



***ICT ADOPTION AND ITS INFLUENCE ON ECONOMIC GROWTH AND  
INNOVATION***

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**SPE 2020 12**



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INNOVATION**

By

**HALIMAHTON SA'DIAH LET**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra  
Malaysia, in Fulfilment of the Requirements for the  
Degree of Doctor of Philosophy**

**March 2020**

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

## **ICT ADOPTION AND ITS INFLUENCE ON ECONOMIC GROWTH AND INNOVATION**

By

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**March 2020**

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The rapid growth of Information and Communication Technology (ICT) has been found to be an important element in enhancing countries' economic growth and innovation. The question of why some countries grow faster while some are lagged behind has ever been one of the debated topics. However, ICT adoption contributes to a broadening gap between the better-off and worse-off countries, which characterizes the unequal distribution across the world. Hence, this study aims to: (a) investigate the determinants of ICT adoption: (b) examine the influences of ICT adoption on economic growth: (c) identify the impact of ICT adoption on innovation.

Two methodologies were used to achieve the objectives of the study. In the first objective, the study applies dynamic panel estimator GMM which covers 44 developed countries and 58 developing countries from 2008 until 2016. The result indicates that for all four types of ICT adoption (mobile broadband, fixed broadband, mobile telephone subscriptions and internet user) were highly correlated with income. Countries with more prosperity and prosperous populations tend to spend more on ICT products and services. However, the adoption of fixed broadband subscriptions and Internet user seems to decrease with the rise of income in developing countries. Higher education is essential to determine the ICT adoption in developed and developing countries. On top of that, the capacity of the countries to innovate is associated with ICT adoption in developing countries compared to developed countries.

As for second objective, the study proceeds to examine the impact of ICT adoption on economic growth using the dynamic panel estimator GMM based on the data obtained from 2008 until 2016 covering both developed and developing countries. The analysis covers 44 developed countries and 45

developing countries using the Cobb-Douglas production function. The results suggest that for the type of ICT adoption; mobile broadband and mobile telephone subscriptions drive the economic growth for developed countries. Moreover, the findings indicate that human capital is associated with the high economic growth in developed countries. In developing countries, all types of ICT adoption (mobile broadband, fixed broadband, mobile telephone subscriptions and internet use) seem to have greater influence on economic growth. Besides, developed and developing countries have shown to have larger coefficients of labor and capital inputs which lead to faster growth.

For the third objective, the study applies fixed-effect model based on the data spanning from 2008 until 2016 for 38 developed countries and 30 developing countries. The results indicate that high levels of Internet use are associated with high levels of ICT innovation in developed countries. Most of the wealthy countries, particularly, developed countries are actively rolling out ultrafast internet connections, and providing for the foundation innovations such as artificial intelligence, the Internet of Things, and Industry 4.0. As for developing countries, mobile and fixed broadband subscriptions are strongly influencing ICT innovation of the nation. It is believed that ultrafast broadband internet connections are becoming the critical foundation of boosting the digital economy in developing countries.

In conclusion, countries with more wealth and prosperous populations are willing to adopt ICT. Compared with the older population, the young population students, tend to be more adventurous and highly demand for ICT specifically on the Internet. A good and innovative package of ICT offer might further promote the demand for ICT. The skilled and knowledge worker is essential to enable better adoption of new technology and implementing domestic innovation and influence the economic growth. In addition, good infrastructure network enables individuals and entrepreneurs engage in e-commerce, and businesses to manage their supply chains on cloud computing.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia  
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

## **PENGGUNAAN ICT DAN PENGARUHNYA TERHADAP PERTUMBUHAN EKONOMI DAN INOVASI**

Oleh

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**Sekolah : Perniagaan dan Ekonomi**

Pertumbuhan Teknologi Maklumat dan Komunikasi (ICT) yang pantas merupakan elemen yang penting dalam menghubungkan negara untuk meningkatkan pertumbuhan ekonomi dan daya saing. Persoalan mengapa sesetengah negara bertumbuh dengan pesat dan sesetengah negara ketinggalan dalam kemajuannya menjadi topik perdebatan yang hangat pada masa kini. Namun, penggunaan ICT telah menyumbang kepada jurang yang semakin besar antara negara lebih baik (*better-off*) dengan negara kurang baik (*worse-off*) dan menunjukkan ciri-ciri taburan yang tidak sama rata dalam penggunaannya di serata dunia. Oleh itu, kajian ini bertujuan untuk: (a) menyasiat penentu-penentu penggunaan ICT: (b) mengkaji kesan penggunaan ICT terhadap pertumbuhan ekonomi (c) mengenalpasti kesan penggunaan ICT terhadap inovasi.

Dua metodologi telah digunakan untuk mencapai objektif kajian ini. Bagi objektif pertama, kajian ini menggunakan panel dinamik *Generalized Method of Moments* (GMM) merangkumi 44 buah negara maju dan 58 buah negara membangun dari tahun 2008 dan 2016. Dapatan kajian menunjukkan bagi semua kategori penggunaan ICT, mempunyai hubungan yang tinggi dengan tahap pendapatan. Negara-negara yang kaya dan penduduk yang makmur, cenderung membelanjakan lebih banyak produk dan perkhidmatan ICT. Walaubagaimanapun, langganan jalurlebar tetap dan pengguna Internet berkurangan dengan peningkatan pendapatan di negara-negara membangun. Berpendidikan tinggi adalah faktor penting untuk menentukan penggunaan ICT di negara maju dan negara membangun. Di samping itu, keupayaan untuk membuat pembaharuan dalam inovasi lebih signifikan di kalangan negara-negara membangun berbanding dengan negara maju sebagai penentu penggunaan ICT.

Bagi objektif kedua, kajian ini mengkaji penggunaan ICT terhadap pertumbuhan ekonomi menggunakan panel dinamik *Generalized Method of Moments* (GMM). Data yang digunakan adalah berdasarkan data yang diperoleh dari 2008 hingga 2016 yang meliputi 44 negara maju dan 45 negara membangun, menggunakan fungsi pengeluaran Cobb-Douglas. Dapatan kajian menunjukkan bahawa bagi jenis penggunaan ICT iaitu langganan jalurlebar mudahalih dan telefon bimbit memacu pertumbuhan ekonomi untuk negara maju. Manakala, negara-negara membangun, kesemua jenis penggunaan ICT (langganan jalurlebar mudahalih, jalurlebartetap, telefon mudahalih dan pengguna Internet) mempengaruhi pertumbuhan ekonomi. Di samping itu, negara maju dan membangun memiliki pekali yang besar untuk input buruh dan modal yang membawa kepada pertumbuhan ekonomi yang lebih pantas.

Untuk objektif ketiga, kajian ini menggunakan model *Fixed-effect* berdasarkan data yang meliputi tahun 2008 hingga 2016 untuk 38 negara maju dan 30 negara sedang membangun. Dapatan kajian menunjukkan bahawa tahap penggunaan Internet yang tinggi dikaitkan dengan tahap inovasi ICT yang tinggi di negara maju. Negara-negara yang kaya, terutamanya negara maju secara aktif menyediakan sambungan internet berkelajuan tinggi, dan menyediakan inovasi asas seperti *Artificial Intelligence*, *Internet of Things*, dan Industri 4.0. Bagi negara-negara membangun, langganan jalurlebar mudahalih dan tetap sangat mempengaruhi tahap inovasi negara. Adalah dipercayai bahawa, sambungan internet jalurlebar berkelajuan tinggi menjadi asas kritikal bagi kerancangan ekonomi digital di negara membangun.

