cobb-Douglas production function by KEI:

$$lnA = lnKEI_{it}$$

$$lnY_{it} = lnKEI + \alpha_0 lnL_{it} + \alpha_1 lnK_{it} + \varepsilon_{it} \quad (3)$$

KEI denotes knowledge economy index that is developed by World Bank which is being used to analyze the impact of four knowledge economy pillars.

A knowledge economy framework has been developed by World Bank which constituted by four knowledge economy pillars: (a) government incentive and institutional regime, (b) education and skilled workers, (c) effective innovation system, and (d) information and communication technology to access the knowledge of the country, which also known as Knowledge Economy Index (KEI) from the country. With respect to this well-formed and rigid framework, the equation stated as follows:

KEI = f (Government Incentive and Institutional Regime, Education and Skilled Workers, Effective Innovation System. Information and Communication Technology)

KEI = f (EI, ED, IN, ICT)

Where EI denotes Government Incentives and Institutional Regime, ED denotes Education and Training, IN denotes Innovation System and ICT denotes Information Infrastructure.

By substituting and incorporating the knowledge economy framework into Cobb-Douglas production function, a new model will be formed as follows:

$$lnRGDP_{it} = \beta_0 + \beta_1 lnEI_{it} + \beta_3 lnED_{it} + \beta_4 lnIN_{it} + \beta_5 lnICT_{it} + \alpha_0 lnL_{it} + \alpha_1 lnK_{it} + \varepsilon_{it} \quad (4)$$

We have adopted several proxies for each and every pillar shown in Knowledge Economy Framework. We have adopted Trade (lnTRD), Government Effectiveness (lnGOE), and Regulatory Quality (lnREQ) as the proxies of Government Incentive and Institutional Regime Pillar; Adjusted Saving: Education Expenditure (lnADSV) and Government Expenditure on Education (lnEDU) as the proxies of Education and Training Pillar; Scientific and Technical Journal Articles (lnST) and Patent Application (lnPAT) as the proxies of Innovation System Pillar; Internet Users (lgINT), Fixed Broadband Subscriptions (lnFBS) and Mobile Cellular Subscriptions (lnMCS) as the proxies of Information Infrastructure Pillar. When all the proxies have been added into the equation, the model will be expanded to:

$$\begin{aligned} lnRGDP_{it} = \beta_0 &+ \beta_1 lnTRD_{it} + \beta_2 lnGOE_{it} + \beta_3 lnREQ_{it} + \beta_4 lnADSV_{it} \\ &+ \beta_5 lnEDU_{it} + \beta_6 lnST_{it} + \beta_7 lnPAT_{it} + \beta_8 lnINT_{it} \\ &+ \beta_9 lnFBS_{it} + \beta_{10} lnMCS_{it} + \alpha_0 lnL_{it} + \alpha_1 lnK_{it} + \varepsilon_{it} \quad (5) \end{aligned}$$

After all the adjustments and modifications has been made, the conventional growth model has been transformed into the new model, equation (5), which indicates the economic growth is explained by all the proxies taken from the knowledge economy framework, together with the capital and labour which stated earlier in conventional Cobb-Douglas production function.

3.2 Research Design

Our research objective can be reached by using quantitative study. In our problem statement outlined in Chapter 1, we have discussed about less researchers study on the knowledge economy using qualitative data. Thus, in our research applying quantitative method is particularly useful when comes to result interpretation and comparison among countries or regions over a period of time. This is due to when researchers seek to study on a larger scale of behavioural pattern instead of a smaller one, it becomes easier to measure and quantify the results. Therefore, data has been collected for our research and being analyzed in the form of mathematical and numerical way.

3.3 Data Description

Panel data has been used in our study to analyze the main relationship between the four knowledge economy pillars and economic growth. A set of secondary data was taken from World Bank, ranging from year 2000 to year 2012 across a randomly picked 55 different countries as the sample of our research. The Summary of data descriptions are shown in Table 3.1 and Table 3.2.

Table 3.1 Summary of Variables, Abbreviation of Data and Source of Data

	Abbreviation	Variable	Source
Economic Growth	lnRGDP	GDP per capita	World Bank
Cobb-Douglas	lnL	Labour force, total	World Bank
	lnK	Capital stock at constant 2011 national prices (in mil. 2011US$)	Penn World Table
Government Incentives and Institutional Regime	lnTRD	Trade (% of GDP)	World Bank
	lnGOE	Government Effectiveness (Rank, percentage among all countries 1-100)	The Worldwide Governance Indicators
	lnREQ	Regulatory Quality (Rank, percentage among all countries 1-100)	The Worldwide Governance Indicators
Education and Training	lnADSV	Adjusted savings: education expenditure (constant US$, 2010=100)	World Bank
	lnGOE	Government expenditure on education, total (% of GDP)	World Bank
Innovation System	lnST	Scientific and technical journal articles	World Bank
	lnPAT	Patent applications, residents	World Bank
Information Infrastructure	lnINT	Internet users (per 100 people)	World Bank
	lnFBS	Fixed broadband subscriptions (per 100 people)	World Bank
	lnMCS	Mobile cellular subscriptions (per 100 people)	World Bank

Source: World Bank and the Worldwide Governance Indicators

3.3.1 Definition of Variable

Table 3.2 Definition of Variables

Abbreviation	Definition
lnRGDP	This variable is being used as an indicator of economic growth. GDP per capita is GDP divided by midyear population whereas GDP is the sum of gross value added by all resident producers in the economy.
lnL	Total labour force comprises people ages 15 and older who meet the International Labour Organization definition of the economically active population which includes both the employed and the unemployed.
lnK	Capital Stock includes the common stocks and preferred stock which issue by the issuing companies. It is measured by the equity capital in the countries' businesses.
lnTRD	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product.
lnGOE	Reflects perceptions of the quality of public services, civil service, policy formulation and implementation, as well as the credibility of the government's commitment to such policies.
lnREQ	Reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.
lnADSV	Education expenditure refers to the current operating expenditures in education, including wages and salaries.
lnGOE	General government (local, regional and central) expenditure on is expressed as a percentage of GDP. It includes expenditure funded by transfers from international sources to government.
lnST	Refers to the number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics,

	clinical medicine, biomedical research, engineering and technology, and earth and space sciences.
lnPAT	Patent applications are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office for exclusive rights for an invention.
lnINT	Internet users are individuals who have used the Internet in the last 12 months.
lnFBS	Fixed broadband subscriptions refers to fixed subscriptions to high-speed access to the public Internet which include cable modem, DSL, fiber-to-the-home/building, other fixed (wired)-broadband subscriptions, satellite broadband and terrestrial fixed wireless broadband.
lnMCS	Mobile cellular telephone subscriptions are subscriptions to a public mobile telephone service that provide access to the PSTN using cellular technology. The indicator includes the number of postpaid subscriptions, and the number of active prepaid accounts.

Source: World Bank and The Worldwide Governance Indicators

3.3.2 Rationale behind choosing our proxies

3.3.2.1 Real Gross Domestic Product per capita (RGDP)

GDP is an important variable to measure economic growth and standard of living. GDP is the total value of output of goods and services produced within an economy in a given time period. Whereas economic growth is defined as the growth of potential output caused by the growth of aggregate demand, which in other words an increase in the value of goods and services produced by an economy over a period of time. It is conventionally measured by the percentage change of real GDP in order to estimate one's economy size and determine whether or not one's country is experiencing growth (Callen, 2012). The higher the value of GDP the better the growth or living standard. In that sense, it simply means that with just the GDP value we can indicate and identify the one country's health. Therefore, in our case, GDP can be considered an important element worth to be studied. Indeed, there are a lot of factors which can affect the magnitude of GDP, yet we decided to narrow down the scope and focus only on the role of knowledge which is represented by the knowledge economy framework and investigate their impact on growth using a panel data analysis.

In short, we have chosen real GDP per capita as our dependent variable and a proxy for economic growth across 55 counties. The reason we employed real GDP is that it makes our result more reliable and accurate as it has adjusted for inflation compared to nominal GDP which does not.

3.3.2.2 The Knowledge Economy Framework

The knowledge economy framework has been defined and elaborated earlier in our research background. It consisted of four knowledge pillars: government incentive and institutional regime, education and skilled workers, effective innovation system and information infrastructure. We have chosen 2 to 3 proxies for each of the knowledge economy pillar and sums up a total of 10 proxies to explain our knowledge variable. For instance, we have trade, government effectiveness and regulatory quality under first pillar; education spending and government expenditure on education under second pillar; scientific and technical journal articles and patent applications under third pillar; followed by internet users, fixed broadband and mobile cellular subscriptions under fourth pillar. The reason we choose this framework to represent our role of knowledge because it is well-developed by World Bank in 1999 and this indirectly makes our studies to be supported by a strong and rigid foundation.

3.3.2.3 Labour (L) and Capital (K)

As mentioned in our theoretical model earlier, labour and capital are the main engines to determine one country's economy status. They are both the core and most common variables for a country's standard growth. Therefore, we include both labour and capital as a foundation for our first model using Cobb Douglas production function before we further extend our model. Undeniably, labour is usually a topic of discussion when we relate to economic growth rate. This is because labour is the most basic factor or input for production in economic theory. According to Bryant, Jacobsen, Bell and Garrett (2004), increase the labour force participation in top five OECD countries has a positive effect on economic growth whereby it created an additional GDP of 1,215 million USD. On the other hand, capital stock also found to have significant impact on growth too. According to Boskin and Lau (1991), capital formation is a crucial factor in enhancing economic growth. The higher the capital stock relative to labour, the higher the growth benefited from technological progress.

Based on those past studies, we are confident to adopt labour and capital as our controlled proxy and we expect a significant relationship between them and real GDP. We have chosen total labour force comprises of people ages 15 and above who meet the International Labour Organization definition as our proxy for labour variable. The reason is that it includes both employed and unemployed person who active in the production of goods and services during a particular period but exclude those homemakers and workers in informal sector which for us to better reflect our ultimate goal on growth. Whereas for the variable of capital we have chosen capital stock as proxy, which includes private and public investment in fixed assets, such as common stock and preferred stock. Since GDP components include investment, we believed this is an appropriate proxy for us to determine its impact on economic growth.

