Telecommunications Infrastructure and Regional Economic Growth in Indonesia

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GDP	Gross Domestic Product
GFCF	Gross Fixed Capital Formation
ICT	Information and Communication Technology
TI	Telecommunications Infrastructure

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Abstract

TI is usually associated with the improvement of economic development of a country. This paper aims to examine the association between TI and economic growth in Indonesia. In order to reach the objective, this paper use panel data from 33 provinces in Indonesia for eleven-year period from 2007 to 2017. The variables for TI are fixed telephone subscriber, cellular telephone subscriber, and internet subscriber.

The results provide positive and strong association between TI and economic growth in provincial level in Indonesia. The results except for the fixed telephone are positive and significant association which imply that TI give strong and positive impact toward economic growth in Indonesia. Regarding the negative impact from fixed telephone, we can propose an explanation which is the decreasing condition of fixed telephone subscriber in Indonesia while cellular telephone subscriber and internet subscriber increased dramatically in the last decade.

Relevance to Development Studies

The study of infrastructure is important in development studies because there are many countries including Indonesia which are trying to improve infrastructures in the country. The development of telecommunications technology is very rapid in the last two decade which attracted many researchers to examine the association between telecommunications and economic growth.

As far as the author knows, in Indonesia there is still few researches that analyzed the association especially between TI and economic growth in provincial level of Indonesia. Therefore, this research paper tries to fill the gap in the literature regarding this issue.

This paper use data from Indonesia which is a part of developing countries. The study regarding factors which can promote economic performance becomes very important because Indonesia is in the position to continue to grow and break away from the middle-income trap.

Keywords

Economic growth, TI, regional development

Chapter 1 Introduction

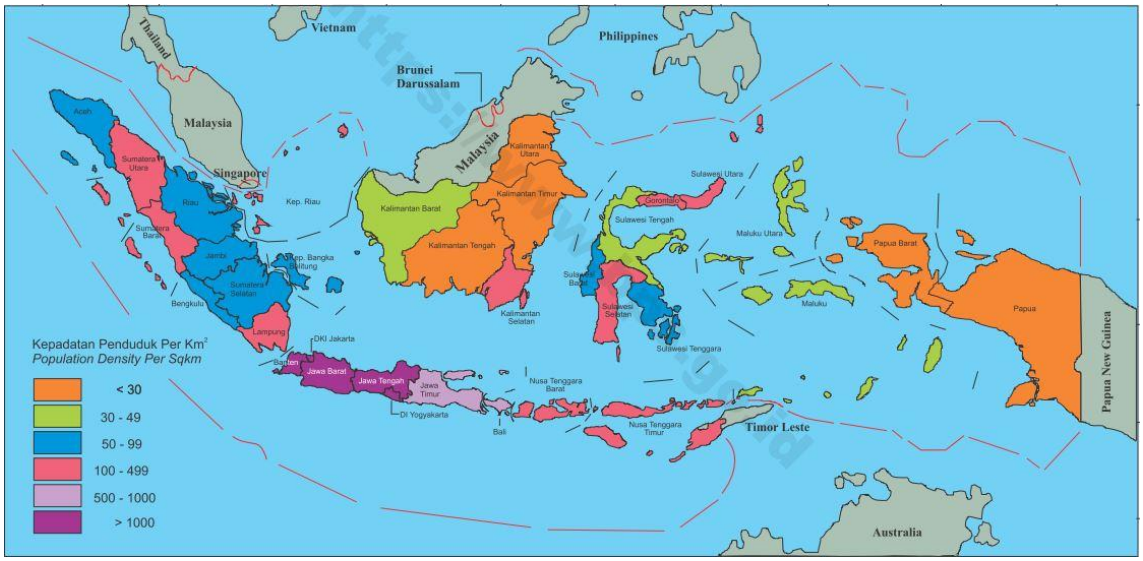
1.1 Background

Indonesia is considered as one of the most populous countries in the world because it has approximately 270 million people which puts Indonesia in the fourth position in the most populous countries in the world. Total area of Indonesia is 1.916 million square kilometres with more than 16,000 islands. The ethnicity in Indonesia varies greatly because the country has hundreds of diverse ethnic and cultural backgrounds. The population distribution in Indonesia is uneven because most of the population, around sixty percent, live on the island of Java. Regarding income distribution, the island of Java also has the biggest share of it with around sixty percent[1].

Figure 1.1 shows the map of Indonesia's provinces with the information about population density per square kilometres. From the Figure 1.1, we can see that the most densely population is in Java island which have more than 500 people per square kilometres while other islands only have mostly below 100 people per square kilometres.

Figure 1.1

Map of the provinces of Indonesia regarding population density per square kilometres



Source: Statistics of Indonesia 2019

Indonesia has many natural resources and human resources that can be a source of welfare. However, after more than seventy years of independence, Indonesia still faces many problems such as inequality and poverty. Inequality in income distribution between the island of Java and the rest has caused negative sentiment among some of Indonesia's population. One effort to find a solution related to this problem is by implementing a decentralized system so that all provinces and districts/cities can improve their welfare through increasing gross regional domestic product (regional economic growth), reducing poverty and unemployment so that the inequality is expected to decrease.

[1] Statistics of Indonesia 2019, Statistics Bureau of Indonesia

Economic growth is considered as one of the factors that shows the success of a country. Economic growth is necessary in enhancing prosperity and economic performance. Many researchers are interested in conducting research related to factors that can explain the sources of economic growth. The famous paper which investigated economic growth were Solow and Swan (Solow 1956, Swan 1956). Many papers were conducted since then to explore further (Romer 1986, Barro and Sala-i-Martin 1992, Mankiw et al. 1992).

Infrastructure is important for economic growth. Based on literature, infrastructure can affect economic development by decreasing the cost of production which can enhance productivity and by increasing the quality of public needs which can increase the quality of life. In firm level, infrastructure is considered as one of the inputs in production. When the cost of the input decrease then the output and profit will increase. Infrastructure can also increase the other factors productivity. In the household level, infrastructure affects the consumption such as water, energy, and telecommunications. This condition will also stimulate job opportunities for the households (Kessides 1996). Adequate infrastructure is needed to improve economic performance of a country. Private sector will experience difficulties in carrying out its activities if proper infrastructure such as roads, energy, electricity, water, telecommunications, and transportation are not available. Poor infrastructure will increase the investment cost and decrease the economic efficiency.

Nowadays, TI is very important for a country. TI has different characteristics compare to other types of infrastructure. The impact of TI seems bigger because it has network externalities which related to the more users the more benefit that can be achieved. Because of these characteristics, TI is expected to have bigger impact to the economy (Pradhan et al. 2013).

The importance of TI towards economic growth has made many researchers trying to find the association between them in the recent economic literature. The existence of network externalities has made the possibility of significant impact toward economic growth. The growth of TI in the recent decades was very rapid so that the development of a country will also be determined by the growth of this type of infrastructure.

The using of cellular phone and the internet have brought new opportunities to the population. In Indonesia, information that used to take days to be received from Java to Papua, now can be received in seconds. Nowadays TI connects people across province within urban and rural in an easier, cheaper and faster way. After the invention of the smartphone the telephone function became not just a simple communication but also a multifunctional tool. Purchase of goods can be done easily only from the palm of your hand without the need to go to the market or supermarket. The development of e-commerce increasingly widespread in recent years makes shopping easier and cheaper. Some other services can also be obtained by smartphone users such as transportation services, food purchasing services, goods purchasing services, financial transactions, and many more innovations in the use of smartphones. The emergence of many economic opportunities through applications in smartphones raises strong suspicions that this will have a major impact on the Indonesian economy. The effect of the use of TI is a major concern of stakeholders related to its association with economic growth and poverty alleviation.

1.2 Economic Growth in Indonesia

In Indonesia, economic growth fluctuates from time to time. In the early period after independence, in Soekarno era, Indonesia had experienced negative economic growth and very high inflation rate up to 600 percent. In the next period, in Soeharto era, Indonesia had experienced highest economic growth which was more than 10 percent. However, when the Asian financial crisis happened in 1997, Indonesia was suffering and experienced the worst

economic growth which was minus 13.13 percent in 1998 (Azam et al. 2013). The difference between those two leaders was their policy towards foreign aids and Foreign Direct Investment (FDI). Soekarno was quite strict about FDI while Soeharto was quite open towards foreign investor. Soeharto's open economy made the investment increase dramatically reaching more than 300 percent compare to Soekarno's period in the first five years of Soeharto's era. During period of 1967-1973, Indonesia's economic growth was getting better which reached the average number just below 8 per cent. In 1966, the inflation reached the highest number of 636 per cent, but only in four years after reaching the highest inflation in Indonesia's history, the inflation declined to only 9 per cent in 1970 (Wihardja and Negara 2015).

In the reformation era, an era after the fall of president Soeharto, the new president, B.J. Habibie, formulated several economic programs which could increase economic growth from minus 13.13 percent in 1998 to 0.85 percent in 1999. In the next period, after Asian financial crisis and the beginning of the reformation, Indonesian economic remain stable with the GDP growth ranging between 4-6 percent.

In the last decade, as shown in Figure 1.2, economic growth in Indonesia was quite stable ranging between 4-6 percent. The lowest growth happened in 2009 when the situation was not good because of the global crisis in 2008 and the national election in 2009. The effect of the crisis made the growth decrease from 6.35 percent in 2007 to 4.63 percent in 2009. However, after the election, Indonesia can bounce back again to more than 6 percent in 2010. In the Figure 1.2 we can see the economic growth of Indonesia from 2007 until 2018.

Figure 1.2
Economic growth of Indonesia 2007-2018

Source: Statistics Bureau of Indonesia

The Indonesian economy in the last few decades has shown good development marked by stable economic growth. The development of infrastructure which is very rapid in recent years is expected to drive Indonesia's economic growth in the next decades. The Indonesian government continues to strive to bring in investors to boost the economy. However, the implementation of appropriate policies and the eradication of corruption, collusion and nepotism will be the key for Indonesia to continue to grow and break away from the middle-income trap.