Sebagai kesimpulan, negara-negara yang mempunyai lebih banyak kekayaan dan penduduk yang makmur lebih bersedia menggunakan ICT. Berbanding dengan penduduk yang lebih berumur, penduduk muda khususnya pelajar, yang suka menyahut cabaran cenderung untuk memberikan permintaan yang lebih tinggi untuk menggunakan ICT khususnya, Internet. Pakej ICT yang baik dan inovatif yang ditawarkan mungkin menggalakkan lebih permintaan ICT. Pekerja mahir dan pengetahuan adalah penting dalam menggunakan teknologi baru dan melaksanakan inovasi domestik yang boleh mempengaruhi pertumbuhan ekonomi. Di samping itu, penyediaan rangkaian infrastruktur yang baik membolehkan individu dan usahawan melibatkan diri dalam aktiviti e-dagang dan perniagaan untuk menguruskan rantai bekalan mereka pada perkhidmatan pengkomputeran awan.

## ACKNOWLEDGEMENTS

### بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

First and foremost, I would like to dedicate my gratitude to my supervisor, Dr. Hanny Zurina Hamzah, who made the completion of this thesis possible. Her kindness, patience, and dedication have been inspiring and encouraging. I really enjoyed working under her supervision. Furthermore, I would like to thank Professor Zulkornain Yusop and Dr. Nur Syazwani Mazlan as my supervisory committee members for their invaluable suggestions and constructive comments. I warmly appreciate their fruitful advice and support.

I am also thankful to all lecturers in the Department of Economics at Universiti Putra Malaysia (UPM) for the knowledge gained from them that enable me to work seamlessly with my thesis. Special thanks also go to my employer, Malaysia Productivity Corporation (MPC) for allowing me to pursue studies and Public Services Department (JPA) for study funding. I thank also my fellow friends *viz.* Ah Fatt, Salleh, Zaliza, Idah, Izzati, Liya, Rizal and Lok Lee Lee for their due assistance and unwavering support throughout the course of thesis completion.

Finally, this thesis would have never been completed without unequivocal support and prayers from my husband, Mohd Rais Ramli. I humbly thank him and my three lovely kids, Zarrif, Shazia and Qhaleesya for their love and understanding.



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## LIST OF ABBREVIATIONS

EDGE	Enhanced Data Rate for Global Evolution
GCI	Global Competitiveness Index
GCR	Global Competitiveness Report
GII	Global Innovation Index
GNI	Gross National Income
GSM	Global System for Mobile Communication
ICT	Information and Communication Telecommunication
IDI	ICT Development Index
INSEAD	European Institute for Business Administration
ITU	International Telecommunication Union
LTE	Long-Term Evolution
Mbit/s	Mega bit Per Second
SDG	Sustainable Development Goals
UN	United Nations
USD	United State Dollar
WB	World Bank
WEF	World Economic Forum
WIPO	World Intellectual Property Organisation
1G	First Generation Mobile Networks
2G	Second Generation Mobile Networks
3G	Third Generation Mobile Networks
4G	Fourth Generation Mobile Networks
5G	Fifth Generation Mobile Networks

HTTP

HyHyper Text Transfer Protocol

IP

Internet Protocol



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# CHAPTER 1

## INTRODUCTION

### 1.1 Overview

This chapter begins with background of the study, followed by problem statement. Next, research questions, research objectives and significance of the study are delineated in the subsequent subtopics. Finally, organization of the thesis concludes this chapter.

### 1.2 Background of the Study

Information and Communications Technology (ICT) has been making significant strides in the past few decades with the rise in globalization. Starting from year 1492 to 1800 with the discovery of America and trade between the Old World and New World, followed by the second era from year 1800 to 2000, had shown changes of production process driven by Europe and United States. Today, the world has transformed technological products from small to tiny equipment and being conquered by countries which were previously left behind in terms of economic development such as China and India (Friedman, 2005). The Third Industrial Revolution (IR 3.0) has shown that ICT revolution rapidly spreads since the middle of last century and has been used to automate the production process. Therefore, the arrival of the Fourth Industrial Revolution (IR 4.0), which builds on IR 3.0, provides new avenues for growth and development in the future through technological oriented scopes; physically, digitally, and biologically (WEF, 2016).

Given vast technological abundance in the age of IR 4.0, countries are now racing towards championing economic growth and innovation by capitalizing on their technological advances, including ICT. These concerns have brought various stakeholders e.g. policymakers, academic hats, and trade conglomerates to devise various policy instruments in ensuring sustained economic growth and innovation. This study intends to scrutinize the sources of ICT adoption and its important role in influencing economic growth and innovation across the globe.

### ***Definition of ICT adoption***

International Telecommunication Union (ITU) measured the ICT adoption through ICT Development Index<sup>1</sup>(IDI) and documented annually. IDI is used to measure the extent of digital divides across countries and aggregated quantitatively according to three sub-indices; ICT access, ICT use and ICT skills. ICT access refers to the reflecting the level of networked infrastructure and access to ICTs. It comprises the components of fixed-telephone subscriptions; mobile-cellular telephone subscriptions; international Internet bandwidth (bit/s); households with a computer; and households with Internet access. While, ICT use is the level of use of ICT in the society which covers individuals using the Internet; fixed-broadband subscriptions; and active mobile-broadband subscriptions. Finally, ICT skills comprises the components of mean years of schooling; secondary gross enrolment; and tertiary gross enrolment (ITU, 2016).

Quibria, Ahmed, Tschang, & Reyes-Macasaquit (2003) divided the ICT according to three broad categories, for computing, communication, and Internet, which is enabled communication and computing. ICT can be described as a technology that supports data and information processing, storage and analysis, as well as data and information transmission and communication, via the Internet and other means. Van Ark et al, (2003) presumes that ICT is the latest in the series of new technology adoption. Study on ICT adoption has been debated among researchers to have significant influence on economic growth of the countries (Erumban & de Jong, 2006). Bagchi (2005) refers ICT as telephone (fixed and mobile), personal computer and Internet subscribers. Hence, this study defines ICT adoption as the acceptance of information and communication technology, comprises of computer-mediated networks and normal usage of computers by individual or firms for businesses activities including administrative, production, transaction and services. The activities included the adoption of computer, laptop, mobile telephone, internet, network infrastructure such as fixed and mobile broadband subscribers etc.

To date, ICT has become significant to human lives, communication, improving education, health services and occupation (ITU, 2015), while at national level, ICT may also have an impact on the economy, institutions, and investment. In order to become more innovative, countries need to be competitive globally, sustain its impressive run of growth, and reach high-income status.

However, the world manifests a broadening gap of ICT between developed and developing countries. Countries that aim to attain the developed nation status tend to innovate and adopt ICT to stay competitive globally. In the modern business world, ICT is essential to enhance the competitiveness of businesses, specifically to improve knowledge management, easy access to business information, resourceful administration, control and accountability, access to

---

<sup>1</sup> IDI is a benchmark measure that can be used to monitor and compare developments in the ICTs between countries and over time

markets which contributes to growth of businesses. Nonetheless, those with less ICT adoption are gradually lagging behind because of inefficient policies and insufficient investments in the ICT sector (Ejiaku, 2014). In addition, World Economic Forum (WEF) acknowledged that the ability of an economy in ICT adoption is able to influence economic growth and innovation (WEF, 2016).

The Roger's theory (1995) on technology diffusion<sup>2</sup> (DOI) relates to the different factors which influence the diffusion among different groups of people or countries. The speedy growth rates in the richest ones are driven by the faster adoption of innovation specifically in new technology such as ICT. Hence, the adoption may bring about a broadening gap of technology between the rich and the poor one (Akiyoshi & Ono, 2008). On top of that, according to ITU (2015), there are approximately 4.3 billion people worldwide who do not access to the internet and almost 90 percent of them live in the developing countries. Meanwhile, factors like telecommunications services as well as the infrastructures are moderate in the least developed countries (Ejiaku, 2014). This is in contrast with the developed countries whose investments emphasize on the improvement of technologies, thereby benefiting all groups of people in their countries (Gulati & Yates, 2012). Thus, this study aims to address three important issues on the roles of ICT adoption with respect to influence on economic growth and innovation.