3.4 Econometric Model

3.4.1 Unit Root Test

Augmented Dickey-Fuller (ADF) test has been employed to determine whether the variables in the model achieved the properties of stationary in order to avoid spurious regression and misleading conclusion. According to Yule (1926), he showed that even if the sample is very large, the spurious correlation could persist in non-stationary series. In order to ease the explanation, 2 random walk models will be formed:

$$Y_t = Y_{t-1} + u_t \tag{11}$$

$$X_t = X_{t-1} + v_t \tag{12}$$

Where the observation of u_t from u_t ~N(0,1) and v_t from v_t ~N(0,1), and assume the initial X and Y value are zero. These two models are non-stationary if u_t and v_t showed is serial uncorrelated or mutually correlated. Since both X and Y are uncorrelated, the R^2 from the regressions should tend to be zero. In others, there will be no relationship between the two variables.

However, the regressions may generate a positive R^2 in the model. If so, that there might be something wrong in the proceeding regression along with the extremely low Durbin-Watson (DW) *d* value, which indicates the strong first order correlation. Even if the *d* is higher, the estimated regression will also be suspected as spurious model if $R^2 > d$ as suggested by Granger and Newbold (1974). Furthermore, the models will showed the zero of R^2 and about 2 of DW *d* value after the first difference models of X_t and Y_t are regressed.

Augmented-Dickey test is employed as the unit root test and the null hypothesis and alternate hypothesis are as follow:

H_0: Series is non-stationary (has unit root)

H_1: Series is stationary (has no unit root)

By using the critical value tabulated by MacKinnon (2010), the null hypothesis of having a unit root will be rejected if t-statistic is less than the critical value and vice versa. The rejection of null hypothesis also showed that the model is stationary and away from spurious regression problems whereas the acceptance of null hypothesis indicates the model is non-stationary and the there is a relationship between dependent variable and independent variable.

3.4.2 Redundant Fixed Effect- Likelihood Ratio

As we employed Pooled Ordinary Least Square (POLS) regression to examine our panel data, they might possibly mislead the results of the relationship between the independent variables and dependent variable. This approach has disregarded the time and space dimension of the pooled data and it just estimate the usual OLS regression on the panel data. Hence, it will show the identical intercept across all the sample countries that will be used as treating them with the same intercept.

Therefore, Fixed Effect Model (FEM) will be used in order to capture the true relationship between the variables. Furthermore, FEM has the ability to control the characteristics of the individual study. With this feature, it can eliminate much of the error variance that is presented in such conventional model as POLS. According to research done by Choudhury (1993), it is reported that the conventional estimation ignore the effect of non-participation which could lead to the cause for higher estimates of discrimination (bias). With FEM approach, the equation results in significant lower measures discrimination. However, using time invariant model will severely lost the information and this will lead to the loss of degree of freedom. Hence, model with larger sample size is not recommended to use FEM unless it is necessary.

In order to test which models between POLS and FEM fit our panel data the most, Likelihood Ratio Test (LRT) has been employed to examine their suitability. The null hypothesis and alternate hypothesis are as below:

H_0: $\mu_i = 0$ (POLS is preferable)
H_1: $\mu_i \neq 0$ (FEM is preferable)

The condition of whether or not to rejecting null hypothesis are as below:

Assume significant value (α) of the test to be 1%, 5% and 10%.

Reject null hypothesis if: (1.) Test statistic > Critical Value
(2.) probability (p) test < α

Otherwise, do not reject null hypothesis.

Given that the null hypothesis is rejected, we could say the FEM is proved to have a better suitability over POLS model. Hence, FEM is preferable.

3.4.3 Omitted Random Effect- Lagrange Multiplier

As we mentioned earlier, POLS may not provide a better and convincing result, we would run another model which is Random Effect Model (REM) for our research. REM captures the variations over time and cross-sectional samples. Furthermore, the error terms in REM are independently distributed with the variables. In REM, the individual-specific effect is a random variable. In other words, it is uncorrelated with the independent variables across all the time periods, including past, present and future.

In order to compare whether POLS or REM, Lagrange Model (LM) test has been employed. The null hypothesis and alternate hypothesis are as below:

H_0: $\mu_i = 0$ (POLS is preferable)
H_1: $\mu_i \neq 0$ (REM is preferable)

The condition of whether or not to rejecting null hypothesis are as below:

Assume significant value (α) of the test to be 1%, 5% and 10%.

Reject null hypothesis if: (1.) Test statistic > Critical Value
(2.) probability (p) test < α

Otherwise, do not reject null hypothesis.

Given that the null hypothesis is rejected, we could say the REM is proved to have a better suitability over POLS model. Hence, REM is preferable.

3.4.4 Correlated-Random Effect- Hausman Test

As both FEM and REM have its advantages over the POLS, we would like to apply Hausman Test to determine the preference between REM and FEM. It tests whether or not the model is having the correlation between error term and independent variables (Cor (μ_i, X_i)). The null hypothesis and alternate hypothesis are as below:

H_0: Cor (μ_i, X_i) = 0 (REM is preferable)
H_1: Cor (μ_i, X_i) $\neq$ 0 (FEM is preferable)

The condition of whether or not to rejecting null hypothesis are as below:

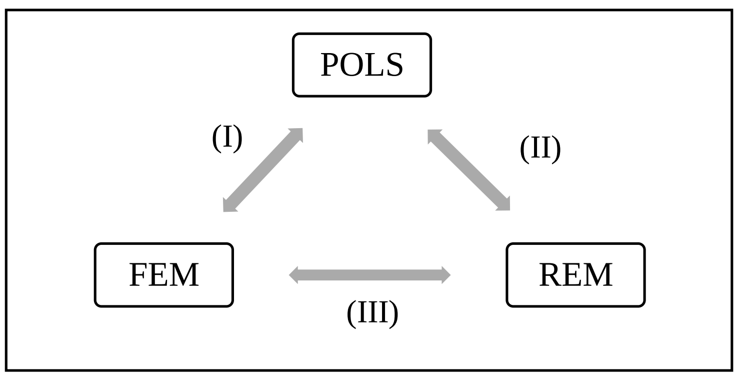
Assume significant value (α) of the test to be 1%, 5% and 10%.

Reject null hypothesis if: (1.) Test statistic > Critical Value
(2.) probability (p) test < α

Otherwise, do not reject null hypothesis.

Given that the null hypothesis is rejected, we could say the FEM is proved to have a better suitability over REM model. Otherwise, REM is more preferable.

Figure 3.1 The Econometric Model Used to Test the Different Models



(I): Likelihood Ratio Test
(II): Lagrange Multiplier Test
(III): Hausman Test

3.4.5 Average Impact Index Model

In order to identify the most impactful pillar towards economic growth and fulfill one of our objectives, we have taken into account the coefficient of each variable. However, by using the conventional method, it is not very convincing as it makes the comparison to solely look into the coefficients of each variable itself. Therefore, we have developed an equation to overcome the limitation of the conventional method:

$$\gamma_p = \frac{\sum|\beta_v \mu_v|}{n_v} \tag{13}$$

Note that γ_p is the average impact index of each pillar, whereas β_v is the coefficient of each proxy, μ_v is the mean value of each proxy, n_v is the number of proxies used in the particular pillar.

3.4.6 Fixed Effect Least Square Dummy Variable Model (FLSDV)

Dummy variable is a qualitative or nominal scale that is relatively difficult to measure (Gujarati, 2004). The reason we have three different dummy variables is because different region could have different result. The Group of Seven (G7) is defined as a group of industrialized democracies countries included United States, Canada, France, Germany, Italy, Japan and United Kingdom that meets yearly to discuss the issues of global economic governance, international security, and energy policy (Laub & McBride, 2014). By adding the dummy variable, G7 dummy, into each of the independent variables, we are keen to know the impact of every proxy in each pillar on G7 and non G7 countries. Coe and Helpman (1995) also adopt the similar method by interacted the G7 dummy impact of domestic R&D stock on total factor productivity. Based on previous researcher, they do show the different impact or no impact of each proxy on economic growth. In G7 countries, trade activities do bring greater impact on economic growth than non G7 countries (O'Donnell, 2015).

Whether the countries are developed or developing, it purely depends on the average of individual in the specific country income level. World Bank (2017) stated that only high income economies with 12,476 dollar or more are considered developed country, otherwise they are considered developing country. In developed countries, fixed broadband subscription does bring lower impact on economic growth than developing countries in the research of World Bank (as cited in United Nations Educational, Scientific and Cultural Organization [UNESCO], 2010).