1.3 Telecommunications Infrastructure in Indonesia

World Economic Forum and INSEAD in their report, The Global Information Technology Report, showed Indonesia's position regarding information and communication technology development in the world. The reports provided the measurement of the drivers from the information and communication technology development by using the Networked Readiness Index. This index consists of four categories which contain of ten subcategories and 53 indicators. One of the subcategories was TI. Regarding the measurement of the infrastructure, in 2016 report, Indonesia was still left behind compared to some ASEAN countries namely Singapore, Malaysia, Brunei Darussalam, Thailand, Philippines, and Vietnam. Indonesia was ranked 85 in 2014, 98 in 2015, and 105 in 2016. However, the newest report of The Global Information Technology Report was in 2016, so the current development from Indonesia's infrastructure was not covered in the last report. In Figure 1.3 we can see the data from Ministry of Finance which show government's budget for infrastructure development. The infrastructure budget has increased dramatically in the last five years under the leadership of President Joko Widodo, which is from IDR 177.9 trillion in 2014 to IDR 399.7 trillion in 2019.

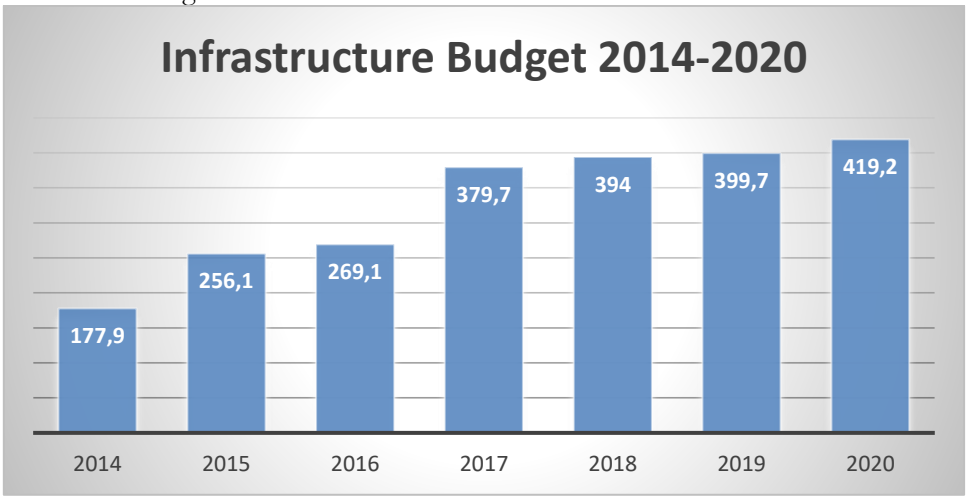
Table 1.1
The Networked Readiness Index of ASEAN Countries 2014-2016

No	ASEAN Countries	2014 (148 countries)		2015 (143 countries)		2016 (139 countries)	
		Value	Rank	Value	Rank	Value	Rank
1	Singapore	5.97	2	6	1	6	1
2	Malaysia	4.83	30	4.9	32	4.9	31
3	Brunei Darussalam	4.34	45				
4	Thailand	4.01	67	4	67	4.2	62
5	Indonesia	4.04	64	3.9	79	4	73
6	Philippines	3.89	78	4	76	4	77
7	Vietnam	3.84	84	3.9	85	3.9	79
8	Lao PDR	3.34	109	3.6	97	3.4	104
9	Cambodia	3.36	108	3.3	110	3.4	109
10	Timor Leste	2.69	141	2.8	134		
11	Myanmar	2.35	146	2.5	139	2.7	133

Source: The Global Information Technology Report 2014, 2015, 2016

Table 1.1 provided the position of Indonesia's information and communication technology development in ASEAN region from 2014 to 2016. The table showed that Indonesia's position was in the middle both in the world and the ASEAN region. In the last report in 2016, Indonesia was ranked number 73 in the world out of 139 countries while in the ASEAN region, Indonesia was ranked number 4 out of 9 countries because Brunei Darussalam and Timor Leste were not included in the 2016 report. Indonesia was ranked behind Singapore, Malaysia, and Thailand.

Figure 1.3
The Budget for Infrastructure of Government of Indonesia 2014-2020

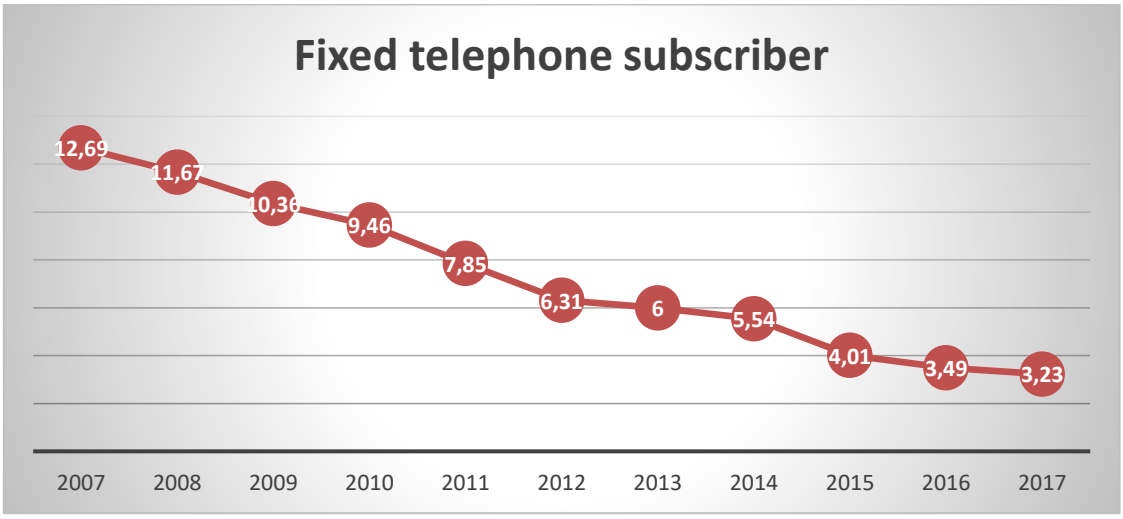


Source: Ministry of Finance

Figure 1.3 provided the development of the budget for infrastructure of government of Indonesia from 2014 to 2020. In 2014, Indonesia was led by President Susilo Bambang Yudhoyono. In the last year of his reign, the budget for infrastructure was quite high because it increased every year. However, President Joko Widodo is allocating more infrastructure budgets which reached 419.2 trillion rupiahs in 2020's budget plan.

TI in Indonesia mainly consist of fixed telephone, cellular telephone, and the internet. Figure 1.4 show the development of fixed telephone subscriber from 2007 to 2017. We can see from Figure 1.4 that the subscriber of fixed telephone decreased every year from 12.69 percent in 2007 to 3.23 percent in 2017. The number of fixed telephone subscriber decreased because of the rise of cellular telephone. The user of fixed telephone is mainly office or firm and households who use the telephone not only for communication purpose but also as an internet broadband subscription.

Figure 1.4
Percentage of fixed telephone subscriber 2007-2017

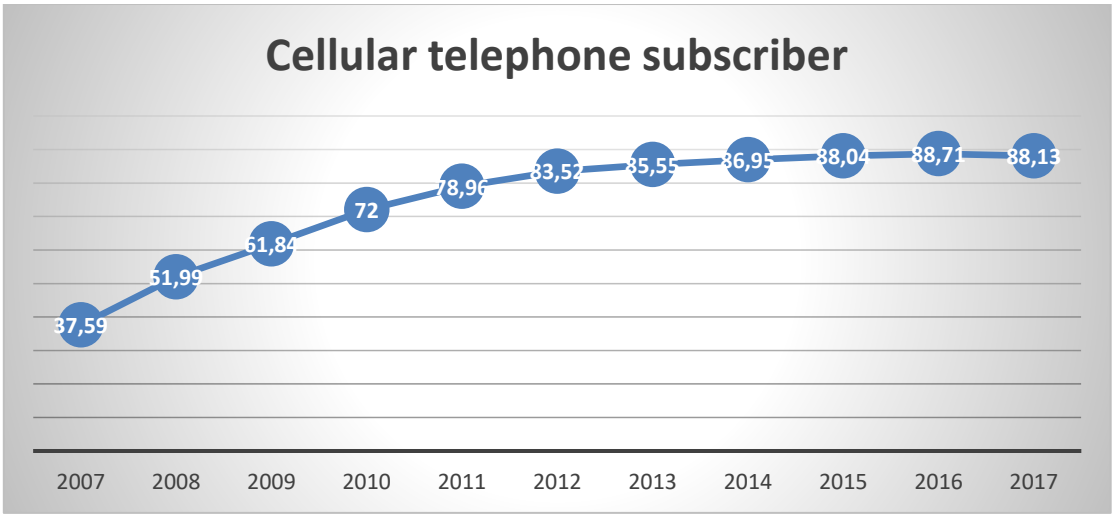


Source: Statistics Bureau of Indonesia

The number of cellular telephone subscriber is increased sharply in the beginning of 2000s while the fixed telephone subscriber is reduced. Figure 1.5 show the development of cellular telephone subscriber in the household level from 2007 to 2017.The increase was very sharp until 2011 which was from 37.59 percent in 2007 to 78.96 percent in 2011. The number of cellular telephone subscriber was increased more than 100 percent in only four years period. After 2011, it only slightly increased from 78.96 percent in 2011 to 88.13 percent in 2017. Nowadays most of Indonesian people have cellular telephone.