### **1.2.1 Determinants of ICT adoption**

The first issue focuses on the determinants of ICT adoption. ICT adoption arises when the countries invest in technology to support daily businesses and production activities and influences people to start using ICT. ICT adoption is growing globally and offers benefits from information systems (IS) and electronic commerce (e-commerce) and is best perceived in building a prosperous global economy (Gulati & Yates, 2012; Lehr, Osorio, Gillett, & Sirbu, 2006; Yates, Gulati, & Marabelli, 2015). Furthermore, ICT adoption enhanced the preparedness of the population in a country to keep pace with technological evolution. Accelerated economic growth is often characterized by high technological adoption and is significant in developed countries as compared to developing countries (Gulati & Yates, 2012). In other words, countries with high ICT adoption enjoy greater economies of scale, thereby influence growth and innovation (Helen, 2006). Nevertheless, divergence in ICT adoption tends to grow wider worldwide due to different economic sizes (Zhang, 2017). Slow growth of ICT adoption in developing countries are often associated with multiplicity factors in the midst of stiff global competition and technological changes very fast. In addition, people in these countries are less ready in

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<sup>2</sup>Rogers defined technology as design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome, while diffusion as a process by which an innovation is communicated through certain channels over time among members of a social system. It covers 4 aspects: innovation (defined as "an idea, practice, or project that is perceived as new, communication channels ("process in which participants create and share information", time (as an element determining the strength of the process) and social system ("a set of interrelated units") (Lechman, 2013)

embracing the evolution, thereby impeding technological diffusion into the countries. In the presence of global dynamics, this situation therefore necessitates a thorough examination of factors in explaining the ICT adoption gap across the globe.

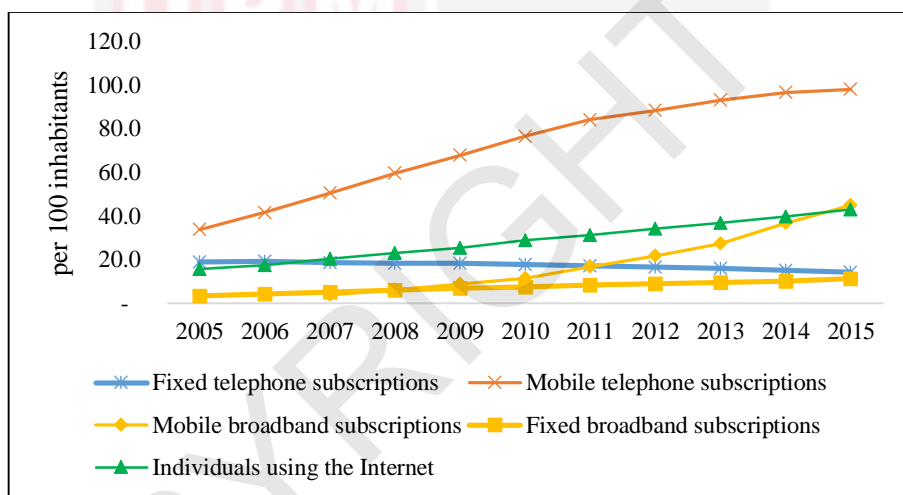
According to ICT Development Index (2016), the top 10 countries are developed countries, among which, South Korea remained the most ICT adopter economy in the world, followed by Iceland and Denmark (Table 1.1). South Korea has consistently ranked as top for the most connected country in the IDI due to active ICT adoption. However, most developing countries, which were ranked above 30<sup>th</sup>, recorded IDI index at an average between 3.00 and 7.00. ITU found that the gap between developed and developing countries may thus be widening in terms of the higher speed of Internet and more sophisticated services provided by the countries. Since 2015, developed countries had stopped offering broadband connection with speeds below 1 Mbit/s as compared to developing countries. For example, developed countries e.g. South Korea, Hong Kong and Singapore, now have accessibility to high speed internet and more sophisticated digital services (ITU, 2016). Singapore has initiated Singapore's Next Generation Nationwide Broadband Network in 2008. Since 2013, Singapore had actively reached 95 percent of homes and businesses accessing Internet. Hence, this initiative will provide ultrafast broadband access of 1 Gbps and above, which is expected to facilitate new applications, including software as a service, remote data backup and restoration, high-definition video conferencing, and improved online gaming. Meanwhile, the South Korea plans to commercialize 10 Gbps broadband services by 2022.

**Table 1.1 : ICT Development Index (IDI) ranking and index for selected countries in 2016**

Rank	Country	Score (range from 0 to 10)	Rank	Country	Score (range from 0 to 10)
1	South Korea	8.84	32	Czech Republic	7.25
2	Iceland	8.83	33	Slovenia	7.23
3	Denmark	8.74	55	Argentina	6.52
4	Switzerland	8.68	56	Chile	6.35
5	United Kingdom	8.57	60	Malaysia	6.22
6	Hong Kong	8.46	63	Brazil	5.99
7	Sweden	8.45	82	Thailand	5.18
8	Netherlands	8.43	107	Philippines	4.28
9	Norway	8.42	115	Indonesia	3.86
10	Japan	8.37	116	Sri Lanka	3.77

(Source : International Telecommunication Union ITU, 2016)  
N=175

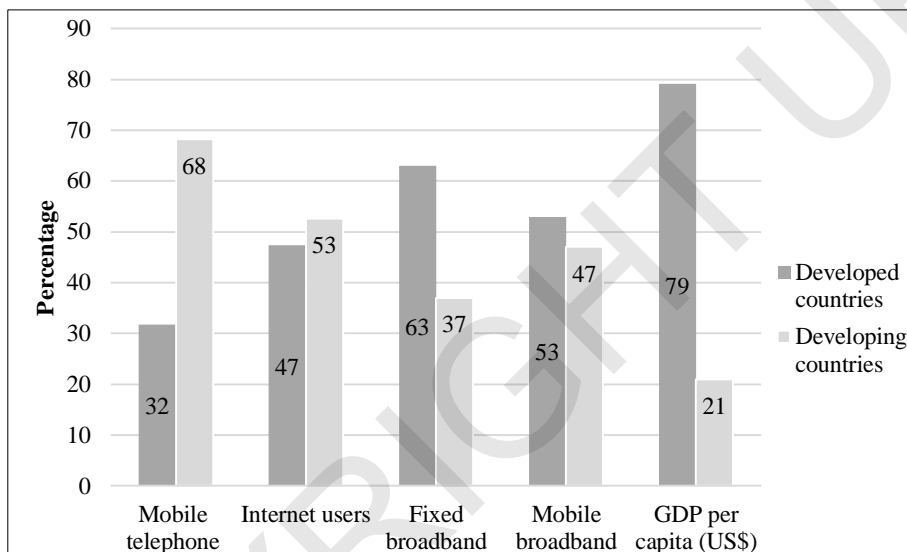
Figure 1.1 shows the increasing and decreasing trends of ICT adoption. For the past 10 years, there has been global changes in the ICT adoption, mainly mobile telephone subscriptions and Internet use. Internet users are estimated to have grown rapidly. Individual use of Internet and household access to Internet have continued their steady growth rates, from 40.6 and 43.4 percent, respectively, to 43.9 and 46.4 percent at the global level. As for mobile-cellular subscriptions, over 40 percent of the world's population is now estimated to be using the Internet, while, global population covered by mobile-cellular networks is now over 95 percent (ITU, 2015). Fixed telephone line shows a deteriorating subscription over the years. Fixed telephone line has witnessed unpopular usage as there is an increasing demand for mobile telephone in daily activities. Because of the fall, fixed-broadband subscriptions have been more sluggish compared to the mobile broadband subscriptions.



**Figure 1.1 : Global changes in major ICTs from 2005-2015**  
 (Source : International Telecommunication Union ITU, 2005-2015)

Figure 1.1 also demonstrates that, active mobile-broadband subscriptions have risen sharply from 4.0 per 100 population to 45.1 per 100 population in 2007 and 2015, respectively. There is an increase in the number of people who are connected between 2011 to 2014, from 2.3 billion people (32 percent penetration) to 2.9 billion people or 40.4 percent of the world's population, respectively. In 2016, mobile broadband networks had covered 84 percent of the world's population (ITU, 2016). The rapid demand for mobile broadband subscriptions is due to the wider availability of mobile-broadband networks, falling prices and the rapidly growing use of smart phones and tablets.