Asia countries are a group of 50 independent countries divided according to the location of country. The largest geographical area of Asian countries is Russia, it occupies 30% of total territory of Asian countries and the smallest geographical area goes to Maldives (Country of the World, 2017). In Asian countries, education expenditure does bring lower impact on economic growth than non-Asian countries. From the information obtained, we are inspired to create comparison according to different group of region which are Asian and non-Asian countries, developing and developed countries as well as G7 and non G7 countries. Therefore, dummy variables will apply in ours model namely, G7 dummy, income level dummy and Asian dummy. In order to study the impact of the knowledge economy framework interact with dummy variables on economic growth, we employed fixed effect LSDV model with the interaction term added into equation (10) to show how large the degree of impact on economic growth can be affected. Both labour and capital will be eliminated from the equation as our main focus is the knowledge economy framework. From the below equations, if the coefficient value is negative sign, denotes of 1 will have lower impact of independent variables on dependent variable compare to denotes of 0. The fixed effect LSDV model can be expanded into equation (14) with G7 dummy variables, (15) with income level dummy variables and (16) with Asian dummy variables as follows:

$$lnRGDP_{it} = \beta_0 + \beta_1 lnTRD_{it} + \beta_2 lnGOE_{it} + \beta_3 lnREQ_{it} + \beta_4 lnADSV_{it} + \beta_5 lnEDU_{it} + \beta_6 lnST_{it} + \beta_7 lnPAT_{it} + \beta_8 lnINT_{it} + \beta_9 lnFBS_{it} + \beta_{10} lnMCS_{it} + \gamma_1(G7DlnTRD_{2it}) + \gamma_2(G7DlnGOE_{3it}) + \gamma_3(G7DlnREQ_{4it}) + \gamma_4(G7DlnADSV_{5it}) + \gamma_5(G7DlnEDU_{6it}) + \gamma_6(G7DlnST_{7it}) + \gamma_7(G7DlnPAT_{8it}) + \gamma_8(G7DlnINT_{9it}) + \gamma_9(G7DlnFBS_{10it}) + \gamma_{10}(G7DlnMCS_{11it}) + \alpha_0 lnL_{it} + \alpha_1 lnK_{it} + \varepsilon_{it} \quad (14)$$

Where, G7D = 1, if it is G-7 countries, otherwise 0, interaction term is G7D.lnTRD, G7D.lnGOE, G7D.lnREQ, G7D.lnADSV, G7D.lnEDU, G7D.lnST, G7D.lnPAT, G7D.lnINT, G7D.lnFBS, G7D.lnMCS.

$$lnRGDP_{it} = \beta_0 + \beta_1 lnTRD_{it} + \beta_2 lnGOE_{it} + \beta_3 lnREQ_{it} + \beta_4 lnADSV_{it} + \beta_5 lnEDU_{it} + \beta_6 lnST_{it} + \beta_7 lnPAT_{it} + \beta_8 lnINT_{it} + \beta_9 lnFBS_{it} + \beta_{10} lnMCS_{it} + \gamma_1(IDlnTRD_{2it}) + \gamma_2(IDlnGOE_{3it}) + \gamma_3(IDlnREQ_{4it}) + \gamma_4(IDlnADSV_{5it}) + \gamma_5(IDlnEDU_{6it}) + \gamma_6(IDlnST_{7it}) + \gamma_7(IDlnPAT_{8it}) + \gamma_8(IDlnINT_{9it}) + \gamma_9(IDlnFBS_{10it}) + \gamma_{10}(IDlnMCS_{11it}) + \alpha_0 lnL_{it} + \alpha_1 lnK_{it} + \varepsilon_{it} \quad (15)$$

Where, ID = 1, if it is developed countries, otherwise 0, interaction term is ID.lnTRD, ID.lnGOE, ID.lnREQ, ID.lnADSV, ID.lnEDU, ID.lnST, ID.lnPAT, ID.lnINT, ID.lnFBS, ID.lnMCS.

$$lnRGDP_{it} = \beta_0 + \beta_1 lnTRD_{it} + \beta_2 lnGOE_{it} + \beta_3 lnREQ_{it} + \beta_4 lnADSV_{it} + \beta_5 lnEDU_{it} + \beta_6 lnST_{it} + \beta_7 lnPAT_{it} + \beta_8 lnINT_{it} + \beta_9 lnFBS_{it} + \beta_{10} lnMCS_{it} + \gamma_1(ADlnTRD_{2it}) + \gamma_2(ADlnGOE_{3it}) + \gamma_3(ADlnREQ_{4it}) + \gamma_4(ADlnADSV_{5it}) + \gamma_5(ADlnEDU_{6it}) + \gamma_6(ADlnST_{7it}) + \gamma_7(ADlnPAT_{8it}) + \gamma_8(ADlnINT_{9it}) + \gamma_9(ADlnFBS_{10it}) + \gamma_{10}(ADlnMCS_{11it}) + \alpha_0 lnL_{it} + \alpha_1 lnK_{it} + \varepsilon_{it} \quad (16)$$

Where, AD = 1, if it is Asia countries, otherwise 0, interaction term is AD.lnTRD, AD.lnGOE, AD.lnREQ, AD.lnADSV, AD.lnEDU, AD.lnST, AD.lnPAT, AD.lnINT, AD.lnFBS, AD.lnMCS.

In order to have comparison of knowledge economy between different regions, we further enhance the formula create in the earlier part equation (13). We total up the coefficient of the dummy variable with each proxies, δ_v, and coefficient of each proxy, β_v, to know the total coefficient value if it is G7, developed and Asian countries or not. After that we multiply the mean value of each proxy without taking into account the consideration of dummy variables in order to get no bias result. Following, we absolute it to know the impact without looking at the sign because our main concern is the degree of impact in each pillar. Finally, we divide number of proxies in each pillar to get the average impact index (revised version) as follow:

$$\theta_p = \frac{\sum|(\beta_v + \delta_v(X))\mu_v|}{n_v} \quad (17)$$

Note: X=1, if the region is G7, Developed Countries, Asian Countries, otherwise 0, θ_p is the average impact index of each pillar, whereas $\beta_v$is the coefficient of each proxy, δ_v is the coefficient of the dummy variable of each proxies, μ_v is the mean value of each proxy, n_v is the number of proxies used in the particular pillar.

Then, in Chapter 4 result interpretation later, we will show the significant interaction terms accordingly to observe the degree of impact towards economic growth. Whereas for those insignificant interaction terms, we will provide reasonable explanation. Lastly, we will do comparison of knowledge economy between G7 and non-G7, developed and developing nations, as well as Asia and non-Asia regions.

3.5 Chapter Summary

In short, we have built our models by deriving from Cobb-Douglas production function. A thorough derivation and compilation of previous empirical models has been done to ensure our model serve as a solid foundation for our studies. Also, we extracted our data from different online database sources to make sure we employ the best data set for our variables across 55 countries from 2010 to 2012. Then, we had made comparison of model between POLS, FEM and REM. We also employed Augmented Dickey Fuller test and Fixed Effect Least Square Dummy Variable for our research. Last but not least, we developed our own Average Impact Index Model to identify the most impactful pillar on economic growth for a whole sample countries as well as across different regions. Lastly, the interpretation of result for the entire test will be shown in the following chapter.

CHAPTER 4: RESULT & INTERPRETATION

4.0 Introduction

In this chapter, the results formed by our econometric model and empirical finding will be explained accordingly. A POLS model has been regressed based on Cobb-Douglas production function to determine the relationship and the impacts between the economic growth and KEI components. In order to check on the goodness of fit of the model with each pillar, we have added each pillar into the POLS according. FEM and REM have been regressed to improve the result of our analysis. Likelihood Ratio (LR) test has been applied to compare FEM and POLS whereas Lagrange Model (LM) test has been applied to compare REM and POLS as well. After that, Hausman Test has been used to determine whether FEM or REM is best suit to our analysis.

4.1 Unit Root Tests

By conducting the unit root test, stationarity of the data could be identified. Table 4.1 reported the result of several unit root tests at level and first difference from taking into account the case of individual intercept and trend. By assuming there is a common unit root process in our panel data, we first look into the Levin, Lin & Chu (LLC) test and Bretitung (BT) test as they have the smallest size distortion and the perform best against the homogeneous alternative, where the autoregressive coefficient is the same for all panel unit (Breitung & Pesaran, 2005). In order to test the consistency of the result we have taken into consideration of individual unit root process. The Im, Pesaran and Shin (IPS) test is based on the cross-sectional independence assumption as it begins by specifying a separate Augmented Dickey-Fuller (ADF) regression for each cross section (Hurlin & Mignon, 2007). However, Maddala and Wu (1999) claimed that by comparing IPS panel data unit root tests with the Fisher test, Fisher test is simple and straight forward to use and is a better test than IPS tests. Hence, these tests will be conducted to elaborate the stationarity of the data. When the data are consider economic statistic, we must consider their trend of changing. Based on Hegwood and Papell (2007), they claimed that long-horizon real GDP and real GDP per capita data in favour of the trend stationarity alternative using panel methods survives the incorporation of structural change. Thus, we include the intercept and trend into the consideration and test equation. The optimal number of lag lengths is chosen based on Schwarz Information Criteria as it is more consistent and would not overestimate the positive possibility of unit root test (Cavaliere et al., 2012).

By using LLC test, the t-statistics of all the variables at level form are statistically insignificant to reject the null hypothesis of non-stationary or unit root at 10%, 5% and 1% significant level. However for BT test, the result showed there are unit roots in the data in level form. The failure of rejecting null hypothesis means the panel data has one or more unit root and therefore we proceed to the first difference form. In first difference form, almost all the variables showed the statically significant result as shown in Table 4.1. We have also taken IPS Test and ADF Test into account to prove the result consistency. In Table 4.2, most of the results are said to be statistically significance at the first different form. Thus, we have sufficient evidences to conclude that our panel data have only one unit root or integrated of order one (I (1)). However, there is one variable, the Capital (LGK) showed the insignificant result across the entire test except LLC Test. This proved that out data set is not long enough to make the unit root effect seeable. Thus, the unit root tests that we have done can only can be a reference for our test but could not be depended too much as it may not accurately pin point the problem of stationarity.

Table 4.1 Unit Root Tests Result (Assume Common Unit Root Process)

Sample Size: 55 Cross Sectional Data with Data Period from year 2000 to 2012				
	LLC Test		BT Test	
Variables	Level	First Difference	Level	First Difference
LNRGDP	-3.8719***	-15.4492***	2.6396	-7.2221***
LNL	-5.7443***	-23.6564***	1.7944	-5.2832***
LNK	-4.3035***	-7.4792***	6.4027	-0.1621
LNTRD	-8.9858***	-20.4596***	-2.6925***	-12.1892***
LNGOE	-10.8427***	-21.7581***	0.2692	-6.9153***
LNREQ	-7.0576***	-16.7471***	0.4140	-8.7256***
LNADSV	-12.1638***	-22.2141***	-0.1838	-6.4932***
LNEDU	-6.0063***	-15.5386***	0.0252	-5.6971***
LNST	-4.3995***	-17.2596***	3.1818	-5.4093***
LNPAT	-9.7790***	-23.4224***	0.7512	-6.2741***
LNINT	-43.4626***	-32.3765***	3.4550	-6.0094***
LNFBS	-60.6677***	-24.9117***	7.8705	1.3154
LNINT	-43.4626***	-32.3765***	3.4550	-6.0094***

Notes: *, ** and **** implies that the rejection of the null hypothesis of non-stationary at 10%, 5% and 1% significance level respectively.