Figure 1.5

Percentage of cellular telephone subscriber 2007-2017

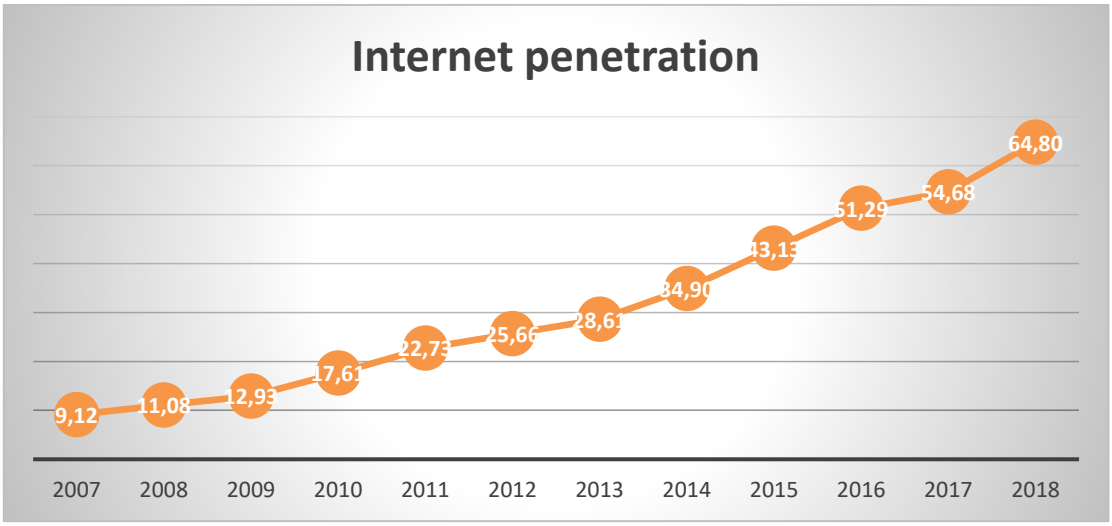


Source: Statistics Bureau of Indonesia

Internet user growth in Indonesia is very promising. In 2007, internet user in Indonesia was only 20 million, but in 2018 the number was increased sharply to 171.17 million. Figure 1.6 show the development of internet penetration from 2007 to 2018. The internet penetration increased dramatically from 9.12 percent in 2007 to 64.8 percent in 2018.

Figure 1.6

Internet penetration 2007-2018



Source: Indonesian Internet Service Providers Association (APJII)

1.4 Research Objective

The study of infrastructure is important in development studies because there are many countries including Indonesia which are trying to improve infrastructures in the country. The relations between infrastructure and economic growth seems quite strong. However, as far as the author knows, in Indonesia there is still few researches that analyzed the association especially between TI with economic growth in provincial level of Indonesia. Therefore, this research paper tries to fill the gap in the literature regarding this issue.

1.5 Research Question

This research will try to answer these research questions: What is the association between TI and regional economic growth using provincial data in Indonesia? And what is the type of TI (fixed telephone, cellular telephone, and the internet) which will give the bigger impact on economic growth?

1.6 Scope and Limitation of the Study

In this research paper, the research will focus on investigating the effect of TI on regional economic growth in Indonesia. This research will use secondary data which will be obtained from online sources. Since the online data of TI especially on provincial level are very limited, this research will use the data depend on the availability.

1.7 Contribution to the Literature

This paper will study about the association between TI and regional economic growth using provincial data in Indonesia. The result from this paper is intended to fill the gap in the literature regarding the use of fixed telephone, cellular telephone, and internet data in Indonesia. The previous researches mainly used between fixed and cellular telephone or internet data. This paper will contribute in providing the recent data regarding TI and economic growth nexus.

1.8 Organization of the Study

This research paper will be divided into five chapters. In the first chapter is introduction. The second chapter will explore the theoretical framework and empirical evidence from previous studies. The third chapter will present the data, variables, and methodology used in this paper. The empirical finding and discussion of the regression results will be provided in chapter four. Finally, the final chapter will state the conclusion of this paper.

Chapter 2 Theoretical Framework and Empirical Evidence

This chapter will provide two main subsections which are theoretical framework and empirical evidence. In the first subsection, theoretical framework, the paper will discuss the definition of infrastructure especially TI and the channel on how TI might affect economic growth. In the second subsection, empirical evidence, the paper will present previous researches which investigate the effect of TI on economic growth.

2.1 Key Concepts

2.1.1 Definition of Infrastructure

In the World Development Report 1994, World Bank defines infrastructure as economic infrastructure which is divided into three categories. First category is public utilities such as telecommunications, energy, electricity, water supply, sanitation and sewerage, gas, etc. Second category is public works such as roads, dam, canal and drainage, etc. The last category is other transport (World Bank 1994)

Infrastructure is important for households and firms and for the economy. Households will mainly get advantages from water, energy, and telecommunications. In addition, the firms will mainly get advantages from road and TI. The cost of production and distribution will become lower than before because of the smaller cost of transportation and telecommunication (Straub 2011). In the last three decades, the development of the TI has risen in the world and become the main discussions in some literatures.

Many theoretical and empirical studies show that the availability of infrastructure improves the long-term production and income levels of an economy. Without infrastructure support, private sectors need to develop their own supporting facilities before starting their business operations. This condition will increase the costs of investment and hence reduces economic efficiency.

2.1.2 Telecommunications Infrastructure

TI as a part of ICT, the World Bank in the ICT Sector Strategy Paper, define that ICT is "consist of hardware, software, networks, and media collection, storage, processing, transmission, and presentation of information (voice, data, text, images)" (World Bank 2002). In the previous literatures, they define TI as mainly fixed telephone facilities in the early stage and then they add cellular telephone facilities in the next stage. Nowadays, TI has developed and refers to not only fixed and cellular telephone but also the internet technologies and other communications technologies.

Nowadays, TI is very important for a country. TI has different characteristics compare to other types of infrastructure. The impact of TI seems bigger because it has network externalities which related to the more users the more benefit that can be achieved. Because of these characteristics, TI is expected to have bigger impact to the economy (Pradhan et al. 2013).

2.2 Theoretical Framework on How Telecommunications Infrastructure affects Economic Growth

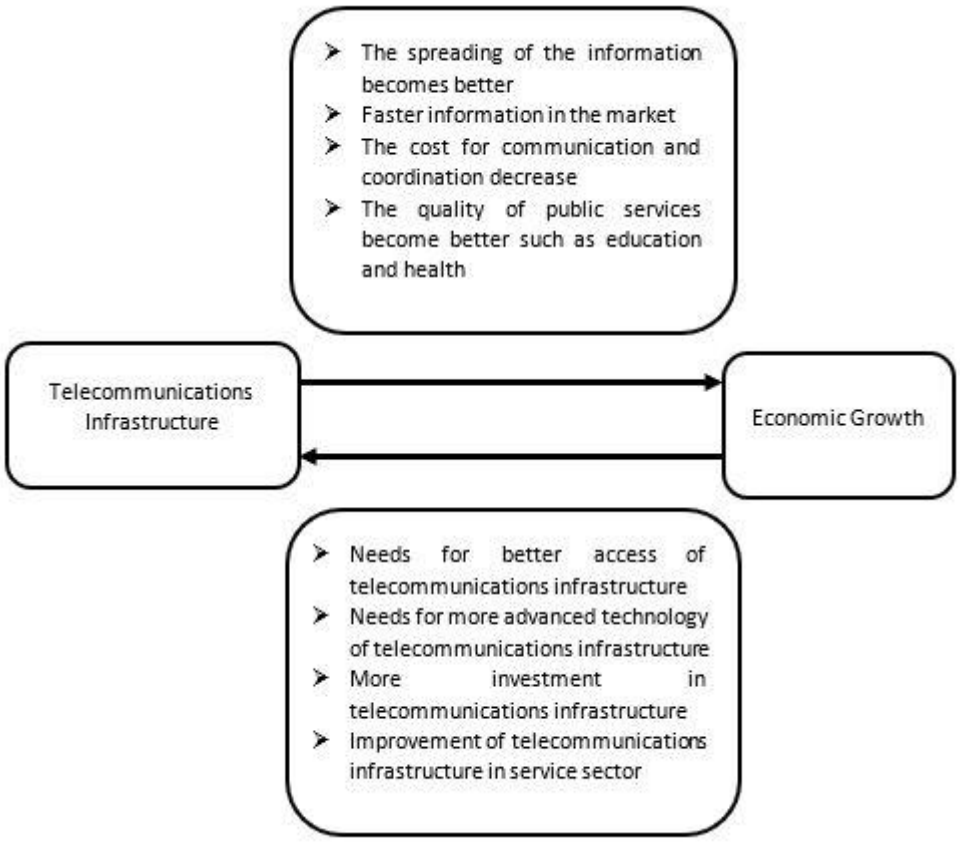
The rapid development of TI in the world in the last thirty years has made many researchers trying to study regarding the issue of the effect of TI on economic growth. Some contemporary theories of economic growth have provided the importance of TI for economic growth and also showing the strong association between them. Some of the prominent theories are neo-Schumpeterian theories and Solow's neo classical growth theory. In both theories, TI as part of the technologies and as an input factor in the economy play important rule in the production process which are advancing the technologies and increasing the quality of labor. The value added as a result of the infrastructure effect creates positive impact towards firm level which will lead towards economic growth (Bahrini and Qaffas 2019).

The development of infrastructure in every country has one main purpose which is to enhance economic growth. TI is one of the types of infrastructure that needed by consumers and producers in the economy. Nowadays many countries are trying to improve their TI so that many more people in the country can get access of the services. In some literatures, infrastructure can enhance economic growth in some channels such as improving the efficiency of the production processes by decreasing the cost of production. TI also have the same characteristics with the other types of infrastructure which is can increase the productivity in the production processes by using the technology. The using of telecommunications technology can help lowering the cost of production.

Some researchers in the literature believe that TI is not the same with other types of infrastructure such as roads, railways, energy, etc. because there is exist the possibility of network externalities which are the increasing value related to the number of the users.