Meanwhile, Figure 1.2 illustrates the differences in ICT adoption and GDP per capita. Developed countries registered 79 percent of total GDP per capita, with mobile and fixed broadband subscriptions more than developing countries at 63 percent and 53 percent, respectively. While developing countries registered 21 percent of GDP per capita, recorded mobile telephone and internet users more than developed countries at 68 percent and 43 percent, respectively. In contrast with broadband network, adoption of mobile phones and internet users is more evenly spread, with developing countries representing a high share.



**Figure 1.2 : Comparison of major ICTs between developed and developing countries in 2015**

(Source : World Economic Forum Dataset)

Several factors could be attributed to the differences of ICT adoption found between developed and developing countries. A significant disparity persists between those with income, associated with ICT adoption; with higher or lower educational attainment, particularly associated with the capabilities required for Internet use; and with other factors affecting the inclusion or marginalization of particular social groups, for example persons with disabilities (Andres, Cuberes, Diouf, & Serebrisky, 2010; Billon, Marco, & Lera-Lopez, 2009; James, 2009; Kyobe, 2011; Puspitasari & Ishii, 2016; Quibria et al., 2003). ICT adoption has been revealed as key potential factor for economic growth, social development, and cohesion (Billon et al., 2009). Because ICT adoption drives access to information and knowledge, the uneven distribution of ICT between developed and developing countries may have a very different impact on economic development, and therefore on wealth and affluence, as shown in Figure 1.2.



On the other hand, over the past few years, ICT adoption e.g. broadband network has greatly increased over the world, reaching an ever-larger share of broadband consumers as presented in Figure 1.1. According to Ericsson Mobility Report (2015), the demand for accessing information through mobile broadband networks are expected to almost double by 2021 (Ericsson, 2015). Hence, the trend of using the mobile telephones including smartphones<sup>3</sup> make up the majority of mobile broadband devices today and subscriptions are expected to almost double by 2021. Yet, in developing countries, over two-thirds of the people remain unconnected and over 90% of people in the world's 48 developing countries (Broadband Commission, 2014). While, fixed broadband penetration is essential for the country's economy, with 10 per cent increase in fixed broadband penetration will contribute to an increase of 1.38 percent growth in developing countries (Qiang, Christine Zhen, 2010).

In today's world of rapid globalization, people are always connected rather than going connected (ITU, 2016). An increasing rate of getting information through Internet is faster, and the universality and openness have transformed the way many people live, communicate and do business. The demand for faster internet speed continues to grow and have gone through the revolution and converged from Global System for Mobile Communication (GSM), Second Generation (2G) Mobile Networks, Third Generation (3G) Mobile Networks, and Fourth Generation (4G) Long-Term Evolution (LTE)<sup>4</sup> technologies could be further developed. In 2009, Sweden and Norway were the first countries to offer LTE, followed by South Korea and Hong Kong in 2012. Start 2012, half of the population of Sweden have access to 4G networks (ITU, 2013).

According to Ericsson Mobility Report (2015), the mobile data traffic is in high demand and the subscriptions are expected to reach 7.7 billion of population globally by 2021. In the future, mobile networks will continue to evolve with higher speeds, including new functionality. The new speed network, such as Fifth Generation Mobile Networks (5G), is expected to be deployed commercially in 2020. 5G is one of the most anticipated advances in the ICT industry. The introduction of 5G will accelerate transformation in many industries e.g. Internet of Things (IoT)<sup>5</sup>, Artificial Intelligent (AI), automation and big data. The product and services provided by these industries are expected to influence the industries to innovate actively (Ericsson, 2015). By 2021, around 10 percent of the world's population will be covered by 5G networks. Advanced countries e.g.

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<sup>3</sup>Mobile phones with open OS, e.g. iPhones, Android OS phones, Windows phones but also Symbian and Blackberry OS. Today, around 45 percent of all mobile phone subscriptions are associated with smartphones (Ericsson, 2015)

<sup>4</sup> LTE is a wireless communication standard for high-speed data for mobile devices and data terminals. The core characteristics of LTE include its capability to provide peak data rates of up to 100 Mbit/s in the download and 50 Mbit/s in the uplink for 20 MHz of spectrum.

<sup>5</sup>Internet of Things is a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies. The widespread connectivity of devices allows them to share data and exercise control through the Internet, whether directly through their own IP address and ensuing Internet connection or indirectly through other telecommunication protocols, such as WiFi or Bluetooth.

South Korea, Japan, China and the United States, are expected to have the fastest uptake of 5G subscriptions in 2021 (Ericsson, 2015). For each second, 20 new mobile broadband subscriptions are activated in the world. This indicates that the number of subscriptions will lead to rapid increase in data consumption and enhance competitive innovation. There were 750 million mobile subscriptions worldwide recorded in 2000, and, the number has reached 7.1 billion in 2014 and expected to touch 9 billion by 2021, accounting for nearly 90 percent of the world population (Ericsson, 2016).

In this regard, ICT adoption has become more important for people to get connected in getting information efficiently. Table 1.2 shows that the total number of worldwide mobile subscriptions in 2015 was around 7.4 billion and mobile broadband subscriptions was at 3.6 billion. Hence, mobile broadband network is becoming more and more relevant, with potential bandwidth and speed appropriate to basic fixed broadband.

**Table 1.2 : World statistics of mobile subscriptions**

Mobile subscriptions	2014	2015	Forecast 2021	CAGR 2015-2021	Unit
Mobile subscriptions	7,100	7,400	9,100	5%	Million
Smartphone subscriptions	2,600	3,400	6,400	10%	Million
Mobile broadband subscriptions	2,900	3,600	7,700	15%	Million
Mobile subscriptions, GSM/EDGE <sup>6</sup> -only	4,000	3,600	1,300	-15%	Million
Mobile subscriptions, LTE	500	1,000	3,200	25%	Million
Mobile subscriptions, 5G	-	-	150	-	Million

(Source : Ericsson, 2015)

Notes: Compound Annual Growth Rate (CAGR)

In the last decade, mobile telephones have been continuously and substantially developed from only being communicating devices to multimedia devices. From previously only allowing voice calls and text messages, a mobile telephone can now be used as a music player, camera and mini personal computer. Since the late 1990s access to ICT has seen tremendous growth driven by the wireless technologies and liberalization of telecommunications markets. In 2016, there were more than 7.3 billion mobile phone subscriptions worldwide. Globally, 3.5 billion people were using the Internet, of which 2.5 billion were from developing countries. Mobile-broadband subscriptions have risen constantly to reach 3.6

<sup>6</sup>EDGE is Enhanced Data Rates for Global Evolution

billion, while the number of fixed-broadband subscriptions reached more than 84 million during the same period (World Bank, 2018).

In addition, the European Union (EU) has planned to provide 1 gigabit per second (Gbps) connectivity for all major urban centers, schools, transportation hubs, and public facilities, and a minimum of 100 Mbps (upgradeable to 1 Gbps) for all households, by 2025. Meanwhile, Singapore is well on its way to providing download speeds of 1 Gbps and above; and the South Korea plans to commercialize 10 Gbps broadband services by 2022.