Table 4.2 Unit Root Tests Result (Assumes Individual Unit Root Process)

Sample Size: 55 Cross Sectional Data with Data Period from year 2000 to 2012				
	IPS Test		ADF Test	
Variables	Level	First Difference	Level	First Difference
LNRGDP	2.7475	-5.0947***	91.3066	185.438***
LNL	1.0065	-12.3183***	104.998	290.783***
LNK	1.5020	0.4002	131.665*	107.334
LNTRD	-1.7720**	-10.3578***	126.805	287.570***
LNGOE	-3.0124***	-11.5701***	159.964***	320.487***
LNREQ	-0.8791	-8.5949***	124.570	252.624***
LNADSV	-4.7150***	-13.1514***	212.050***	349.948***
LNEDU	-2.0608**	-9.4397***	156.472***	289.885***
LNST	0.4886	-9.2801***	121.394	273.539***
LNPAT	-2.37057***	-12.6860***	156.434***	338.597***
LNINT	-14.5649***	-16.6767***	254.273***	378.774***
LNFBS	-28.0193***	-16.2210***	372.887***	391.695***
LNINT	-1.7046**	-8.8600***	175.635***	259.779***

Notes: *, ** and **** implies that the rejection of the null hypothesis of non-stationary at 10%, 5% and 1% significance level respectively.

4.2 Model Comparison

In order to test our panel data with different assumption from different models, we have regressed several models as we mentioned earlier which are POLS, FEM and REM.

4.2.1 POLS

From the POLS model, it showed the model is statistically significant with the 0.9647 goodness of fits. Furthermore, some of the variables are statistically insignificance and most of the its sign are different from our theoretical expectation, such as trade (LNTRD), government effectiveness (LNGOE), regulatory quality (LNREQ), government expenditure on education (LNEDU), and fixed broadband subscriptions (FBS).

Besides, labour force (LNL), government effectiveness (LNGOE), adjusted saving: education expenditure (LNADSV), government effectiveness (LNGOE), and internet user (LNINT) are statistically significant at 1% significant level. Whereas for the capital stock (LNK), fixed broadband subscription (LNFBS), and mobile cellular subscriptions (LNMCS), are statistically significant at 5% significant level. And the rest of the variables are not significant toward the dependent variable.

4.2.2 FEM

By using FEM, it showed the higher adjusted R^2 compared to POLS. The adjusted R^2 has increased to 0.9993 from 0.9647. However, the significant variables have been reduced to seven variables from nine variables out of twelve variables. Moreover, there are also four variables showed inverse relationship with our theoretical expectation, which are labour force (LNL), trade (LNTRD), patent application (LNPAT), and government expenditure on education (LNEDU).

There are five variables statistically significant at 1% significant level which are capital stock (LNK), government effectiveness (LNGOE), and the variables from information infrastructure pillar which are internet user (LNINT), broadband subscription (LNFBS), and mobile cellular subscriptions (LNMCS). While for government expenditure on education (LNEDU) and patent applications (LNPAT), they are statistically significant at significant level of 5% and 10% accordingly. Trade (LNTRD), regulatory quality (LNREQ), labour force (LNL), adjusted saving: education expenditure (LNADSV) and scientific and technical journal articles (LNST) are proved to not have the significant relationship with RGDP in this model.

4.2.3 REM

In this model, the goodness of fit are lower compared to POLS model. It lower down by about 10% from 0.9653 to 0.8757. Yet, the sign of the variables showed seems much closer to our theoretical expectation. Among all independent variables used including labour, capital and the variables of Knowledge Economy Framework, only four variables showed unfavourable result from our expectation which are trade (LNTRD), government expenditure on education (LNEDU), scientific and technical journal articles (LNST) and patent applications (LNPAT).

All the independent variables in this model have shown they have the significant relationships towards RGDP; only adjusted saving: education expenditure (LNADSV) is the exceptional variable. labour force (LNL), capital stock (LNK), government expenditure on education (LNEDU), scientific and technical journal articles (LGST), internet user (LNINT), broadband subscription (LNFBS), and mobile cellular subscriptions (LNMCS) are shown statistically significant at 1% significant level, trade (LNTRD) and regulatory quality (LNREQ) at 5% significant level, and patent applications (LNPAT) at 10% significant level.

Table 4.3 Model Comparison of POLS, FEM and REM

Model	POLS	FEM	REM
C	-1.7175*** (0.4001)	6.3626*** (0.6496)	0.1420 (0.4132)
LNL	0.1559*** (0.0247)	-0.0196 (0.0457)	0.2603*** (0.0338)
LNK	0.8434** (0.0251)	0.4290*** (0.0350)	0.5839*** (0.0294)
LNTRD	-0.0479 (0.0371)	-0.0075 (0.0174)	-0.0421** (0.0170)
LNGOE	-0.2431*** (0.0624)	0.0711*** (0.0184)	0.0904*** (0.0182)
LNREQ	-0.0362 (0.0409)	0.0245 (0.0158)	0.0365** (0.0156)
LNADSV	0.0523*** (0.0090)	0.0009 (0.0017)	0.0025 (0.0017)
LNEDU	-0.1320*** (0.0384)	-0.0231** (0.0095)	-0.0330*** (0.0094)
LNST	0.0178 (0.0179)	0.0108 (0.0098)	-0.0263*** (0.0091)
LNPAT	0.0191 (0.0117)	-0.0158* (0.0066)	-0.0111* (0.0065)
LNINT	0.1871*** (0.0319)	0.0359*** (0.0076)	0.0287*** (0.0076)
LNFBS	-0.0262** (0.0116)	0.0119*** (0.0025)	0.0088*** (0.0024)
LNMCS	0.0107** (0.0220)	0.0473*** (0.0045)	0.0404*** (0.0045)
R^2	0.9653	0.9993	0.8757
Adjusted R^2	0.9647	0.9993	0.8736
Prob(F-Statistic)	0.0000	0.0000	0.0000
D-W test stat	0.09670	0.4798	0.3659

Notes: *, ** and **** implies that the rejection of the null hypothesis of insignificant relationship at 10%, 5% and 1% significance level respectively. Standard Error in parentheses.

4.2.4 Comparison Test

In order to choose the best model to explain the relationship between knowledge economy components and economic growth through Cobb-Douglass production function, several additional tests have been conducted. Firstly, we have performed Likelihood Ratio (LR) Test to compare the preference between POLS and FEM. As from Table 4.4, the result stated that the test statistic of 2808.16632 with the p-value of 0.0000 which is smaller than the significance level of 1%/5%/10%. Since the null hypothesis has been rejected, we now have sufficient evidence to prove that the suitability of FEM is better than POLS. Next, we proceed to Lagrange Multiplier (LM) test to compare between POLS and REM. The result shows the test statistic of 3333.386 which is significantly larger than the critical value of 7.289/4.321/2.952 at significant level of 1%/5%/10% respectively. Therefore REM is more preferable compared to POLS as the null hypothesis of LM test has been rejected. Knowingly both of the tests have shown FEM and REM are more suitable for our panel data compared to POLS, we have then constructed the Hausman Test to compare FEM and REM to select the best model. With the test statistic of 208.8348, we reject its null hypothesis since the p-value of 0.000 is less than the significant level of 1%/5%/10%. Therefore, we can conclude that the REM is inconsistent and inefficient, and FEM is the best model of our panel data.

Table 4.4 Model Comparison Test

	LR Test	LM Test	Hausman Test
Test Statistic	2808.163***	3333.386***	208.8348***
Decision Making	Reject null hypothesis	Reject null hypothesis	Reject null hypothesis
Conclusion	FEM is preferable compared to POLS	REM is preferable compared to POLS	FEM is preferable compared to REM

Notes: *, ** and **** implies that the rejection of the null hypothesis at 10%, 5% and 1% significance level respectively.

4.3 Fixed Effect Model (FEM)

After we identified that the FEM is the best model among all three models, we then proceed to the stage of detecting the interaction between the pillars with the conventional Cobb-Douglass Function. We have adopted multiple-stage regression by adding the targeting pillar into the model. Table 4.5 indicates the RGDP (LNRGDP) as the dependent variable and it summarized all the regressions that have been regressed separately with different pillar. With this pillar, all the necessary details such as the significance of the variables and model will be explained pillar by pillar. Equation (1) showed the model used in the conventional Cobb-Douglas production function with the variables of labour and capital. Clearly, it showed that capital has a significant positive relationship towards economic growth whereas is having a negative relationship. It posed a very high R^2 of 0.9983 and hence it proves the economic growth have a high variation with labour and capital.

In order to determine the relationship towards economic growth from each pillar, Equation (1), Equation (2), Equation (3), Equation (4) are hence been formed. Equation (1) has added with the first pillar which is government incentives and institutional Regime in Cobb-Douglass production function. Three proxies of the first pillar has been added which are trade (LNTRD), government effectiveness (LNGOE) and regulatory quality (LNREQ). It is having relative high Adjusted R^2 of 0.9984. However, LNTRD and LNGOE showed the insignificant result in the model while LNREQ has a significant positive relationship with RGDP. Whereas for the Equation (2), we have tested the model by adding in the second pillar which are education and training pillar into our original model. Two proxies of the pillar which are adjusted saving: education expenditure (LNADSV) and government expenditure on education (LNEDU) have been taken into account. LNADSV showed the insignificant positive relationship and LNEDU showed the significant negative relationship with the relative high goodness of fit of 0.9986.