Figure 2.1 shows the possible channels on how TI affects economic growth. In the figure, there is a possibility of causal association between TI and economic growth in both directions. One of the effects of infrastructure is faster information. As mentioned in the introduction, in Indonesia, information that used to take days to be received from Java to Papua, now can be received in seconds because of the development of TI. This development decreased the cost for communications and provided faster information in the market. These conditions will stimulate economic activity in the market. On the other direction, these conditions will increase demand for TI development because market participants need to get better and faster information and communications (Dutta 2001). However, the empirical results regarding the causality are varied in some ways. Some researchers found bi-directional association (Dutta 2001, Wolde-Rufael 2007, Pradhan et al. 2016) while others did not find causality results. Some papers showed single-direction causalities. Some papers found single-direction causalities from TI towards economic growth (Cieslik and Kaniewska 2004, Bahrini and Qaffas 2019) while some other papers found single-direction causalities from economic growth towards TI (Beil et al. 2005, Pradhan et al. 2013).

Figure 2.1
The possible channels on how TI affects economic growth



Source: (Dutta 2001)

2.3 Empirical Evidence

Most of the existing empirical evidences of the effect of TI in the last thirty years by using variation of methodologies, the periods of the researches, and the data in many countries or single country shows that TI has positive impact towards economic growth. Some recent studies are trying to examine the possibility of causal association between TI and economic growth. Some researchers had found the existence of causality between economic growth and TI (Toader et al. 2018).

Regarding the association between TI and economic growth, some researchers found the strong and positive association between them (Roller and Waverman 2001, Ahmed and Ridzuan 2013, Chavula 2013, Sassi and Goaied 2013, Batuo 2015, Toader et al. 2018, Bahrini and Qaffas 2019). Previous researches using different dataset, method, and years have found similar results. A research by Roller and Waverman using data of 21 OECD countries during the period 1970-1990 has founded the existence of network externalities characteristics in the results (Roller and Waverman 2001). These results have been confirmed by Datta and Agarwal who conducted a research using similar data with Roller and Waverman which were 22 OECD countries. The results showed strong association between TI and economic growth. The results also founded the existence of diminishing returns which suggested that in the earlier stage of development, the effect of telecommunications investment will be bigger (Datta and Agarwal 2004). While Datta and Agarwal showed the existence of diminishing returns, Batuo provided the existence of increasing returns by using data of 44 African

nations during the period 1990-2010. He used OLS and GMM test in the estimation (Batuo 2015).

Ahmed and Ridzuan using data of ASEAN5 (Indonesia, Thailand, Singapore, Malaysia, and Philippines) and 3 countries (China, Korea, and Japan) during the period 1975-2006 and using some test such as general least squares, panel cointegration, panel unit root test, and Hausman test to determine the perfect model have founded the positive and strong association between variables. The results also showed long-run association between TI and economic growth (Ahmed and Ridzuan 2013). Mehmood and Azim also using data of Asian countries have been conducted a research to examine the economic convergence. The results suggested that TI has contributed to economic convergence. This research was using data of 24 Asian countries for the period 2000-2010 in the estimation (Mehmood and Azim 2013).

Regarding researches from African countries, there were many papers which investigated this issue. Sassi and Goaied using time series data of MENA nations in the period 1960-2009 examined the association between TI, financial development, and economic growth. GMM test was used in the estimation. The results showed that economic growth was affected directly by the development of TI. The results also provided the importance of both financial development and TI in order to reach better economic impact (Sassi and Goaied 2013). Bahrini and Qaffas using similar data of SSA and MENA countries for the period of 2007-2016 and using same estimation method (GMM) have found similar results. Regarding the types of TI, they found that cellular telephone, internet, and broadband have positive and significant impact towards economic growth. Fixed telephone was not proven in affecting economic growth (Bahrini and Qaffas 2019). A research by Chavula was supported these results which emphasized the importance of cellular telephone. The results showed that fixed and mobile phone and the internet effect upper-middle income while only mobile phone affect upper-low and low-income countries. This research was using data of 49 African countries in the estimation (Chavula 2013).

Another research using data of 159 countries for ten years period from 2000 to 2009 found the indication of positive association between TI and economic growth. This research used ICT index as a proxy of TI which was obtained from cellular telephone subscribers, internet users, and fixed broadband subscribers. GMM estimator was used in this research. The results showed that the impact from ICT was bigger in the advanced nations rather than developing nations. The results suggested that low and developing nations should implement better policies to catch up with advanced nations (Farhadi et al. 2012).

Regarding the existence of causality, some researchers have found it in their results. Previous study using data of thirty countries which are consist of developed and developing countries for at least 24 years period during 1970-1993 found the existence of causality association in bi-directional on both the type of sample countries. The causality from TI towards economic growth seems bigger than the reverse direction (Dutta 2001). Study using data of G-20 countries for fifty years period from 1961 to 2012 and by examining using single country data, group of developed and developing nations and using all countries data found the existence of causality. However, the causality relation is not the same for all observations, it depends on the country as the sample. The long-run equilibrium association was existed between these variables. The strong and positive association was established not only in the aggregate data but also in each country (Pradhan et al. 2016). Similarly, by using U.S. data and examining the causality association, the result show the causality (Wolde-Rufael 2007). They support the hypothesis of bi-directional linkages between TI and economic growth.

The next hypothesis is single direction causality from economic growth towards TI (Beil et al. 2005, Pradhan et al. 2013). The study using time series U.S. data for the period 1947-1996, confirmed the causality but only in one direction. Economic growth can cause the

increase on TI demands (Beil et al. 2005). In addition, by using data of 34 OECD countries during the period 1961-2011, they support this finding (Pradhan et al. 2013).

The last hypothesis is no causality association between TI and economic growth. using data of five highest TI of African countries over the period 2000-2011 found the existence of positive and significant association between TI and economic growth, but there is no evidence of causal association between them (Wilson et al. 2014).

On the single country data, using time series data of Pakistan during the period 1968-2007, they found that teledensity and telecommunications investment can enhance economic growth (Hashim et al. 2009). In China, using data of 29 regions of China over the period 1986-2002 support the results. They used dynamic fixed effects model to estimate the association between variables. Despite founding the positive and significant association between TI and economic growth, they also found the diminishing returns in telecommunications investment which means that the effect in the earlier period is bigger than the last period (Ding and Haynes 2006). The diminishing returns results is found in another research in China by using 31 China's provinces in the period 1991-2010 (Ward and Zheng 2016). Another single country research was conducting by using 49 Poland regions for ten years periods (1989-1998) to capture the impact of TI towards regional economic growth. They used the number of telephone subscribers per 100,000 population as a proxy of teledensity. The results from both pooled data approach (OLS) and panel data approach (fixed effect and random effect) show the positive and significant association between TI and economic performance. The Granger causality tests were used to test the existence of causal association between variables. The results provide support to the existing literature which imply that TI is causing economic development (Cieslik and Kaniewska 2004). Shahiduzzaman and Alam using single country data of Australia for almost forty years period from 1975 to 2011. This research using aggregate production function which considered TI as an input alongside with labour and non-ICT capital. The results provided significant evidence that TI give positive impact towards labour productivity and output in the economy. The impact was bigger in 1990s while in recent years the impact was smaller (Shahiduzzaman and Alam 2014).

In Indonesia, there is only few researches regarding this specific topic. One of them is a research using time series data of Indonesia during the period 1998-2014 and using only internet as the determinant of TI found that TI has positive and significant association toward economic growth (Hariani 2017).

The empirical evidence shows that the association between TI and economic growth is still debatable. The previous studies show different result regarding the causality effect and the direction between TI and economic growth. However, most of the previous researches provide the positive and significant effect of TI and economic growth.

The previous studies show the relation between TI and economic growth in cross-country analysis and single country analysis. Most of the results show the positive correlation between them. However, this paper will focus on Indonesia and the regional level which is not many researches that investigate the relations especially using not only telephone data but also internet data.

Table 2.1

Summary of empirical results of the association between TI and economic growth

No	Author	Country and Years	Method	Result
1	Roller and Waverman 2001	21 OECD countries (1970-1990)	Generalized method of moment (GMM)	The existence of network externalities

2	Dutta 2001	Developed and developing countries (1970-1993)	Granger causality test	Bi-directional causality
3	Ding and Haynes 2004	29 regions in China (1986-2002)	Dynamic fixed effects model	Strong association with the indication of diminishing returns
4	Datta and Agarwal 2004	22 OECD countries (1980-1992)	Dynamic fixed effects method	Positive and strong association
5	Cieslik and Kaniewska (2004)	49 Poland regions (1989-1998)	Granger causality test	TI is causing economic development
6	Beil et al. 2005	U.S. data (1947-1996)	Granger causality test	One direction from economic growth towards TI
7	Wolde-Rufael 2007	U.S. data (1947-1996)	Granger causality test	Bi-directional causality
8	Hashim et al. 2009	time series data of Pakistan (1968-2007)	Ordinary least squares (OLS)	Positive and strong association
9	Farhadi et al. 2012	159 countries (2000-2009)	GMM	The impact was higher in the high-income countries rather than low and middle-income countries
10	Ahmed and Ridzuan 2013	ASEAN5+3 Countries (1975-2006)	Generalised least squares (GLS)	The existence of long-run association
11	Chavula 2013	49 African countries (1990-2007)	OLS	Cellular telephone gave the biggest effect
12	Sassi and Goaied 2013	17 MENA countries (1960-2009)	GMM	Positive and strong association
13	Mehmood and Azim 2013	24 Asian countries (2000-2010)	GMM	The existence of economic convergence
14	Pradhan et al. 2013	34 OECD countries (1961-2011)	Granger causality test	One direction from economic growth towards TI
15	Wilson et al. 2014	African countries (2000-2011)	OLS and Granger causality test	No causality
16	Shahiduzzaman and Alam 2014	single country data of Australia (1975-2011)	vector autoregressive (VAR) model and Granger causality test	The impact was bigger in 1990s while in recent years the impact was smaller
17	Batuo 2015	44 African countries (1990-2010)	GMM	Strong association with the indication of increasing returns
18	Ward and Zheng 2016	31 China's provinces (1991-2010)	OLS and GMM	Strong association with the indication of diminishing returns
19	Pradhan et al. 2016	G-20 countries (1961-2012)	Granger causality test	Causality depends on the country
20	Hariani 2017	time series data of Indonesia (1998-2014)	Endogenous growth model with OLS	Positive and strong association
21	Toader et al. 2018	European Union countries (2000-2017)	GLS	Positive and strong association, but the magnitude depends on the level of technology
22	Bahrini and Qaffas 2019	SSA and MENA countries (2007-2016)	GMM	TI except fixed telephone has significant impact on economic growth

Source: author's elaboration

Chapter 3 Data and Methodology

3.1 Data Source

Regarding the data collection, this paper will use secondary data which will be obtained from official online sources. The data will be collected from Central Bureau of Statistics in the various reports. The data will be from 33 provinces of Indonesia for eleven years period (2007-2017). This period was the newest data available. The data chosen were based on the newest method to collect the data which based from 2010. Data which were older than 2010 and needed to be adjusted will be adjusted with the constant price of 2010.