### 1.2.2 ICT adoption and economic growth

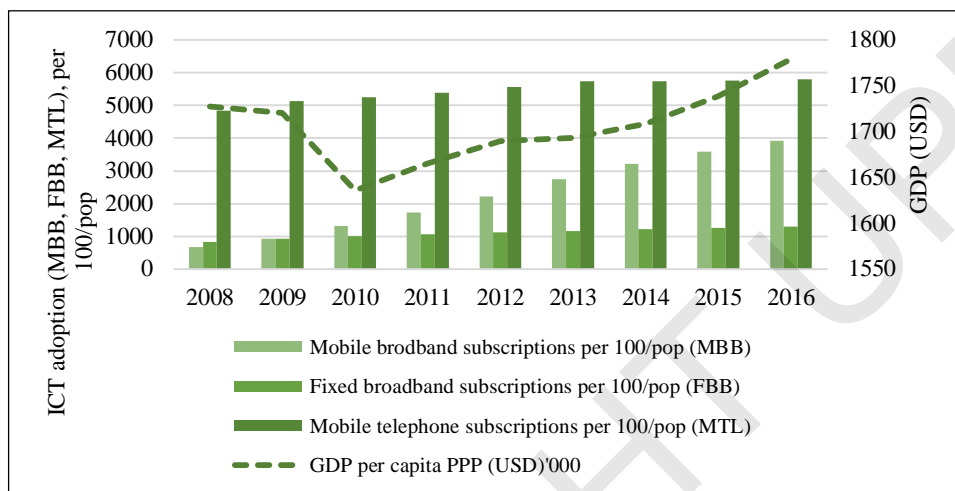
The second issue focuses on the relationship between ICT adoption and economic growth. Since the mid-1990s, economic development across the globe has increasingly been driven by technological progress through a continuous advancement of technology, information and skills (Jorgenson, 2001; Lam & Shiu, 2010; Venturini, 2009; Vu, 2011; Ceccobelli, Gitto, & Mancuso, 2012). In addition, technology has been empirically shown to be the most fundamental pillar for a country to progress into the innovation-driven stage<sup>7</sup> of development given the improved physical and human capital combined. Contrary, the combination of both physical and human capital does not guarantee sustained economic growth, it only pushes an economy to achieve an improved standard of living (McArthur & Sachs, 2001) while remaining on the same isoquant. This situation might probably explain the difficulty encountered by many countries in raising economic growth for nearly 10 years after being hard hit by the Great Recession in 2007-2008 (WEF, 2016). Countries with less adopting technology tend to take a longer time to realize the full potential of technology in enhancing economic growth.

Figure 1.3 and Figure 1.4 show that the world's ICT adoption increased over the years parallel to an increasing of GDP per capita in developed and developing countries. According to the three types of ICT adoption, mobile telephone subscriptions indicate the highest subscribers from 2008 to 2016. For developed countries, mobile broadband subscriptions recorded 671 to 3928 subscribers per 100 population in 2008 and 2016, respectively. While, fixed mobile broadband has increased from 831 to 1300 subscribers per 100 population from 2008 to 2016, respectively. In the case of mobile telephone subscriptions, it shows an increasing trend from 2008 to 2016, recorded 4839 to 5301 subscribers per 100 population, respectively. GDP per capita for developed countries has registered USD1727 per capita for thousand population in 2008. However, it decreased in

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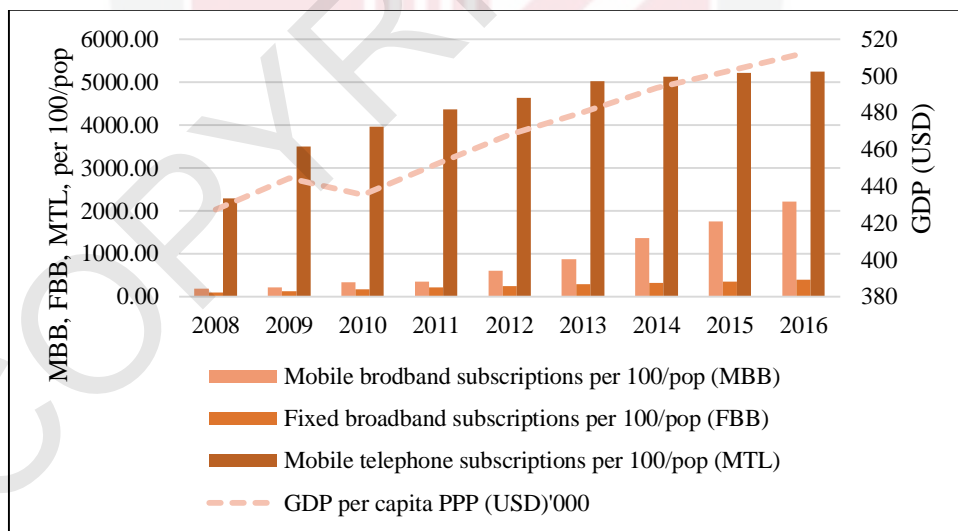
<sup>7</sup>Innovation-driven economies with GDP per capita > \$17,000 (WEF, 2016)

2010 but started to increase the following years and achieved USD1780 per capita for thousand people in 2016.



**Figure 1.3 : ICT adoption vs GDP per capita PPP (USD) '000 in developed countries from 2008-2016**

(Source : International Telecommunication Union ITU dataset)



**Figure 1.4 : ICT adoption vs GDP per capita PPP (USD) '000 vs in developing countries from 2008-2016**

(Source : International Telecommunication Union ITU dataset)

Figure 1.3 and Figure 1.4 also demonstrate that the ICT adoption in developing countries has been even more remarkable compared to developed countries. Mobile telephone subscriptions indicate the highest subscribers from 2008 to 2016 recorded 427 to 512 subscribers per 100 population, respectively. Mobile broadband subscriptions drastically recorded tremendously increased from 182 to 2210 subscribers per 100 population in 2008 and 2016, respectively. While, fixed mobile broadband has increased from 91 to 391 subscribers per 100 population from 2008 to 2016, respectively. GDP per capita for developing countries has registered USD427 to USD512 per capita for thousand population in 2008 and 2016, respectively.

The ICT adoption, particularly in broadband infrastructure went from low rate in 2008 to impressively high rates even in the poorest and most isolated nations. The blowout of ICT into all parts of the world has had a significant effect on economic development, particularly in areas where communication, access to information, learning, research, and innovation play a key role in driving success. Hence, this situation provides an avenue to redress the issue by examining the roles of in ICT adoption in influencing the economic growth across the globe (WEF, 2016).

According to the experiences by developed countries, various initiatives have been introduced by governments to encourage ICT adoption which could accelerate growth. In 2015, South Korea had introduced the “Development and Supply of IT Assistance Devices”, “Supply of Green PCs of Love” and “Telecommunication Relay Service” as part of the country’s efforts to encourage ICT adoption across the entire population specifically to the unconnected groups (ITU, 2016). In the case of Iceland, with the aim of bridging the final digital divide, the government has approved an expenditure of USD 4 million for the development of high-speed networks in 2016. This initiative enables and allows almost all households in the country to have access with at least a 100 Mbit/s connection by the year 2020 (Post and Telecom Administration in Iceland, 2015). In Denmark, the government launched national broadband strategy, which aims to enable all households and businesses to have access to at least 100 Mbit/s download and 30 Mbit/s upload speeds by 2020 (ITU, 2016).

Towards the rapid revolution in IR 4.0, ICT industry is not left behind as it plays significant roles in the economic development. Furthermore, from 2010 onwards, World Bank and ADB (2012) emphasize that the ICT policy implication is essential to increase economic growth. Weber & Kauffman (2011) found that the policy of improving the quality and affordability of broadband services and easy access to internet is important. This policy can reduce entry barriers for more investments and increase competitiveness in the market. In fact, ICT would be a significant driver of socioeconomic development in the world by 2030 (ITU, 2015).

OECD (2008) reported that ICT investment positively impacts on the gross domestic product (GDP) growth. Table 1.3 indicates that ICT investment has contributed significantly to GDP growth in developed and developing countries. ICT investment in developed countries increased from 15.6 percent to 19.5 percent, recorded GDP growth of 2.94 percent to 7.18 percent in 2010 and 2016, respectively.