Besides, we have derived the Equation (3) by adding in the third pillar, innovation system pillar. In this equation, scientific and technical journal articles (LNST) and patent application (LNPAT) has been added into the model as the proxies of the pillar. Clearly, LNST is showing significant positive relationship and LNPAT is showing insignificant negative relationship with RGDP, with the goodness of fit of0.9986. Furthermore, in Equation (4), we have added the last pillar of information infrastructure pillar and found that the goodness of fit of the model has been resulted in relative high number of 0.9992 by adding in the proxies of internet user (LNINT), fixed broadband subscriptions (LNFBS) and mobile cellular subscriptions (LNMCS) into the equation. Furthermore, these three variables are having a significant positive relationship with RGDP.

Moving further by adding in all the four pillars together into conventional Cobb-Douglas production function as shown in previous chapter, the Equation (5) has been formed. We first look into its Adjusted R^2 .We believed that the goodness of fit of overall model has become 0.9993. From our hypothesis, we expected that all of the knowledge economy pillars including its proxies will have the positive significant relationship towards economic growth. However, by regressing the model in the most preferable model, FEM, it showed the different results from our expectations. Firstly, some of the proxies showed insignificant relationship towards the economic. For instant, LNTRD and LNREQ from first pillar, LNADSV from second pillar, LNST from third pillar. Secondly, the proxies have resulted the negative relationship towards the Economic Growth, such as LNTRD from first pillar, LNEDU of third pillar, and LNPAT from third pillar. The results showed in these regressions are inconsistent with our expectation.

Table 4.5 Economic Growth Regression using Fixed Effect Model (FEM)

Model	(1)	(2)	(3)	(4)	(5)
C	-0.7563 (0.7563)	2.0547*** (0.6963)	3.9207*** (0.8860)	7.2637*** (0.5631)	6.3626*** (0.6496)
LGL	-0.0256 (0.0630)	-0.0847 (0.0580)	-0.1901*** (0.0632)	-0.0564 (0.0446)	-0.0196 (0.0457)
LGK	0.9449*** (0.0330)	0.8732*** (0.0310)	0.8079*** (0.0423)	0.4276*** (0.0314)	0.4290*** (0.0350)
LGTRD	0.0211 (0.0249)	-	-	-	-0.0075 (0.0174)
LGGOE	0.0407 (0.1050)	-	-	-	0.0711*** (0.0184)
LGREQ	0.1193*** (0.0219)	-	-	-	0.0245 (0.0158)
LGADSV	-	0.0035 (0.0023)	-	-	0.0009 (0.0017)
LGEDU	-	- 0.1280*** (0.0114)	-	-	-0.0231** (0.0095)
LGST	-	-	0.0900*** (0.0133)	-	0.0108 (0.0098)
LGPAT	-	-	-0.0138 (0.0092)	-	-0.0158* (0.0066)
LGINT	-	-	-	0.0510*** (0.0072)	0.0359*** (0.0076)
LGFBS	-	-	-	0.0126*** (0.0024)	0.0119*** (0.0025)
LGMCS	-	-	-	0.0426*** (0.0043)	0.0473*** (0.0045)
R^2	0.9985	0.9987	0.9986	0.9993	0.9993
Adjusted R^2	0.9984	0.9986	0.9984	0.9992	0.9993
Prob(F-Statistic)	0.0000	0.0000	0.0000	0.0000	0.0000
D-W test stat	0.2430	0.3485	0.2564	0.4590	0.4798

Notes: *, ** and **** implies that the rejection of the null hypothesis of insignificant relationship at 10%, 5% and 1% significance level respectively. Standard Error in parentheses.

4.4 Average Impact Index

From the table 4.4, we have taken out the mean value of every single proxies in each pillar and multiply with its coefficient to calculate the impact index which is used to identify how impactful of each pillar toward the economic growth. In order to have the better estimation of the impacts, the impact index has been normalized by using absolute value. Furthermore, we have divided the number of proxies in each pillar from the impact index to equalize the impact index. Thus, average impact index has been formed. And the result shows that the government incentive and intuitional regime is the most impactful pillar with the average impact index of 0.1430, followed by information infrastructure pillar, innovation system pillar and education and training with the average impact index of 0.1064, 0.0975 and 0.0302 accordingly. Therefore, we may conclude that government incentive and institutional regime pillar has the largest impact toward the economic growth. Moreover, we have regressed a set of fitted lines to identify which pillar is most impactful toward economic growth. From the Diagram 4.1, it also clearly showed that the government incentive and institutional regime is has the largest impacts among all the pillars. Thus, our conclusion tends to be more accurate since both of the estimation showed the same result.

Table 4.6 Average Impact Index of Knowledge Economy Pillar

Pillar	Variable	Mean (μ_v)	Coefficient (β_v)	$\beta_v . \mu_v$	Average Impact Index(γ_p)
First Pillar	LGTRD	4.3715	-0.0075	0.032786	0.1430
	LGGOE	4.154	0.0711	0.295349	
	LGREQ	4.1199	0.0245	0.100938	
Second Pillar	LGADSV	22.8103	0.0009	0.020529	0.0302
	LGEDU	1.7217	-0.0231	0.039771	
Third Pillar	LGST	8.263	0.0108	0.08924	0.0975
	LGPAT	6.6998	-0.0158	0.105857	
Fourth Pillar	LGINT	3.2994	0.0359	0.118448	0.1064
	LGFBS	0.7534	0.0119	0.008965	
	LGMCS	4.053	0.0473	0.191707	

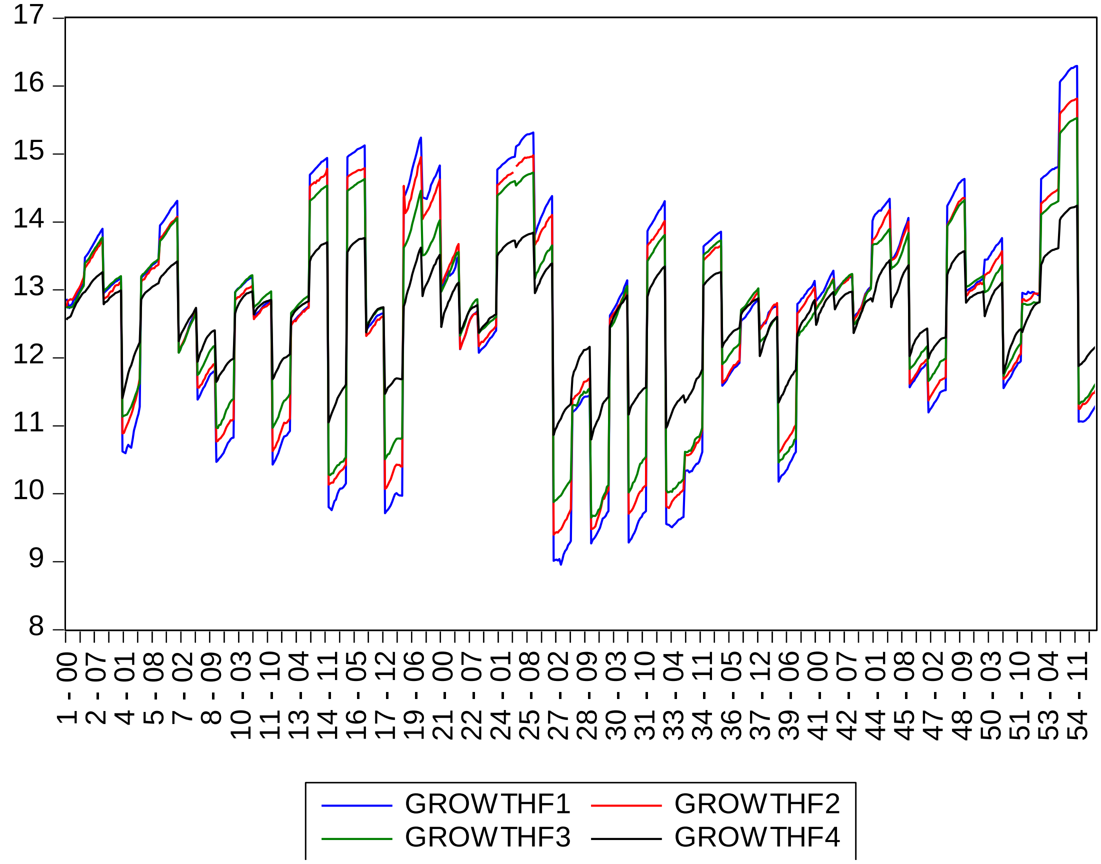
Notes: First Pillar = Government Incentive and Institutional Regime Pillar

Second Pillar = Education and Training Pillar

Third Pillar = Innovation System Pillar

Fourth Pillar = Information Infrastructure Pillar

Figure 4.1 The Growth Fitted Line for Each Pillar



Notes: GROWTHF1= Government Incentive and Institutional Regime Pillar

GROWTHF2= Education and Training Pillar

GROWTHF3= Innovation System Pillar

GROWTHF4= Information Infrastructure Pillar

4.5 Fixed Effect Dummy Variable Model (FLSDV)

Table 4.7 presents the result of fixed effect LSDV model's interaction term variables. We able to retrieve the information with significance of degree of impact of the proxies with three dummy variables which are G7 countries dummy, G7D, Income level dummy, ID, and Asian dummy, AD on economic growth by using equation in chapter 3 equation (14), (15) and (16). Three of the models (14), (15), (16) are important. This is because the null hypothesis is rejected since their p-value (F-statistic) is less than the significance level of at least 1%. However, equation (16) provides more information for ours study compare to equation (14) and (15), the reasons are the equation did have more significant interaction term variables and the Durbin Watson value is smaller compare to the two equations. It also provides more convincing information with least error. Therefore, we will focus on the equation that contains more information.