Table 3.1
Source of the data

Variables	Data Source
Dependent Variable	
Growth rate per capita	Statistics Bureau of Indonesia 2007-2017
Independent Variables	
Initial GDP per capita	Statistics Bureau of Indonesia 2007-2017
Education	Statistics Bureau of Indonesia 2007-2017
Population growth	Statistics Bureau of Indonesia 2007-2017
Gross Fixed Capital Formation	Statistics Bureau of Indonesia 2007-2017
TI	
- Fixed telephone subscriber	Statistics Bureau of Indonesia 2007-2017
- Cellular telephone subscriber (household)	Statistics Bureau of Indonesia 2007-2017
- Cellular telephone subscriber (population)	Statistics Bureau of Indonesia 2007-2017
- Internet penetration (household)	Statistics Bureau of Indonesia 2007-2017
- Internet penetration (population)	Statistics Bureau of Indonesia 2007-2017
Further analysis	
Regional division	Statistics Bureau of Indonesia 2019
Fiscal capacity	Ministry of Finance 2008-2017
Government quality	Ministry of Home Affairs 2010-2017

3.2 Definitions of Variables

3.2.1 Dependent Variable

This paper will use growth rate per capita which is annual growth rate of GDP per capita as the dependent variable. In the literature, usually researcher will use data related to GDP as a proxy of economic growth. Some of the proxies in the literature are provided below:

- annual growth rate of GDP per capita as dependent variable (Datta and Agarwal 2004, Ding and Haynes 2006, Sassi and Goaied 2013, Pradhan et al. 2013)
- annual growth rate of GDP as dependent variable (Hariani 2017)
- real GDP per capita (Bahrini and Qaffas 2019)

- logarithm of real GDP (Ahmed and Ridzuan 2013, Wilson et al. 2014, Toader et al. 2018)

This paper will use annual growth rate of GDP per capita as dependent variable.

3.2.2 Independent Variable

This research will use TI as the independent variables. TI consists of five types of data namely fixed telephone subscriber, cellular telephone subscriber (household), cellular telephone subscriber (population), internet subscriber (household), internet subscriber (population). Some of previous researches used teledensity which is the number of telephones subscriber per 100 population (Farhadi et al. 2012, Wilson et al. 2014, Batuo 2015) or the number of internet user (Hariani 2017). In this paper, the data that will be used are the percentage of population who have access towards TI. The expected sign is positive.

3.2.3 Control Variables

- Lag of annual growth rate of GDP per capita
  The assumption of using this variable is the association between the annual growth rate of GDP per capita with growth in the previous period.
- Lag of natural logarithm of GDP per capita
  This variable is intended to test the existence of conditional convergence in the estimation. The expected sign is negative.
- Natural logarithm of Gross Fixed Capital Formation
  Gross Fixed Capital Formation (GFCF) is included as a proxy for investment in the production function. The expected sign is positive.
- Population growth
  Population growth is included as a factor in the production function.
- Education
  Education is included as a factor of human capital in the production function.

Table 3.2 shows the definition of variables which will be used in the analysis.

Table 3.2 Definitions of variables

Dependent Variable		Code	Description
	Growth rate per capita	Growthp.c	Annual growth rate of GDP per capita
Independent Variable			
	Lag growth rate per capita	Growth p.c(t-1)	The lag value of annual growth rate of GDP per capita (t-1) or last year growth
	Lag of natural logarithm of GDP per capita	LnGDP p.c(t-1)	The lag value of natural logarithm GDP per capita (t-1) or last year GDP per capita
	Education	Educ	The number of years of education completed in school
	Population growth	Pop growth	The percentage number of populations growth in each province
	Natural logarithm of Gross Fixed Capital Formation	LnGFCF	GFCF is part of an overall physical investment process. In this research paper, Gross fixed capital formation is used as an indicator of investment at constant price 2010 and in billion rupiahs.[2]

[2] Statistics of Indonesia 2017, Statistics Bureau of Indonesia 2018

			Natural logarithm of Gross Fixed Capital Formation.
	TI	TI	TI is divided in five data as stated below:
	Fixed telephone subscriber	Fixed	Percentage of households who have fixed telephone
	Cellular telephone subscriber (household)	Cell_hh	Percentage of households who have cellular telephone
	Cellular telephone subscriber (population)	Cell_pop	Percentage of populations who have cellular telephone
	Internet penetration (household)	Net_hh	Percentage of households who have access to internet
	Internet penetration (population)	Net_pop	Percentage of populations who have access to internet

Source: Statistics Bureau of Indonesia

3.3 Statistics Descriptive

Table 3.3 present the descriptive statistics for all variables.

Table 3.3

Statistics descriptive of the variables

No	Variable	Obs	Mean	Std. Dev.	Min	Max
1	Growth rate per capita	363	3.943	2.913	-8.44	23.64
2	growth rate per capita (t-1)	330	3.979	3.005	-8.44	23.64
3	Ln GDP per capita (t-1)	330	17.103	0.569	15.966	18.825
4	Ln GFCF	363	31.162	1.222	28.4	34.191
5	Population growth	363	1.81	1.685	-13.217	12.29
6	Education	363	11.7	0.989	8.73	14.689
7	Fixed telephone	363	6.234	5.174	0.18	37.45
8	Cellular (household)	363	74.266	19.638	16.76	98.04
9	Cellular (population)	297	47.214	13.326	15.25	76.99
10	Internet (household)	363	27.171	17.706	0.97	85.7
11	Internet (population)	264	17.582	9.528	3.78	60.65

Source: author's elaboration

Considering the provision of infrastructure, author will use factor which could be related to the quality and quantity of infrastructure provided in each province. The factor is regional division consideration.

Table 3.4 provided the data of regional division of provinces in Indonesia. The division was made based on the location of the provinces. Indonesia has five big islands which could be represented as regions. The Indonesia's provinces will be divided into five regions which can be seen in Table 3.4.

Table 3.4 Regional Division of Indonesia's Provinces

No	Region I		No	Region III
	Sumatera			Kalimantan
1	Aceh		1	West Kalimantan

2	North Sumatera		2	Central Kalimantan
3	West Sumatera		3	South Kalimantan
4	Riau		4	East Kalimantan
5	Jambi			
6	South Sumatera		No	Region IV
7	Bengkulu			Sulawesi
8	Lampung		1	North Sulawesi
9	The Bangka Belitung Islands		2	Central Sulawesi
10	The Riau Islands		3	South Sulawesi
			4	Southeast Sulawesi
			5	Gorontalo
No	Region II		6	West Sulawesi
	Java			
1	DKI Jakarta		No	Region V
2	West Java			Papua
3	Central Java		1	Maluku
4	DI Yogyakarta		2	North Maluku
5	East Java		3	West Papua
6	Banten		4	Papua
7	Bali		5	West Nusa Tenggara
			6	East Nusa Tenggara

3.4 Empirical Model and Hypothesis

3.4.1 Empirical Model

Solow and Swan in the 1950s developed a model of growth. In the earlier stage, there are only two inputs which are labour and capital. The capital is subject to diminishing return. The growth of population and saving rates are classified as exogenous. The progress of technology is classified as exogenous. The Cobb-Douglas model is as follow (Solow 1956, Swan 1956):

$$Y_t = AK_t^{\alpha} L_t^{\beta} \quad (1)$$

Y_t = production level in year t

K_t = stock of capital

L_t = labour

A_t = technological level

The model assumption is the existence of convergence which indicates that low income countries will catch up in the long run to the high income countries. Technological advances is considered constant in the Cobb-Douglas production function:

$$Y_t = K^{\alpha}(AL)^{1-\alpha} \quad (2)$$

Because of the equations above are not in a linear shape, the equations should be modified using natural logarithm to make it linear. As a result of the natural logarithm function are as follows:

$$ln\,Y_t = \alpha lnK + (1-\alpha)\,(lnA + lnL)^{1-\alpha} \quad (3)$$

Then, if we want to make it as a model for econometrics purpose, the equations become as follows:

$$ln\,Y_t = \beta_0 + \beta_1 K_t + \beta_2 A_t + \beta_3 L_t + \varepsilon_{it} \quad (4)$$

In this paper, the author will develop empirical model based on the existing theories and empirical model on previous studies regarding the same topic. This research will modified empirical model from previous researches which investigate the effect of TI and economic growth (Ding and Haynes 2006, Sassi and Goaied 2013).