**Table 1.3 : The impact of ICT investment on GDP growth in developed and developing countries**

	Developed countries		Developing countries	
	2010	2016	2010	2016
ICT investments <sup>8</sup> (% of revenue)	15.6	19.5	19.15	21.3
GDP growth (annual %)	2.94	7.18	2.32	4.50
<i>ICT adoption:</i>				
Mobile-telephone subscriptions (per 100 people)	108.8	125.9	74.8	101.5
Fixed-broadband subscriptions (per 100 people)	26.3	31.9	4.6	10.3
Households with Internet access at home (%)	73.3	86.1	16.25	42.15

(Source : The Little Data Book on Information and Communication Technology, World Bank, 2018)

While, ICT investment in developing countries increased at 19.15 percent to 21.3 percent, recorded 2.32 percent to 4.5 percent of GDP growth in 2010 and 2016, respectively. Table 1.3 illustrates that, developing countries have identified a strong contribution growth in ICT adoption for mobile telephone, fixed broadband and households with Internet access at home higher than developed countries. In fact, the growth effect of broadband is significant and stronger in developing countries than in developed ones, and higher than that of mobile telephone subscriptions and the Internet users (Qiang, 2009). For every 10-percentage point increase in penetrations of broadband services, there is an increase in economic growth of 1.3 percentage points in developing countries.

A question has always been raised as to why some countries are significantly different in the degree of economic development; some countries are richer, while others, mainly the developing ones, are lagging behind. The success of the developed countries to achieve the developed nation and high-income status are due to their investment on the development of ICT as a whole, while very

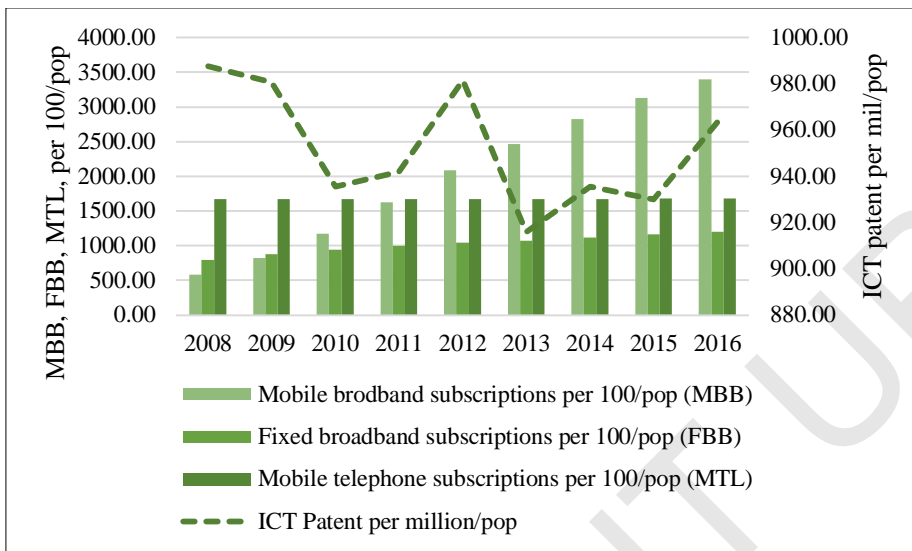
<sup>8</sup>ICT Investment refers to the investment during the financial year in telecommunication services (including fixed, mobile, and Internet services) for acquiring or upgrading property and networks. The indicator is a measure of investment in telecommunication infrastructure in the country, and includes expenditure on initial installations and additions to existing installations where the usage is expected to be over an extended period.

minimal was done by the developing countries (Ejiaku, 2014). Lee (2001) believes that the rapid technological progress, particularly in ICTs, is expected to minimize the gap in income among the countries. Developed countries which have advantages in ICT investment are able to develop well and enhance economic growth while the developing countries are left behind. However, Table 1.3 and Figure 1.4 indicated that, developing countries invested and adopted more on ICT but resulted in a lesser economic growth than developed countries.

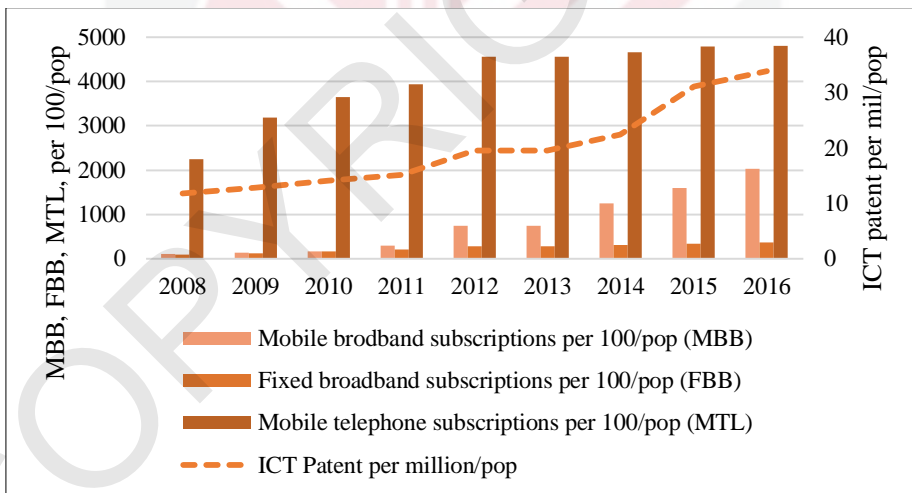
Although ICT adoption has been proven to have substantial spillover on the world economy, the benefit from the development does not appear evenly among countries (Dimelis & Papaionnou, 2010). Therefore, there is a global fear that developing countries, specifically low-income countries will be left behind although they are very productive and have the potential to progress towards a better stage of development.

### **1.2.3 ICT adoption and innovation**

The third issue focuses on the relationship between ICT adoption and ICT innovation. Whilst economic growth remains a priority for most countries, innovation also is an emerging niche area in economic development. In order to innovate, WEF also suggests that economies should emphasize on their capacity to fully leverage ICTs in daily activities and production (WEF, 2015). The investors and policy makers believe that the more countries adopt ICT, the higher level of innovation in their countries (Lee, Nam, Lee, & Son, 2016). On top of that, ICT adoption is essential as enabler to build digital economy through leveraging the internet, smart phones; as well as emerging technologies such as Big Data, copy writing, IoT and AI to spur innovation, and improve livelihoods.



**Figure 1.5 : ICT adoption vs ICT patents grants in developed countries from 2008-2016** (Source : Global Information Technology Report GITR dataset)



**Figure 1.6 : ICT adoption vs ICT patents grants in developing from 2008-2016** (Source : Global Information Technology Report GITR dataset)

Figure 1.5 and Figure 1.6 demonstrates the ICT patents grants growth from 2008-2016 for developed and developing countries. The number of ICT patents grants by the U.S. Patent Trademark Office (USPTO) has been widely used to measure innovative output. For comparison between developed and developing countries, the number of ICT patents grants fluctuated from 2008 to 2016 in developed countries. The highest value was recorded in 2008 at 987 per million



population and the lowest value recorded was in 2013 at 916 per million population of ICT patents grants in developed countries. However, the growth of ICT patents grants increases tremendously in developing countries over the years at 12 per million population to 34 per million population from 2008 to 2016, respectively. Although ICT patents grants indicate an increasing trend, developing countries are still lagging behind in terms of forming, inventing and producing a new integral part of the goods and services as compared to developed countries. ICT innovation significantly contributes to the growth of productivity and economic development (OECD, 2004).

The ICT adoption and innovations are closely connected, particularly where broadband network infrastructure as one of the key drivers of knowledge-based innovation. The deployment of an advanced broadband network accelerates innovation by introducing and encouraging new consumer applications and services (ITU, 2012). As a technological capability, the ICT infrastructure such as broadband influences the development, diffusion, and use of innovations (Fagerberg and Srholec, 2008). In this regard, Yunis (2009) believes that the developed countries are more innovative as they are highly ready in adopting new technologies, in contrast to the developing, thereby enabling them to drive innovations (WEF, 2016). Hence, patents are some of the most important indicators that show developed countries' changes in technology capability across countries over time (Namand Barnett, 2011).