Table 4.7 Fixed Effect Least Square Dummy Variable Model's interaction between each dummy variables with four pillar proxies

Equation (14)		Equation (15)		Equation (16)	
LGTRD.G7D	-0.1243*	LGTRD.ID	0.0449	LGTRD.AD	-0.0029
	(0.0648)		(0.0412)		(0.0426)
LGGOE.G7D	0.1400	LGGOE.ID	0.0010	LGGOE.AD	-0.0998**
	(0.2357)		(0.0802)		(0.0431)
LGREQ.G7D	0.0109	LGREQ.ID	0.3111***	LGREQ.AD	-0.0391
	(0.2201)		(0.0971)		(0.0364)
LGADSV.G7D	-0.0029	LGADSV.ID	0.0032	LGADSV.AD	-0.0067*
	(0.0074)		(0.0038)		(0.0038)
LGEDU.G7D	-0.0360	LGEDU.ID	-0.0428	LGEDU.AD	0.0678***
	(0.0786)		(0.0337)		(0.0224)
LGST.G7D	0.2102*	LGST.ID	0.0193	LGST.AD	0.0090
	(0.1182)		(0.0201)		(0.0190)
LGPAT.G7D	-0.0067	LGPAT.ID	0.0381**	LGPAT.AD	-0.0045
	(0.0772)		(0.0154)		(0.0151)
LGINT.G7D	-0.0850	LGINT.ID	0.0083	LGINT.AD	0.1151***
	(0.0549)		(0.0189)		(0.0178)
LGFBS.G7D	-0.0185	LGFBS.ID	-0.0098*	LGFBS.AD	-0.0145**
	(0.0151)		(0.0057)		(0.0060)
LGMCS.G7D	0.0946	LGMCS.ID	0.0058	LGMCS.AD	-0.0268**
	(0.0853)		(0.0190)		(0.0115)
R^2	0.9992	R^2	0.9992	R^2	0.9992
Adjusted R^2	0.9991	Adjusted R^2	0.9991	Adjusted R^2	0.9991
Prob(F-Statistic)	0.0000	Prob(F-Statistic)	0.0000	Prob(F-Statistic)	0.0000
DW statistic	0.4586	DW statistic	0.4478	DW statistic	0.4828

Note: *, ** and **** implies that the rejection of the null hypothesis of significant interaction term at 10%, 5% and 1% significance level respectively. Standard Error in parentheses.

Table 4.8 represent the total impact of each proxies with Asian dummy from fixed effect least square dummy model which is equation (16). The value is calculated based on coefficient value. If the proxies with denotes 1 of dummy variables, such as Asian countries, G7 countries, Developed countries, the total impact of the proxies with Asian countries will be summed up original proxies coefficient, β_i and interaction term variable coefficient, γ_i. If the proxies with denotes 0 of dummy variables, such as Non-Asian countries, Non-G7 countries and Developing countries, the total impact only consider original proxies coefficient, β_i , itself. The sign only provides us the information of positive or negative impact. Therefore, to identify the highest proxy impact between two countries, we ignore the sign and compare total impact value itself only.

Table 4.8 Fixed Effect Least Square Dummy Model's total impact of each proxies with Asian dummy

		Non-Asian countries	Asian countries
Total impact of each proxies with Asian dummy	LGTRD	0.0528	0.0499
	LGGOE	0.0824	-0.0174
	LGREQ	0.0541	0.0150
	LGADSV	0.0024	-0.0043
	LGEDU	-0.0613	0.0065
	LGST	0.0872	0.0962
	LGPAT	-0.0177	-0.0222
	LGINT	-0.0039	0.1112
	LGFBS	0.0243	0.0098
	LGMCS	0.0572	0.0304

Note: Yellow highlight implies that higher impact of proxies compare to other countries.

4.5.1 Asia dummy

From the table 4.7 result, the null hypothesis of the test is rejected if the p-value is less than the significant level. Otherwise, do not reject null hypothesis. Based on result above, the comparison impact of government effectiveness, adjusted savings: education expenditure, government expenditure on education, internet users, mobile cellular subscriptions and fixed broadband subscriptions proxies between Asian and non-Asian countries on economic growth are important. This is because the null hypothesis is rejected since their p-values are less than the significance level of at least 10%, 5% or 1%. Besides, we found that government expenditure on education and internet users in Asian countries has greater impact on economic growth than non-Asian countries, at least 1% significant level while government effectiveness, adjusted savings: education expenditure, mobile cellular subscriptions and fixed broadband subscriptions in Asian countries has larger impact on real GDP than non-Asian countries, at least 5%, 10%, 5% and 5% significance level respectively. In addition, there is least important to have comparison impact of patent application, trade, regulatory quality and scientific and technical journal articles between Asian and non-Asian countries on economic growth.

4.5.1.1 Importance to compare degree of impact of information infrastructure, education and training pillars and government effectiveness proxy between Asian and non-Asian countries on economic growth.

From table 4.8 result, education expenditure in Asian countries has higher 0.0019% impact on real GDP than non-Asian country. However, government expenditure on education in Asian countries has a lower 0.0548% impact on real GDP than non-Asian country. The reason of weaker impact of government expenditure on education in Asian countries could be due to the inefficiencies of spending on wages of teachers when student-teacher ratio is low. Major countries such as United States, Canada, United Kingdom, Italy, Germany and France from non-Asian countries are not efficient in spending on education. Therefore the greater negative impact will be on non-Asian countries (Verhoeven, Gunnarsson & Schwartz, 2007). Other than that, education expenditure to enhance various elementary is significant to boost the long term economic growth. For example, increase in technical education spending, skilled worker who able to operate a complex machine will bring impact on long term economic benefits in Asian countries (Mallick, Das & Pradhan, 2016; Lahirushan & Gunasekara, 2015).

From table 4.8 result, fixed broadband subscription and mobile cellular subscriptions in Asian countries has a weaker 0.0145% and 0.0268% impact on real GDP than non-Asian countries respectively. However, internet users in Asian countries have a greater impact on real GDP than non-Asia countries by 0.1073%. Internet users via mobile cellular in Asian countries have exceeded the global average and it has better impact because it helps businesses to operate smoothly without financial transfer delay. Therefore, it helps to stimulate growth through the performing businesses and it performed an important role to Asian countries. However, South Korea is the only country with highly advanced ICT infrastructure among Asian countries where 100% of fixed broadband connections with speed above 10 megabits per second. It showed a lesser impact of fixed broadband subscriptions and mobile cellular subscriptions in our case because of the rest listed in advanced ICT infrastructure countries are fall on the category of non-Asian countries. Although the investment on fixed broadband penetration has been made in Asian countries, but it is wasted without an expert to understand how hardware helps to achieve meaningful economic benefits as advanced countries (Hartley, 2016; Straub & Terada-Hagiwara, 2010).

From table 4.8 result, government effectiveness in Asian countries has a lower 0.065% impact on real GDP than non-Asian countries. Past researchers Brewer, Choi and Walker (2007), shared the same result with ours, the government effectiveness can be measured by the voice and accountability and the control of corruption in a country. With no bribes receive from government from any services, it is likely to be more effective at delivering public services. It shows non-Asian countries has strong positive impact of government effectiveness on economic growth. However, Asia countries has weaker impact due to some countries are no doing well in controlling corruption.

4.5.1.2 Least important to compare degree of impact of remaining proxies between Asian and non-Asian countries on economic growth.

The insignificance in comparison of impact of innovation system on economic growth between Asian and non-Asian countries is mainly because of creative innovation is equally significant for economic growth. In order to prevent from aggregate country risk, each country will have their specialized creative innovation. It can expand property right to protect from each scientific innovator in country's education sector and research capacity. Besides, scientific achievement is also complemented by the level of creativity on other sector, such as entertainment field (LeBel, 2008).

4.5.2 Comparison of knowledge economy between G7 and non G7, developed and developing nations, as well as Asia and non-Asia regions

After looking at the specific proxies in relation of each dummy variable on economic growth, we now look at the overall picture with pillar by pillar and dummy itself which are more important. Table 4.9 is the results calculated from the equation (17), the average impact index of each pillar from different region. After we calculated the value with the equation (17), we are able to obtain the value and have comparison between three groups of region countries itself according to pillar. Then, we identify the highest impact of pillar on economic growth among G7, developed and Asian countries itself.

Table 4.9: Average Impact Index of Each Pillar from Different Region

	Geographical Region					
Pillars	Non-G7 Countries	G7 Countries	Developing Countries	Developed Countries	Non-Asian Countries	Asian Countries
First Pillar	0.1972	0.4233	0.1301	0.6240	0.2655	0.1175
Second Pillar	0.0128	0.0772	0.0328	0.0582	0.0797	0.0556
Third Pillar	0.3658	1.2565	0.4363	0.4484	0.4194	0.4718
Fourth Pillar	0.1163	0.2281	0.1127	0.1272	0.0878	0.1659

Notes: First Pillar = Government Incentive and Institutional Regime Pillar

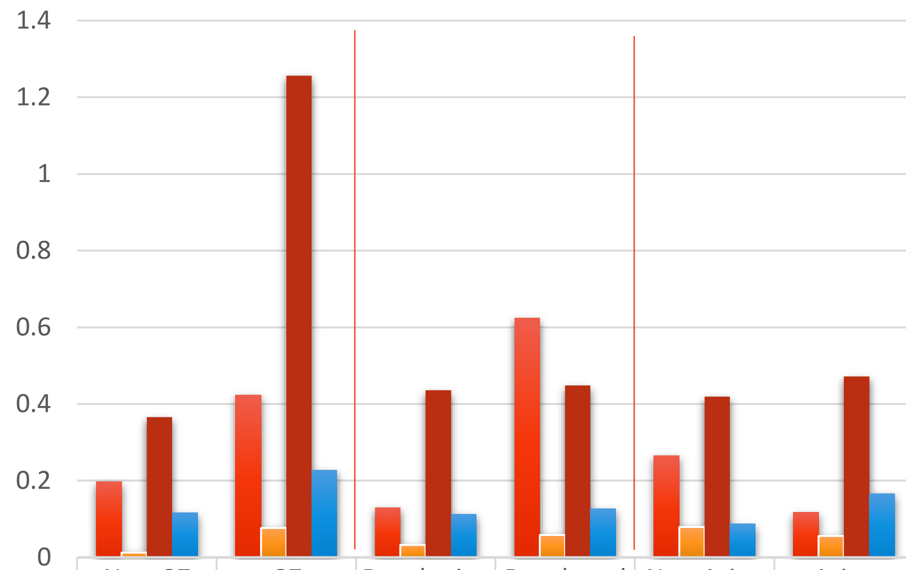
Second Pillar = Education and Training Pillar