Ding and Haynes (2006) develop the model by using the economic growth theory from Solow, Barro, and the modified model by Islam. The model using the assumptions of conditional convergence (Ding and Haynes 2006). The model is as follow:

$$g_{it} = a_0 + a_i + \eta_t + \beta_1 g_{i,t-1} + \beta_2 \ln(y_{i,t-1}) + \beta_3 A_{it} + \beta_4 K_{it} + \beta_5 Lg_{it} + \beta_6 FDI_{it} + \beta_7 Empl_{it} + \varepsilon_{it} \quad (5)$$

g : growth of per capita GDP
$g_{i,t-1}$: growth of per capita GDP (t-1)
$y_{i,t-1}$: per capita GDP (t-1)
A : teledensity
K : investment
Lg : population growth
FDI : share of FDI in investment
$Empl$: share of employment in population
ε : error term

In the next step, they use the lagged values of teledensity ($A_{i,t-1}$ and $A_{i,t-2}$) to confirm that the association between TI and economic growth is not only reverse causality. The equation is stated below:

$$g_{it} = a_0 + a_i + \eta_t + \beta_1 g_{i,t-1} + \beta_2 \ln(y_{i,t-1}) + \beta_3 A_{i,t-1} + \beta_4 K_{it} + \beta_5 Lg_{it} + \beta_6 FDI_{it} + \beta_7 Empl_{it} + \varepsilon_{it} \quad (6)$$

$$g_{it} = a_0 + a_i + \eta_t + \beta_1 g_{i,t-1} + \beta_2 \ln(y_{i,t-1}) + \beta_3 A_{i,t-2} + \beta_4 K_{it} + \beta_5 Lg_{it} + \beta_6 FDI_{it} + \beta_7 Empl_{it} + \varepsilon_{it} \quad (7)$$

Finally, they use the squared value of teledensity (ASq_{it}) to confirm the possibility of diminishing returns (non-linearity) by using this equation:

$$g_{it} = a_0 + a_i + \eta_t + \beta_1 g_{i,t-1} + \beta_2 \ln(y_{i,t-1}) + \beta_3 A_{it} + \beta_4 ASq_{it} + \beta_5 K_{it} + \beta_6 Lg_{it} + \beta_7 FDI_{it} + \beta_8 Empl_{it} + \varepsilon_{it} \quad (8)$$

Sassi and Goaied (2013) also using the growth theory developed by Barro. The initial equation is:

$$g_{it} = \beta_0 + \beta_1 g_0 + \beta_2 FD_{it} + \beta_3 A_{it} + \beta_4 X_{it} + \varepsilon_{it} \quad (9)$$

In the next step, they develop the model to capture the possibility of non-linearity between TI and economic growth.

$$g_{it} = \beta_0 + \beta_1 g_0 + \beta_2 FD_{it} + \beta_3 A_{it} + \beta_4 A^2{}_{it} + \beta_5 X_{it} + \varepsilon_{it} \quad (10)$$

In the last step, they modified the equation to show the interaction between TI and financial development.

$$g_{it} = \beta_0 + \beta_1 g_0 + \beta_2 FD_{it} + \beta_3 A_{it} + \beta_4 FD_{it} A_{it} + \beta_5 X_{it} + \varepsilon_{it} \quad (11)$$

g	: growth of per capita GDP
g_0	: per capita GDP (t0)
FD	: credit to private sector from bank
A	: teledensity
X	: control variables
ε	: error term

The final model that will be used in this research is the modification and adaptation from the equations above. The model is as follow:

$$gk_{it} = \beta_0 + \beta_1 L.gk_{i,t-1} + \beta_2 L.LnGDPk_{i,t-1} + \beta_3 Educ_{it} + \beta_4 TI_{it} + \beta_5 Popg_{it} + \beta_6 LnGFCF_{it} + \varepsilon_{it} \quad (12)$$

gk	: growth of per capita GDP
$L.gk$	: growth of per capita GDP (t-1)
$L.LnGDPk$	: lag of natural logarithm per capita GDP
$Educ$	: years of education completed in school
TI	: TI (divided into five types of infrastructure)
Pop	: the annual growth of population
$LnGFCF$	: natural logarithm of Gross Fixed Capital Formation
ε	: error term

After using the first model, this paper will use the lag value of TI to examine the "reverse causality".

$$gk_{it} = \beta_0 + \beta_1 L.gk_{i,t-1} + \beta_2 L.LnGDPk_{i,t-1} + \beta_3 Educ_{it} + \beta_4 TI_{i,t-1} + \beta_5 Popg_{it} + \beta_6 LnGFCF_{it} + \varepsilon_{it} \quad (13)$$

$$gk_{it} = \beta_0 + \beta_1 L.gk_{i,t-1} + \beta_2 L.LnGDPk_{i,t-1} + \beta_3 Educ_{it} + \beta_4 TI_{i,t-2} + \beta_5 Popg_{it} + \beta_6 LnGFCF_{it} + \varepsilon_{it} \quad (14)$$

Finally, to test the possibility of non-linearity, this paper will use following equation:

$$gk_{it} = \beta_0 + \beta_1 Lgk_{i,t-1} + \beta_2 LnGDPk_{i,t-1} + \beta_3 Educ_{it} + \beta_4 TI_{it} + \beta_5 TIsq_{it} + \beta_6 Popg_{it} + \beta_7 LnGFCF_{it} + \varepsilon_{it} \quad (15)$$

3.4.2 Hypothesis

Based on the theoretical framework, empirical evidence, data, and the empirical model, this research aims to answer several researches question by testing hypothesis as follows:

Ho: TI is not affected growth (β_4=0)

Ha: TI is affected growth (β_4≠0)

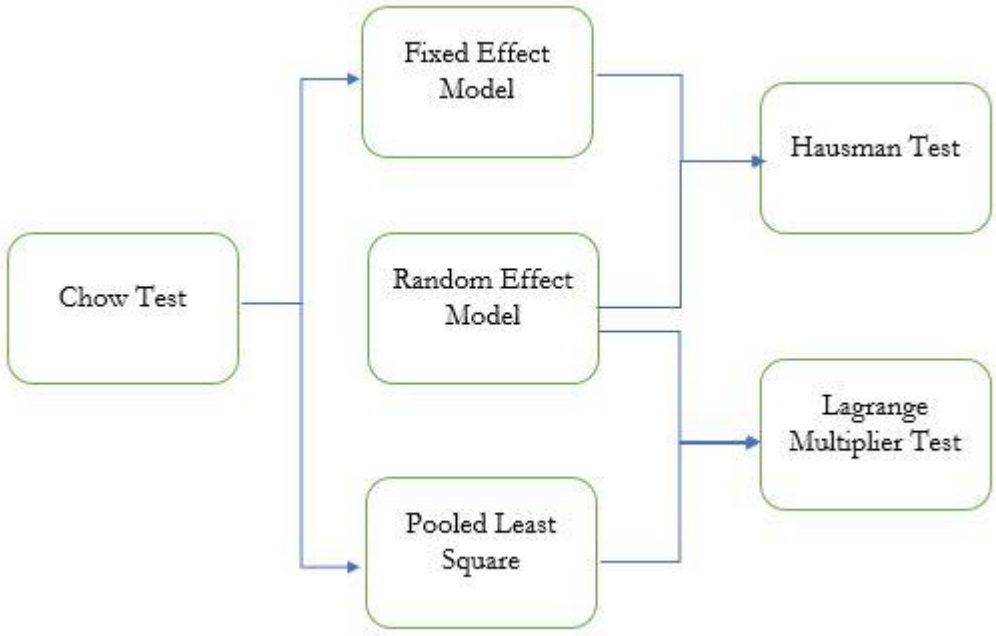
In the hypothesis, the research would like to examine the main research question: Is there any association between TI and economic growth? If the result shows coefficient β_4≠0, means TI influence economic growth. The sign of coefficient (positive or negative) indicates the effect of TI positively or negatively on economic growth. In this research, TI is expected to bring a positive effect on economic growth. The hypothesis is also intended to examine what type of TI that give the bigger impacts towards economic growth.

3.5 Methodology

Panel data is data consisting of combined cross section (several countries) data and time series (several years) data. By doing this could decrease the possibility of multicollinearity problem and keep away spurious regression. There are several techniques to estimate parameters using panel data namely PLS, FEM, and REM (Nachrowi and Usman 2006).

As shown in Figure 3.1, in order to find the best model among the three technique, several tests can be carried out.

Figure 3.1
Panel Model Determining



Source: (Nachrowi and Usman 2006)

Despite using the result from the panel model determining, this study will also use both FEM and REM for comparative reasons and to enable result robustness. The hypothesis to test which is the best between FEM and REM is:

H0: REM

H1: FEM

Chapter 4 Regression Result and Analysis

4.1 Correlation between variables

Table 4.1 show the correlations from all variables which will be used in this paper. The growth of per capita GDP has small correlation with all of the other variables so the estimation with all variables are possible without violating the estimation results. The highest correlation is between cellular telephone subscriber and internet subscriber. This strong correlation is existed because of the using of smartphone which combined between cellular phone and internet in one device. In the regression analysis, these variables will not be analyzed together in one equation to avoid the result bias.

Table 4.1

Correlation table

	gk	Lgk	LGDPk1	LGFCF	LPop	Educ	Fixed	Cell	Cell1	Int	Int1
Growth p.c	1.000										
Growth p.c (t-1)	0.384	1.000									
Ln GDP p.c (t-1)	-0.218	-0.179	1.000								
Ln GFCF	-0.063	-0.051	0.529	1.000							
Population growth	-0.040	-0.153	0.064	-0.151	1.000						
Education	-0.066	-0.015	0.105	0.054	-0.133	1.000					
Fixed	0.035	-0.011	0.370	0.403	-0.051	-0.190	1.000				
Cellular (household)	-0.003	0.023	0.456	0.373	-0.070	0.599	-0.041	1.000			
Cellular (population)	-0.022	0.005	0.464	0.323	-0.066	0.567	-0.174	0.872	1.000		
Internet (household)	-0.029	0.010	0.469	0.385	-0.097	0.660	-0.083	0.768	0.851	1.000	
Internet (population)	-0.027	-0.005	0.479	0.371	-0.076	0.613	-0.107	0.731	0.849	0.966	1.000

Source: author's elaboration

4.2 Panel Model Determining using Hausman test

This paper will use Hausman test to choose between FEM and REM. To conclude the best modal which will be used, this paper will follow this hypothesis:

H 0 : REM is the preferred model

H 1 : FEM is the preferred model

If the p-value is significant ($p<0.05$), this paper will use FEM. However, if the p-value is insignificant ($p>0.05$), this paper will use REM.