Therefore, explaining the linkage between ICT adoption and innovation has been greatly emphasized in the scholarly work (e.g. Mutula & Brakel, 2006; Yunis, 2009). Previously, Mutula and Brakel (2006) found a positive correlation between ICT adoption and innovation. Countries with high ICT adoption tend to capitalize on their technological resources in upgrading their production frontiers, thereby shifting their economies to innovation-driven. The opposite is true in the case of countries whose technological abundance is relatively scarce as equally indicated by low ICT adoption. For example, developed countries leverage ICT adoption in improving production efficiency across various economic sectors (WEF, 2016). However, the extent of ICT adoption in determining innovation of a country remains ambiguous as indicated by the widespread disparity over the years.

**Table 1.4 : ICT Development Index (IDI), 2016 and Global Innovation Index (GII), 2016 performance for selected countries**

Countries	IDI		GII	
	Score (from 0-10)	Rank N=175	Score (from 0-100)	Rank N=127
Korea	8.84	1	57.15	11
Iceland	8.83	2	55.99	13
Denmark	8.74	3	58.45	8
Switzerland	8.68	4	66.28	1
United Kingdom	8.57	5	61.93	3
Hong Kong	8.46	6	55.69	14
Sweden	8.45	7	63.57	2
Netherlands	8.43	8	58.29	9
Norway	8.42	9	52.01	22
Japan	8.37	10	54.52	16
Czech Republic	7.25	32	49.40	27
Slovenia	7.23	33	45.97	32
Argentina	6.52	55	30.24	81
Chile	6.35	56	38.41	44
Malaysia	6.22	60	43.36	35
Brazil	5.99	63	33.19	69
Thailand	5.18	82	36.51	52
Philippines	4.28	107	31.83	74
Indonesia	3.86	115	29.07	88
Sri Lanka	3.77	116	28.92	91

(Source : ICT Development Index IDI, 2016 and Global Innovation Index GII, 2016)

Table 1.4 presents the performance in ICT Development Index (IDI) and Global Innovation Index (GII)<sup>9</sup> for selected countries published by ITU and INSEAD, respectively. The index illustrates how ICT adoption and innovation trends move together for year 2016. The reports show that the top 10 ranked countries in IDI are also top 10 ranked in GII, which is an indication that the highest development in ICT have also performed better in innovation. It was found that countries like Switzerland, United Kingdom, Sweden and Japan, which are listed as top 10 in IDI also recorded the same for innovation. These countries are well known to have rapidly growing ICT development that are attributed to their high levels of innovation (Mutula & Brakel, 2006).

<sup>9</sup>GII is used to identify and analyse global innovation trends. The GII is a source of insight into the multidimensional facets of innovation-driven growth, comprises of 129 economies on an annual basis. GII has evolved into a valuable benchmarking tool that can facilitate public-private dialogue and where policy-makers, business leaders, and other stakeholders can evaluate innovation progress.

According to the number of US patents granted in 2007, Japan, Germany, Taiwan and South Korea were dramatically and relatively known in championing innovation activities since 1980s. However, some developing countries like India and China also have shown significant success in innovation activities (Chakrabarti & Bhaumik, 2009). Chakrabarti & Bhaumik (2009) found that in China, beside new electrical products and ICT technology trajectories, Chinese entities have benefited from the pioneering lead of foreign entities, along with the traditional mechanical and chemical trajectories. Furthermore, the foreign entities have followed the early work of Chinese entities. These elements have boosted China in championing significant successes in innovation in the recent past.

In addition, digitalisation is able to drive economic growth of the countries through three channels. First, the countries can promote inclusion by enabling existing firms and entrepreneurs to serve markets that are currently underserved. Second, they can lower costs and increase efficiency for existing firms and entrepreneurs to make them more competitive. And third, they can encourage innovation and scale economies, allowing entirely new forms of business and entrepreneurship to emerge (World Bank, 2016). Hence, ICT has become essential toward digitalization, transforming a conventional system to the innovation system in businesses, generate new knowledge, such as in the IR4.0 and appear to be the crucial technology for economic development. While, innovations can improve productivity in every sector of the national economy, where it diffused into existing products, later producing to a new creative and essential part of the goods (Lee et al., 2016).

Generally, innovation refers to the talents and skills to compete, aims to be on the top and sustain in the market allowing to grow market share at effective cost, and eventually enable to achieve high profit successfully (Jovan, Zubovic Bradic-Martinovic, 2014). Fagerberg (2007) refers innovativeness of a country as the ability of the country to invent on new goods and services which would compete successfully in markets because technology is always growing and prevent the economic benefit of innovation to spread more. Hence, he observed that R&D activities, patenting, quality of science through the large number of scientific and technical journals publications and ICT infrastructure are associated to innovativeness (Fagerberg, Srholec, & Knell, 2007). On top of that, innovation in technological progress is widely recognized as one of the key drivers of national competitiveness (Lee et al., 2016).

ITU (2012) acknowledges that broadband network infrastructure is one of the key drivers of knowledge-based innovation. The deployment of broadband network accelerates innovation by introducing new consumer applications and services between universities, industries, and governments (ITU, 2012). In addition, ICT adoption influences the development, diffusion, and use of innovations (Fagerberg & Srholec, 2008). In the case of the broadband network infrastructure, it has been a necessary condition of ICT innovation. The coming

of IR4.0, all activities and businesses related to ICT innovations like social computing, cloud services, gaming and creative media are essential with network broadband infrastructure. In the case of China, the country has established Taobao Villages which are heavily engaged in e-commerce, primarily through Alibaba's Taobao Marketplace. This initiative has shown how China has applied digital technologies to boost growth and created job opportunities to local people by developing e-commerce in rural areas. Growth has been rapid since the first Taobao Village emerged in 2009. As of 2015, there were more than 200,000 active online shops in 780 Taobao Villages across the country. Hence, it is essential for empowering Internet use through broadband network infrastructure to facilitate and encourage knowledge-based innovation to contribute to the productivity and growth of an economy, and attracts foreign investment of the countries (Fadul, 2014; Lee et al., 2011). This study is timely as it attends to an important inquiry on the roles of ICT adoption in influencing innovation.

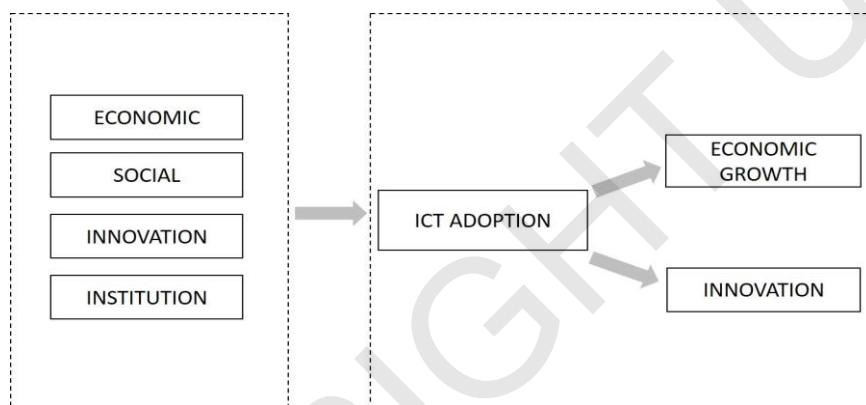
In the digitalization era, people (individual and entrepreneur) nowadays are always connected. The growing of network access speed is crucial for the countries to provide significant social and economic opportunities particularly for studying, reading, shopping, banking and other business activities. Hence, the invention of ICT such as broadband network and innovation are closely connected. Adopting broadband network enables knowledge-based innovation and accelerates innovation by introducing new consumer applications and services (ITU, 2012). Innovation in technology is widely recognized as one of the key drivers of national competitiveness (OECD, 2004). However, Yousefi (2011) found that developing countries are lacking in investing in R&D and adapting ICTs and less in the application of ICTs.

According to the three issues highlighted, developing countries would like to catch up and even surpass developed countries in order for the countries to sustain the growth and innovation. But in reality, the rapid pace of globalization has seen the gap between developing and developed countries widening over the years. In the hope of narrowing the gap and even closing it altogether, some developing countries have sought to adjust their strategies and policies through investment in science and technology initiatives that would enhance the development of their technological capabilities.