Third Pillar = Innovation System Pillar

Fourth Pillar = Information Infrastructure Pillar

The result in table 4.9 shows that three of different groups that have higher impact compare to opponents itself will be highlighted in yellow colour. In overall, four of the pillar with G7 countries has higher impact on economic growth than non G7 countries. Following, four of the pillar with developed countries has higher impact on economic growth than developing countries. In Asian countries, only information infrastructure and innovation system pillar has higher impact on economic growth than non-Asian countries. Next, the highest pillar impact between each of three groups itself will be highlighted red colour. Firstly, G7 countries' innovation system pillar is the most impactful pillar with the average impact index of 1.2565, followed by government incentive and institutional regime pillar, information infrastructure pillar and education and training with the average impact index of 0.4233, 0.2281 and 0.0772 accordingly. Secondly, developed countries' government incentive and institutional regime pillar is the most impactful pillar with the average impact index of 0.6240, followed by innovation system pillar, information infrastructure pillar and education and training with the average impact index of 0.4484, 0.1272 and 0.0582 accordingly. Thirdly, Asian countries' innovation system pillar is the most impactful pillar with the average impact index of 0.4718, followed by information infrastructure pillar with the average impact index of 0.1659. Therefore, we may conclude that G7 and Asian countries' innovation system pillar has the largest impact toward economic growth and developed countries' government incentive and institutional regime pillar has the largest impact toward economic growth. For better illustration, we have constructed a graph as below:

<u>Figure 4.1: Average Impact Index of Each Pillar from Different Region</u>



	Non-G7 countries	G7 countries	Developing countries	Developed countries	Non-Asian countries	Asian countries
First Pillar	0.1972	0.4233	0.1301	0.624	0.2655	0.1175
Second Pillar	0.0128	0.0772	0.0328	0.0582	0.0797	0.0556
Third Pillar	0.3658	1.2565	0.4363	0.4484	0.4194	0.4718
Fourth Pillar	0.1163	0.2281	0.1127	0.1272	0.0878	0.1659

First Pillar Second Pillar Third Pillar Fourth Pillar

Notes: First Pillar = Government Incentive and Institutional Regime Pillar

Second Pillar = Education and Training Pillar

Third Pillar = Innovation System Pillar

Fourth Pillar = Information Infrastructure Pillar

4.6 Chapter Summary

Summing up, among POLS, REM and FEM, FEM is found to be the best suited model to explain the impact of knowledge on economic growth. According to our findings, 7 out of 12 independent variables are statistically significant towards economic growth, including capital, government effectiveness, internet users, broadband subscriptions, mobile cellular subscriptions, government expenditure on education and finally patent applications. Next, by using the average impact index, we found out that the first pillar government incentives and institutional regime is the most impactful pillar on economic growth. Lastly, all the four pillars have higher impact on G7 and developed countries' economic growth compared to non-G7 and developing nations. While for Asia countries, it is found that both two pillars innovation system and information infrastructure have stronger impact on its economic growth as compared to non-Asia countries.

CHAPTER 5: CONCLUSION

5.0 Introduction

The main objective of this study aims to investigate and quantify the relationship between the role of knowledge and economic growth from the view of panel data analysis. By using a secondary data for our sample of study, we compiled a series of data for a total of 55 different countries across 13 years, which is from year 2000 to 2012. We had selected data from 12 Western Europe countries, 2 Developed Oceania countries, 6 East Asia countries, 2 South Asia countries, 15 Europe and Central Asia countries, 6 Latin America and Carribean countries, 5 Middle East and North America countries and lastly G7 countries. Besides, our motivation for this study is to test the causal relationship between each knowledge economy pillar and economic growth. We also keen to identify the best knowledge pillar and make comparison among regions for our final contribution. Therefore, in this chapter, we will summarize the findings of our research and few policy implications will be suggested based on our findings. After then, in order to improve future knowledge economy analysis, we will discuss the limitations or gaps throughout our study and make a few recommendations for a better future research reference.

5.1 Summary of Findings

Firstly, we had developed a Cobb-Douglas production function as a standard growth model before we further incorporate knowledge economy framework to investigate its impact on economic growth. Based on the empirical tests we have conducted in methodology, our findings have managed to answer the research questions we have set back in Chapter 1. According to our findings, FEM is the best model selected to explain the effect of knowledge on economic growth among POLS, FEM and REM, after performing Langrange Multiplier (LM), Likelihood test and

Hausman test. From the best model FEM, we found that there are 7 variables out of 12 statistically significant with our dependent variable: capital, government effectiveness, internet users, broadband subscriptions and mobile cellular subscriptions at 1% significance level; government expenditure on education at 5% significant level and finally patent applications at 10% significance level. On the other hand, there are 4 variables shown an inverse relationship with our theoretical expectation, including labour force, trade, government effectiveness and patent applications.

Next, our second motive is to identify the most impactful knowledge pillar, meaning to say it has the greatest effect on economic growth. By performing the average impact index and growth fitted model, we found out both method have the same consistent result where the first pillar government incentive and institutional regime is the most impactful pillar on economic growth for a 55 sample countries as a whole compared to the other 3 knowledge pillars in the knowledge economy framework.

Finally, the employment of Fixed Effect Least Square Dummy Variable model (FLSDV) to identify the impact of the role of knowledge on economic growth across different regions has provided us with empirical evidence using average impact index. According to our findings, it is shown that while comparing between G7 and non-G7 countries, all of the four knowledge pillars have a greater impact on G7 countries' economic growth. Whereas when it comes to comparing between developing and developed nations, all of the four knowledge pillars are found to have greater impact on developed nations' economic growth. Lastly, the third comparison is between Asian and non-Asian countries. Our empirical result has shown that the first two pillars government incentives and institutional regime and education training have a greater impact on non-Asian countries' economic growth; while the last two pillars innovation system and information infrastructure are more impactful on Asian countries' growth.

5.2 Policy Implications

There are the important policies implications can be attained from the findings of our study. Firstly, our average impact index finding shows that the first pillar, government incentives and institutional regime model brings the largest impact on economic growth than the other three knowledge economy pillar. Besides, the fixed effect dummy variables test results also shows that government incentives and institutional regime has the most crucial impact among the four knowledge pillars toward the developed countries, G7 countries and non-Asian countries' economic growth. In Jones and Olken (2005) work, they stated that a nation leader's notion play an important role in leading a nation's economic growths. As a spiritual leader of a nation, government has the potential to raise the nation's income for the environmental projects and programs by providing a foundation for a transition to an effective economic incentive system. We may suggest government committed to apply regulatory policy principles by embedding the domestic knowledge when preparing regulations that implement sectoral policies, and strive to ensure that regulations serve the public interest in promoting and benefitting from trade, competition and innovation while reducing system risk to the extent practicable. For other developing and non G7 Asian countries, which based on our results, have less impact but a positive relationship from government incentives and institutional regime to economic growth. However, most of these countries are exported oriented countries with raw material and low cost manufacturing, and thus these countries can enact a series of policies to transition from being a raw material and low cost manufacturing to being an exporter of high value added products for the raw materials.

Besides, Debnath (2011) verified that the knowledge creation and diffusion process are completely depended on government policies with its regulatory quality which result the rapid and advanced economic growth. Therefore, we may suggest government to design most favourable policy implication and promote diffusion of knowledge in the arrangement of quality policies and institution for whole nation citizen. The important policies and government regulations that can boost and ease the economic growth of the countries in terms of the foreign direct investments and technology is the protection of the property rights and patents. Government of the countries should make a clear and strict stance on the regulation on property rights so that investors or businessman have confidence to run businesses, notably the high end technology and knowledge operations that concern heavily on the enforcement on patents or property rights. This strengthened protection policies will therefore encourage people and enterprises to innovate and generate publications and patents. Thus, government may suggest on making the most suitable actions and activities according to the culture of each countries.

On the information infrastructure side, the average impact index results shown that it gives the second highest impact to economic growth, which can help the government of the countries to set the priorities right in using limited resources on desirable industries which benefit the most to the country's economic growth. In our empirical results, G7 countries, developed countries and Asian countries' ICT are seen to have significant impact on economic growth. Various countries' governments should continue to emphasize in developing and enhancing information infrastructure, for example the increase broadband speed. This is because the easing and increase efficiency of the information infrastructure will not only reduce the time consuming of transferring important information but at the same time improve economic growth through increase in productivity. Therefore, information-efficient infrastructure could directly boost economic growth. The countries government can allocate portion of budget in support of and invest in ICT sector to boost economic growth. The government can offer incentives to telecommunication companies or broadband provider to enhance or upgrade the broadband speed or other ICT facilities, especially on business sector. One of the ways for government for doing so is to provide rebate or collaborative networking with the major telecommunication firms for such effort so that these firm have incentives to provide high quality ICT facilities such as high broadband speed. The widespread usage of ICT among business and public will also have significant impact on the economic growth, according to our test results. Therefore, for countries where ICT has significant impact on economic growth, government can reward or lower the necessary cost for the society to widely use or subscribe to ICT facilities for business or education purposes.