Table 4.2

The Hausman test results for each regression

	P-value	Preferred Model
Model A (Fixed telephone subscriber)	0.0000	FEM
Model B (Cellular telephone subscriber in household level)	0.0000	FEM
Model C (Cellular telephone subscriber in population level)	0.0000	FEM
Model D (Internet penetration in household level)	0.0000	FEM
Model E (Internet penetration in population level)	0.0000	FEM
Model F (Lag level 1 of cellular telephone subscriber as a proxy of TI)	0.0000	FEM
Model G (Lag level 2 of cellular telephone subscriber as a proxy of TI)	0.0000	FEM
Model H (Lag level 1 of internet penetration as a proxy of TI)	0.0000	FEM
Model I (Lag level 1 of internet penetration as a proxy of TI)	0.0000	FEM
Model J (square of cellular telephone subscriber as a proxy of TI)	0.0000	FEM
Model K (square of internet penetration as a proxy of TI)	0.0000	FEM

Source: author's elaboration

Table 4.2 shows that the preferred model for all regressions are Fixed Effect Model (FEM). However, this study will also use both FEM and REM in some regressions for comparative reasons and to enable result robustness.

4.3 Regression result

This section will provide regressions results from all the models which mentioned in the table 4.2 by using both FEM and REM models. This section will be divided into three subsections to examine the effect of TI on economic growth regarding the positive or negative impact, reverse causality, and non-linearity.

4.3.1 The effect of TI on economic growth

This sub-section provides the results of the effect of TI on economic growth. The empirical evidence which are provided in Table 4.3 shows that TI is associated with economic growth. In the estimation results, the coefficient of cellular (household) is 0.056, cellular (population) is 0.029, internet (household is 0.046, and internet (population) is 0.062. The results are statistically significant at least at 10% level. Therefore, we can interpret that the increase in internet (population) by 10% will increase growth rate per capita by 0.62 percentage point.

Regarding the types of TI, the results in Model A shows that fixed telephone subscriber is negatively associated with economic growth, but it is not statistically significant. The growth of fixed telephone subscriber continues to decline from year to year, from 12.7 percent in 2007 to 3.2 percent in 2017. The slope of fixed telephone's growth is negative. These conditions seem to be the reason for the negative association between these two variables. The results in Model B and Model C present the positive association between cellular telephone subscriber and economic growth. The results are statistically significant at five percent level in model B and ten percent level in model C. These results are in line with the hypothesis in this paper. The last results from this sub-section are from Model D and Model E which show the positive and significant at five percent level association between internet subscriber and economic growth. These results confirm the positive and significant association between TI and economic growth.

Regarding other variables, the estimation results provide positive and significant correlation on two variables namely natural logarithm of Gross Fixed Capital Formation as a proxy

of capital and the growth of population as a proxy of labor. Physical capital is one of the factors that is believed can increase economic growth.

In some literature, population growth has negative impact towards economic growth because the growth of population will add a burden to the economy as the resources will be consumed by more people. However, some researchers found the positive association between population growth and economic growth. Bloom and Canning stated that the growth in population will give positive impact to the economy when the age structure of the population was in a good shape. It implies that big population with productive age will boost the economy (Bloom and Canning 2004). Indonesia has demographic bonus which can lead to enhance the economic performance.

Another significant variable in the estimation results is the lag of natural logarithm per capita GDP. The coefficient is negative and significant at one percent level. This result implies the existence of conditional convergence in the Indonesian economy.

Table 4.3
Estimation results for the effect of TI on economic growth
using fixed effect model

VARIABLES	(Model A)	(Model B)	(Model C)	(Model D)	(Model E)
Growth p.c (t-1)	0.073	0.066	0.074	0.079	0.083
	(0.099)	(0.098)	(0.101)	(0.099)	(0.101)
Ln GDP p.c (t-1)	-20.610***	-19.729***	-20.364***	-21.409***	-21.245***
	(5.414)	(4.900)	(5.345)	(5.627)	(5.436)
Ln GFCF	8.862***	6.760***	7.592***	8.036***	8.109***
	(2.227)	(2.221)	(1.848)	(2.139)	(2.168)
Education	0.523	0.512	0.685	0.479	0.541
	(0.628)	(0.645)	(0.650)	(0.643)	(0.648)
Population growth	0.197**	0.182**	0.199**	0.202**	0.201**
	(0.091)	(0.089)	(0.088)	(0.088)	(0.088)
Fixed phone	-0.128				
	(0.093)				
Cellular (household)		0.056**			
		(0.023)			
Cellular (population)			0.029*		
			(0.017)		
Internet (household)				0.046**	
				(0.021)	
Internet (population)					0.062**
					(0.028)
Constant	73.895	119.464*	105.435	111.762	106.392
	(69.198)	(59.640)	(70.963)	(71.390)	(65.061)
Observations	330	330	330	330	330
R-squared	0.184	0.195	0.189	0.192	0.193
Number of Provinces	33	33	33	33	33

The results from random effect model in Table 4.4 have almost the same results with fixed effect model. The only different result comes from Model A which shows positive and significant association between fixed phone and economic growth while in Table 4.3 shows negative and not significant association. The coefficient results of TI are smaller than the results from fixed effect model.

Table 4.4
Estimation results for the effect of TI on economic growth
using random effect model

VARIABLES	(Model A)	(Model B)	(Model C)	(Model D)	(Model E)
Growth p.c (t-1)	0.349***	0.336***	0.342***	0.339***	0.341***
	(0.051)	(0.051)	(0.051)	(0.051)	(0.051)
Ln GDP p.c (t-1)	-1.082***	-1.222***	-1.199***	-1.216***	-1.229***
	(0.329)	(0.341)	(0.347)	(0.347)	(0.347)
Ln GFCF	0.073	0.064	0.106	0.066	0.078
	(0.154)	(0.152)	(0.150)	(0.153)	(0.152)
Education	-0.050	-0.411**	-0.335*	-0.428**	-0.396*
	(0.160)	(0.199)	(0.191)	(0.218)	(0.203)
Population growth	0.059	0.042	0.048	0.048	0.046
	(0.091)	(0.090)	(0.090)	(0.090)	(0.090)
Fixed phone	0.064*				
	(0.036)				
Cellular (household)		0.031**			
		(0.014)			
Cellular (population)			0.021*		
			(0.011)		
Internet (household)				0.028**	
				(0.014)	
Internet (population)					0.042**
					(0.021)
Constant	18.939***	23.895***	22.798***	25.494***	25.199***
	(5.427)	(6.231)	(6.351)	(7.116)	(6.876)
Observations	330	330	330	330	330
Number of Provinces	33	33	33	33	33

4.3.2 The causality analysis

Some of previous studies present the existence of causality between TI and economic growth. In order to examine the association of both variables, this paper will use the lagged values of the proxy of TI. In this test, the author will use cellular telephone subscriber and internet subscriber in the household level as proxies of TI. In the previous estimation results, we obtain positive and significant results for both variables. Reverse causality exists if the lagged variables have insignificant coefficient result. If the results present positive and significant coefficient, it can be implied that economic growth is positively affected by TI. Table 4.5 presents the estimation results from Model B, Model F, and Model G by using cellular telephone subscriber in household level. Model B, as stated in the previous sub-section, provide positive and significant value at five percent level. Model F and Model G also present

positive and significant value at five percent and one percent level respectively. The results in Table 4.4 suggest that economic growth is positively affected by TI. The association between TI and economic growth is not a result of reverse causality.

Table 4.5
Estimation results for the test of reverse causality in the association of telecommunications infrastructure and economic growth using cellular phone subscriber as proxy of TI

VARIABLES	(Model B)	(Model F)	(Model G)
Growth p.c (t-1)	0.066	0.066	0.061
	(0.098)	(0.097)	(0.098)
Ln GDP p.c (t-1)	-19.729***	-19.918***	-22.711***
	(4.900)	(5.008)	(6.363)
Ln GFCF	6.760***	7.586***	6.453**
	(2.221)	(2.405)	(2.614)
Education	0.512	0.514	0.466
	(0.645)	(0.637)	(0.965)
Population growth	0.182**	0.187**	0.217**
	(0.089)	(0.090)	(0.091)
Cellular (household)	0.056**		
	(0.023)		
Cellular (household) (t-1)		0.031**	
		(0.012)	
Cellular (household) (t-2)			0.057***
			(0.016)
Constant	119.464*	99.040	181.098*
	(59.640)	(66.342)	(94.982)
Observations	330	330	297
R-squared	0.195	0.185	0.187
Number of ID	33	33	33

Table 4.6 presents the estimation results from Model D, Model H, and Model I by using internet user in household level. Model D, as stated in the previous sub-section, provide positive and significant value at five percent level. In Table 4.5, the estimation results of the lagged variables provide positive and significant value. However, in table 4.6, the first lagged variable has positive and significant value at ten percent level while the second lagged variable has positive insignificant value.

Table 4.6
Estimation results for the test of reverse causality in the association of telecommunications infrastructure and economic growth using internet penetration as proxy of TI

VARIABLES	(Model D)	(Model H)	(Model I)
Growth p.c (t-1)	0.079	0.076	0.067
	(0.099)	(0.096)	(0.105)
Ln GDP p.c (t-1)	-21.409***	-21.038***	-23.717***
	(5.627)	(5.467)	(6.879)
Ln GFCF	8.036***	8.413***	8.717***
	(2.139)	(2.139)	(2.434)
Education	0.479	0.437	0.755
	(0.643)	(0.656)	(0.942)
Population growth	0.202**	0.203**	0.239**
	(0.088)	(0.088)	(0.091)
Internet (household)	0.046**		
	(0.021)		
Internet (household) (t-1)		0.041*	
		(0.020)	
Internet (household) (t-2)			0.041
			(0.028)
Constant	111.762	94.500	127.306
	(71.390)	(62.988)	(93.156)
Observations	330	330	297
R-squared	0.192	0.188	0.176
Number of Provinces	33	33	33

4.3.3 Test of non-linearity

This sub-section will provide the estimation results for non-linearity test. Some of the previous studies found the non-linear association between TI and economic growth.