Intense competition and increased importance of knowledge are among the economic drivers. It is vibrant for organizations and governments to fulfil the dynamism and important role of adopting new technology e.g. ICT for sustainability of economic growth and innovation. Whatever the reasons, developing countries should not be left behind in reaping the benefits through technological advances, particularly in adopting emerging technology in ICT in order to stay competitive and productive. In reality, developed and developing countries complement each other. In today's world of rapid globalization, ICT continue to be the enabler to influence economy in receiving new technology

and to produce innovative products and services. On the other hand, developing countries should imitate and innovate in order to produce high-value products and services that ultimately sustain economic growth and innovation.

The research framework of the study as shown in Figure 1.7 is developed to show the determinants of ICT adoption which comprises of economic, social, innovation and institutions. Consequently, these factors would improve ICT adoption and lead to sustain economic growth and increase innovation of the nations.



**Figure 1.7 : Research framework of the study**

### **1.3 Problem Statement**

ICT adoption has been discovered as one of the key potential factors for economic growth, social development, interconnection and access to information and knowledge. However, the disparities of ICT adoption between developed and developing countries have caused a contradicting impact on economic development as well as the wealth. Developed countries have surpassed the high-income level and achieved sustainable economic growth. While, developing countries are moving towards high-income economies where technology is essential. The gap between income groups continues to be debated and remains noteworthy and differs specifically on the newer technologies, e.g. ICT adoption, which is being the most unevenly spread. Therefore, it is necessary to discuss whether the disparities of ICT adoption are due to the economic, social, innovation or institutions factors. The disparities have become a tremendously important issue for policy makers, and a fruitful research topic for researchers as well as a major challenge for many international organizations. By so doing helps us understand better the factors that cause some countries lagging while some progressing faster.

World Bank acknowledges that ICT adoption influences economic growth of the countries. The theory of Solow (1957) also accepts that per capita output and economic growth in long run are influenced entirely by rapid deployment of technological progress and is expected to minimize the gap in income among the countries. Developed countries which have advantages in ICT investment are able to develop well and enhance economic growth while the developing countries are left behind. However, developing countries invested and adopted more on ICT but resulted in lesser economic growth than developed countries. In the same period a discrepancy in economic growth was also recorded between developed and developing countries. The correlation between ICT adoption and economic growth in developing countries appears to be insufficient, where it will be left behind although they are very productive adopting ICT and have the potential to progress towards a better stage of development. According to WEF, technology has yet to show its full impact on economic growth. This is because most of the countries, particularly, developing countries need time to fully leverage technologies in order to re-invent their firms, industries, and organization. However, statistics on ICT adoption from end of 20<sup>th</sup> century indicated that the growth of adopting new technology of ICT in mobile subscriptions and broadband network in developing countries is higher than developed countries. ICT adoption patterns seem to be closely related to the development pattern of the country. Hence, those relationships vary according to a wide variety of factors, such as types of economic development, social contribution, innovation activities and healthy of the institution.

A country that surpassed the high-income economy is said to have innovation which is reflected by the country's adopting ICT technology. However, the extent of ICT adoption in determining the innovation of a country remains ambiguous as indicated by the widespread disparity in innovation activities trend over the years. ICT patents grants have shown an increasing trend, however, developing countries are still lagging behind in terms of forming, inventing and producing a new integral part of the goods and services as compared to developed countries. According to ITU, the wealthy and skilled population in developed countries enable efficient utilization of ICT technology and encourage innovation relative to developing countries. This evidence necessitates an investigation of ICT adoption and to unravel its influence on the innovation of developed and developing countries or to probe into other possible channels that might contribute to the increasing rate of innovation.

The major questions to address this issue require a stronger empirical analysis that can establish the relationship between ICT adoption, economic growth and innovation in the developed and developing countries.

#### **1.4 Research Questions**

This study attempts to address the following research questions;

1. What are the determinants of ICT adoption?
2. How ICT adoption influences economic growth?
3. Does ICT adoption impact innovation?

#### **1.5 Research Objectives**

The general objective is to explore the roles of ICT adoption in economic growth and innovation in the developed and developing countries.

The specific objectives are:

1. To investigate the determinants of ICT adoption;
2. To examine the ICT adoption influences on economic growth; and
3. To analyse the impact of ICT adoption on innovation.

#### **1.6 Significance of the Study**

In general, the present study contributes to the body of knowledge and policy implications. Since the issue of determinants of ICT adoption is still being debated and inconclusive, the findings of the study would complement to the existing studies, given that there are very limited studies especially when comparing between developed and developing countries. Income is one of the essential indicators for the countries to adopt ICT. Although developing countries have increased ICT access and use, the gap between income groups remains remarkable and varies according to the type of technology, with newer technologies (such as broadband) being the most unequally distributed between developed and developing countries. Thus, this study contributes significantly to formulate or reform the existing policy actions that are related with the ICT adoption particularly in broadband adoption based on the findings.

Furthermore, the findings of this study could indicate whether the ICT adoption would contribute to the economic growth in developed and developing countries. ICT is recognized as an enabler which interacts closely across sectors and significantly impacts the overall productivity of a country. However, according to WEF (2016), technology has yet to show its full impact on economic growth because most of the countries, particularly developing countries, need time to fully leverage technologies in order to re-invent their firms, industries, and

organization. While, the correlation between ICT adoption and economic growth indicates uneven growth between developed and developing countries. Hence, the result of the findings could facilitate the design of strategic policies to identify other factors may contribute to the economic growth and expand the existing literature in developed and developing countries.

Moreover, the results of the present study would be useful to policy makers in developed and developing countries. Specifically, the results would be practical to the governments and policy makers of developed and developing countries. The ICT adoption and innovations are closely connected, where the ICTs is one of the key drivers of knowledge-based innovation. For instance, the ICT infrastructure, particularly broadband network infrastructure has been a necessary condition of ICT innovation, and current ICT innovations like social computing, cloud services, and virtual games would not be possible without a broadband infrastructure and adopting ICT. Hence, this study might be used as a starting point toward the formulation of better policies that would encourage more ICT adoption and enabling ICT innovation through creating the cloud services, producing innovative media content enable to enhance productivity and growth of an economy.

### **1.7 Scope of the study**

Since it is almost impossible to include all countries in this research, the study has grouped the countries of interest into two different stages of development *viz.* developed and developing countries, using their Gross National Income (GNI) per capita (UNDP) based on World Bank<sup>10</sup>. Low-income countries are excluded to avoid any bias in the analysis. It is also important to note that the data coverage used for the analysis is captured between 2008 and 2016. The countries' selection was based on the availability of data for the complete set of variables investigated.

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<sup>10</sup>According to calculating World Bank Atlas method, economies are divided according to 2017 GNI per capita. The groups are: countries with GNI per capita less than USD1,005 are categorized as low-income countries, lower-middle income countries are those having GNI per capita between USD1,006 and USD3,955, upper-middle income are those having GNI between USD3,956 and USD12,235; while high-income countries are those with GNI per capita above USD12,236. For developing countries, it is comprises of low, lower middle and upper middle income countries in the World Bank categorization (Aubert, 2004). However, low-income countries were excluded to avoid any bias in the analysis. See <http://www.worldbank.org/data/countryclass/classgroups.htm>



## 1.8 Organization of the Thesis

Chapter 1 provides an overview of the study including the background of the study, problem statement, research objectives, significance of the study and the thesis organization. Next, Chapter 2 provides a comprehensive theoretical and empirical review of literature on ICT adoption, economic growth and innovation. Subsequently, Chapter 3 provides detailed descriptions of data and methodology used in this study. This chapter starts with the theoretical framework of each objective, followed by the model specification, description of variables, empirical methodology, and data sources. Chapter 4 continues to present results and provide critical discussions of the findings. The final chapter of the thesis draws a conclusion, makes policy recommendations, highlights the limitations of the study and provides some suggestions for future research.

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