From our results, although the education and training has weaker impact to the economic growth, but it still has a positive relationship impact especially for G7 countries, developed countries and non- Asian countries from our dummy fixed effect test results. It can be meant that these countries are already implemented successful education and training policies that proven to be successful in spurring economic growth, especially in terms of achieving towards knowledge economy. Thus, the countries in this category can maintain and sustain the same successful policies and allocate resources to area or knowledge economy pillars that are impactful to the economic growth. We may suggest the government to consolidate and restructure the education system. For example, promote more about the home-schooling and parent teaching. This method not only can increases the quality of education, but also fully utilize the resources and facilities. This is because home- schooling education is not like one-size-fits-all education system that offer by government, each of the parents responsible to tailor their children with most suitable education methods.

Lastly, the same results go to the third pillar of innovation system, where our results also shows that although it has weaker impact on economic growth, it is positively related, especially for G7 countries, developed countries and also Asian countries. The weaker impact of this pillar from our results suggest that government of these countries can put resources or concern to other pillars which are more impactful to economic growth. Still, government cannot completely overlook this pillar as it still has a minimal impact, thus a sustained policy to encourage investment in innovation while fostering the diffusion of scientific and technical knowledge and bolstering competition. Besides, government may suggest to provide incentive and full autonomy to innovation discoveries so that it can be attracted more people to involve. Thus, they can be more creative and innovative to do find out those interesting discoveries.

5.3 Limitations

Based on our research, we found that there are few limitations to be proposed for further studies. Insufficient of data during our research would be one of them in our study. We have collected a series of data for a total of 55 different countries ranging from year 2000 to 2012. When we collected each of the empirical data for the proxies of each pillar, we realized that there are unbalanced data within some of the periods and countries. We struggled to find a complete set of data from various database resources and incomplete data between the periods. Kang (2013) stated that an adequate and suitable mechanisms and conceptions should have for a valid statistical analysis on the incomplete data. To overcome this problem, we used the most frequent approach for mildly imbalanced data, which was mean substitutes for handling the missing data. Schafer and Graham (2002) claimed that we would obtain the exact forecast on the missing data by filling in the incomplete data with calculated average of the values to be observed. However, this approach has been warned iteratively as it does not provide accurate result, as it often leads to distort and underestimate of the error, variances, and correlations even this method enable to maintain in the large sample size (Kang, 2013; Schafer & Graham, 2002; Pigott, 2001). Thus, this approach on filling the missing data may influence the finding of the study.

Besides, we have data limitation as we have failed to obtain the Knowledge Economy Index (KEI) data as our dependent variable. World Bank developed the knowledge economy framework and investigated its impact directly on knowledge economic growth using KEI as an indicator of growth. Since we are unable to get the data, we replaced it with real GDP and identify their relationship indirectly, by deriving our own model from the standard Cobb-Douglas production function as it was proven that KEI has correlation with real GDP.

Furthermore, we considered only a few proxies for each of the knowledge economy pillar as a whole and neglected different types and aspects of the indicator for each of the pillar by identifying which would bring the most impact towards economic growth. Indeed, the knowledge economy framework created by World Bank is made up of four knowledge pillars in which there are more than ten proxies served as indicators for each pillar. For example, in the second pillar education and training, some of the researchers test the education by determines the research and development (R&D), education level, schooling system and intellectual capital. This is something that we did not verify as we do not break down each pillar's variables to smaller details. In addition, the number of proxies we had selected to form our model is not tally between those pillars, say some pillars consist of 3 proxies while some only 2. This has caused 'unfair' effect when we want to select the most impactful pillar.

In addition, the limitation in our research is that we are too concentrated on examining the relationship between knowledge economy framework and economic growth. We may have neglected the concern of economy shock or incident like financial crisis which happened in year 2007 to 2008. Financial crisis has affected the global economy and caused the downturn. Many governments, especially the developing economies, have to broad cut the nation's spending while for businesses; they reduced the budget spending in doing research and development activities and even fired more workers to reduce the expenses of firm. Thus, economy shock like financial crisis caused the unemployment rate to increases and it brings a great impact on economy growth. If we ignore this issue, it may lead to imprecise on estimation model.

Lastly, in our paper, we have made the comparison of the impacts of each pillar towards economic growth to examine which pillar is the most impactful pillar among others. With this objective, we have found several variables that are proved to be appropriate proxies of each pillar and the impacts of the proxies will be summed up and accumulated to be the total impact of each pillars and thus the comparison will be made. However, the impacts we compared is the average of the summed up impacts of each single proxies. Therefore, we have ignored the effect of each individual proxy. In other words, the proxies we have taken into our model are meaningless unless the total impacts have been calculated.

5.4 Recommendations

Future researchers can consider taking into account a longer period of time for their study to enhance the accuracy and reliability of findings, especially when the objective is to study economic growth. Next, it is suggested to consider as many knowledge proxies for independent variables and make the number of proxies chosen to be tally between each knowledge economy pillar. This is to make the comparison of knowledge impact become ‘fair’ as people might make assumption where the pillar that consisted highest number of proxies is meant to be the most impactful pillar on economic growth. In addition, future researchers are recommended to identify an extra knowledge proxy- the so called missing piece, other than what was already identified and pre-determined in the knowledge pillars, and then investigate its relationship with KEI to observe its direct impact on a knowledge economy.

Last but not least, future researchers can replicate and improve this study by comparing the knowledge economy between those developing nations with the frontier country, say US, to see how far the gap of differences in emphasizing and utilizing the role of knowledge for economic growth. Besides, it is suggested that future researchers can instead of emphasizing on study the knowledge pillars only, they can study deeper the proxies impact on economic growth. Lastly, since our findings indicate that as an overall the most impactful pillar is the government incentives and institutional regime, it is recommended that future researchers to incorporate all the proxies for this pillar and investigate its relationship across different regions to further enhance its accuracy.

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APPENDIX

Average Impact Index Ratio Calculation

	Variables	Mean	Beta	Impact Index	Average Impact Index
Government Incentive and Instituitional Regime	LNTRD	4.3715	-0.0075	0.0326	0.1430
	LNGOE	4.1540	0.0711	0.2953	
	LNREQ	4.1199	0.0245	0.1010	
Education and Training	LNADSV	22.8103	0.0010	0.0219	0.0308
	LNEDU	1.7217	-0.0231	0.0397	
Innovation System	LNST	8.2631	0.0108	0.0892	0.0977
	LNPAT	6.6998	-0.0158	0.1062	
Information Infrastructure	LNINT	3.2994	0.0359	0.1185	0.1064
	LNFBS	0.7534	0.0119	0.0090	
	LNMCS	4.0530	0.0473	0.1917	

Average Impact Index Ratio Calculation for G7 and Non-G7

Variables	Mean	Beta (non-G7)	Beta (G7)	Impact Index (non-G7)	Average Impact Index (non-G7)	Impact Index (G7)	Average Impact Index (G7)
LNTRD	4.3715	0.0562	-0.1243	0.2457	0.1972	0.297525	0.423258
LNGOE	4.1540	0.0531	0.1400	0.2207		0.802255	
LNREQ	4.1199	0.0304	0.0109	0.1252		0.169992	
LNADSV	22.8103	-0.0003	-0.0029	0.0074	0.012821	0.074065	0.077185
LNEDU	1.7217	-0.0106	-0.0360	0.0183		0.080304	
LNST	8.2631	0.0783	0.2102	0.6471	0.365765	2.383585	1.256502
LNPAT	6.6998	-0.0126	-0.0067	0.0845		0.129419	
LNINT	3.2994	0.0476	-0.0850	0.1572	0.116282	0.123267	0.228127
LNFBS	0.7534	0.0212	-0.0185	0.0160		0.002041	
LNMCS	4.0530	0.0433	0.0946	0.1757		0.559073	

Average Impact Index Ratio Calculation for Developed and Developing Countries

Variables	Mean	Beta (Developing)	Beta (Developed)	Impact Index (Developing)	Average Impact Index (Developing)	Impact Index (Developed)	Average Impact Index (Developed)
LNTRD	4.3715	0.0156	0.04486	0.0684	0.1301	0.264481	0.624024
LNGOE	4.1540	0.0608	0.0010	0.2526		0.256723	
LNREQ	4.1199	0.0168	0.3111	0.0692		1.350867	
LNADSV	22.8103	-0.0021	0.0032	0.0478	0.032797	0.025023	0.058235
LNEDU	1.7217	-0.0103	-0.0428	0.0178		0.091447	
LNST	8.2631	0.0820	0.0193	0.6775	0.436332	0.836915	0.448432
LNPAT	6.6998	-0.0291	0.0381	0.1952		0.059949	
LNINT	3.2994	0.0354	0.0083	0.1167	0.11268	0.144145	0.127153
LNFBS	0.7534	0.0222	-0.0098	0.0167		0.009349	
LNMCS	4.0530	0.0505	0.0058	0.2046		0.227966	

Average Impact Index Ratio Calculation for Asia and Non-Asia

Variables	Mean	Beta (Non-Asian)	Beta (Asian)	Impact Index (Non-Asian)	Average Impact Index (Non-Asian)	Impact Index (Asian)	Average Impact Index (Asian)
LNTRD	4.3715	0.0528	-0.0029	0.2310	0.2655	0.218388	0.117489
LNGOE	4.1540	0.0824	-0.0998	0.3424		0.072067	
LNREQ	4.1199	0.0541	-0.0391	0.2231		0.062013	
LNADSV	22.8103	0.0024	-0.0067	0.0538	0.079703	0.100069	0.055569
LNEDU	1.7217	-0.0613	0.0678	0.1056		0.011069	
LNST	8.2631	0.0872	0.0090	0.7206	0.419446	0.795054	0.471814
LNPAT	6.6998	-0.0177	-0.0045	0.1183		0.148574	
LNINT	3.2994	-0.0039	0.1151	0.0130	0.087761	0.366781	0.165921
LNFBS	0.7534	0.0243	-0.0145	0.0183		0.007427	
LNMCS	4.0530	0.0572	-0.0268	0.2320		0.123556	