If the estimation results show negative sign and significant of the squared variable while the coefficient of the other variable present positive and significant value, then the results support the hypothesis of the existence of "diminishing return". However, the results will support "increasing returns" hypothesis if both the coefficients have positive and significant values. If the results provide positive and significant value for the squared variable's coefficient while other variable has negative and significant value, then these conditions will support "critical mass" hypothesis.

Table 4.7 provide the estimation results from Model J and Model K. The results from Model J suggest that there is no non-linearity association between TI and economic growth because both coefficients are not significant. The results from Model K also support no non-linearity association because the significant value only comes from the non-squared variable which comes from internet (household).

Table 4.7
Estimation results for the test of non-linearity in the association of TI and economic growth

VARIABLES	(Model J)	(Model K)
Growth p.c (t-1)	0.071	0.076
	(0.095)	(0.098)
Ln GDP p.c (t-1)	-20.514***	-21.274***
	(5.223)	(5.673)
Ln GFCF	6.986***	7.611***
	(2.391)	(2.370)
Education	0.398	0.462
	(0.616)	(0.644)
Population growth	0.183**	0.199**
	(0.089)	(0.088)
Cellular (household)	-0.050	
	(0.087)	
Cellular (household) square	0.001	
	(0.001)	
Internet (household)		0.069*
		(0.037)
Internet (household) square		-0.000
		(0.000)
Constant	130.184**	122.572
	(61.848)	(73.820)
Observations	330	330
R-squared	0.200	0.193
Number of Provinces	33	33

4.3.4 The effect of TI on economic growth using one period of lag

Infrastructure usually needs time to be ready to use. There is a time lag before we can feel the benefit of infrastructure. Big infrastructure usually needs time to build, so the effect of the benefits cannot be felt directly. This paper will examine the difference between the normal results and the results by using one period of lag.

Table 4.8 provided the results from the estimation with fixed effect model using one period of lag. We can see that the result is quite similar with the result without using time lag.

Table 4.8
Estimation results for the effect of TI on economic growth
using fixed effect model and using one period of lag

VARIABLES	(Model A with Lag)	(Model B with Lag)	(Model C with Lag)	(Model D with Lag)	(Model E with Lag)
Growth p.c (t-1)	0.081	0.066	0.070	0.076	0.073
	(0.102)	(0.097)	(0.097)	(0.096)	(0.097)
Ln GDP p.c (t-1)	-20.485***	-19.918***	-20.412***	-21.038***	-20.607***
	(5.187)	(5.008)	(5.047)	(5.467)	(5.231)
Ln GFCF	8.608***	7.586***	7.349***	8.413***	8.575***
	(2.143)	(2.405)	(2.322)	(2.139)	(2.187)
Education	0.504	0.514	0.508	0.437	0.472
	(0.660)	(0.637)	(0.649)	(0.656)	(0.647)
Population growth	0.212**	0.187**	0.200**	0.203**	0.199**
	(0.088)	(0.090)	(0.088)	(0.088)	(0.089)
Fixed phone (t-1)	-0.136*				
	(0.077)				
Cellular (household) (t-1)		0.031**			
		(0.012)			
Cellular (population) (t-1)			0.033***		
			(0.012)		
Internet (household) (t-1)				0.041*	
				(0.020)	
Internet (population) (t-1)					0.052**
					(0.025)
Constant	80.015	99.040	115.955*	94.500	82.097
	(59.938)	(66.342)	(57.852)	(62.988)	(58.553)
Observations	330	330	330	330	330
R-squared	0.187	0.185	0.196	0.188	0.187
Number of Province	33	33	33	33	33

The results in Model A (with lag) shows that fixed telephone subscriber is negatively associated with economic growth. The results show statistically significant in the association between both variables. This negative association can be explained with the fact that growth of fixed telephone subscriber continues to decline from year to year. The results in Model B, C, D, and E are similar with the results from the results without using time lag. These results confirm the positive and significant association between TI and economic growth.

Table 4.9 presented the results from the estimation with fixed effect model using one period of lag. We can see that the result is different with the result without using time lag. In the panel model determining using Hausman test, we can see that the preferred model for this panel data is fixed effect model. Therefore, the estimation results from fixed effect model will give more valid information.

Table 4.9
Estimation results for the effect of TI on economic growth
using random effect model and using one period of lag

VARIABLES	(Model A with Lag)	(Model B with Lag)	(Model C with Lag)	(Model D with Lag)	(Model E with Lag)
Growth p.c (t-1)	0.349***	0.342***	0.340***	0.341***	0.342***
	(0.051)	(0.052)	(0.051)	(0.052)	(0.051)
Ln GDP p.c (t-1)	-1.051***	-1.129***	-1.171***	-1.166***	-1.145***
	(0.331)	(0.345)	(0.340)	(0.348)	(0.346)
Ln GFCF	0.093	0.096	0.108	0.083	0.100
	(0.154)	(0.152)	(0.149)	(0.153)	(0.151)
Education	-0.070	-0.321	-0.356*	-0.375*	-0.324
	(0.160)	(0.208)	(0.196)	(0.221)	(0.203)
Population growth	0.052	0.045	0.048	0.051	0.049
	(0.091)	(0.091)	(0.090)	(0.090)	(0.091)
Fixed phone (t-1)	0.041				
	(0.033)				
Cellular (household) (t-1)		0.016			
		(0.012)			
Cellular (population) (t-1)			0.019*		
			(0.010)		
Internet (household) (t-1)				0.025	
				(0.016)	
Internet (population) (t-1)					0.034
					(0.023)
Constant	18.134***	21.439***	22.706***	23.689***	22.446***
	(5.477)	(6.506)	(6.261)	(7.142)	(6.772)
Observations	330	330	330	330	330
Number of Province	33	33	33	33	33

4.3.6 The effect of TI on economic growth by considering regional division

The results from the estimation regarding regional division consideration showed that the most significant variable is internet (population) and internet (household). All of the significant variables have positive impact towards economic growth except fixed phone and cellular telephone (population) in Java region which have negative coefficient. Considering the significant variables, the highest effect is in Papua region while the lowest effect is in Java region. Internet (population) variable is positive and significant in four regions except Sulawesi while internet (household) is positive and significant in three regions except Java and Sulawesi. Fixed phone is negative and significant in Java and Kalimantan. The various results show

that the characteristics of each region is unique. However, the internet penetration seems to grow bigger because in the last decade the growth of internet penetration is very convincing.

Table 4.10
Estimation results with regional division consideration

VARIABLES	Region I (Sumatera)	Region II (Java)	Region III (Kalimantan)	Region IV (Sulawesi)	Region V (Papua)
Fixed phone	0.061	-0.089**	-0.214**	0.071	0.242
	(0.107)	(0.025)	(0.043)	(0.110)	(1.195)
Cellular (household)	0.088***	-0.000	0.054	0.049	0.163
	(0.026)	(0.010)	(0.061)	(0.032)	(0.183)
Cellular (population)	0.011	-0.008**	0.011	0.007	0.337*
	(0.018)	(0.003)	(0.011)	(0.026)	(0.136)
Internet (household)	0.051*	0.024	0.082***	-0.013	0.204*
	(0.023)	(0.023)	(0.011)	(0.025)	(0.096)
Internet (population)	0.117*	0.061**	0.125***	0.021	0.290**
	(0.056)	(0.017)	(0.008)	(0.047)	(0.077)
Observations	100	70	40	60	60
Number of Province	10	7	4	6	6

Table 4.11 presented the results from the estimation with regional division consideration using one period of lag. We can see that the result is different with the result without using time lag. The estimation results give the same result for fixed phone which is negative and significant in Java and Kalimantan. However, both internet (household) and internet (population) are not significant in many regions.

Table 4.11
Estimation results with regional division consideration and using one period of lag

VARIABLES	Region I (Sumatera)	Region II (Java)	Region III (Kalimantan)	Region IV (Sulawesi)	Region V (Papua)
	With Lag	With Lag	With Lag	With Lag	With Lag
Fixed phone (t-1)	-0.022	-0.062*	-0.357**	-0.055	-0.423
	(0.192)	(0.026)	(0.064)	(0.154)	(0.251)
Cellular (household) (t-1)	0.047**	-0.006	0.031	0.032	0.084
	(0.019)	(0.008)	(0.043)	(0.025)	(0.043)
Cellular (population) (t-1)	0.073***	0.025***	0.047*	0.040	0.054
	(0.019)	(0.006)	(0.017)	(0.034)	(0.132)
Internet (household) (t-1)	0.026	0.001	0.079	-0.001	0.115
	(0.017)	(0.016)	(0.046)	(0.036)	(0.099)
Internet (population) (t-1)	0.026	0.036*	0.130**	0.010	-0.149
	(0.022)	(0.017)	(0.023)	(0.042)	(0.371)
Observations	100	70	40	60	60
Number of Province	10	7	4	6	6

Chapter 5 Conclusion

This paper aims to contribute to the literature especially regarding the analysis of the association between TI and economic growth in provincial level in Indonesia. As author knows, the existing literature which use Indonesia's provincial data regarding this topic is very limited.

In the first chapter of this paper, we have an objective to find the association between TI and economic growth in provincial level in Indonesia. We also want to know which type of infrastructure that will give the bigger impact toward economic growth. In order to accomplish this objective and to answer this question, we have consulted to the literature regarding this topic. In the literature, we know that the exact association between these two variables is not uniform from one research to another research. Some paper found bi-directional association (causality association) while others did not find the existence of causality. Some paper suggest that TI is causing growth while others give the reverse results.

Based on the literature review, we collect data related to this topic. Data availability is the main consideration in collecting the data which will be used in the estimation. We collect data regarding TI by using data of fixed telephone subscriber, cellular telephone subscriber in household and population level, and internet subscriber in household and population level. The recent and available data are from 2007 to 2017 for 33 provinces.

We build the model by adapting from the existing literatures which can be used to examine the existing data of Indonesia's provinces. Before proceeding to the final estimation, we conducted test to choose the best model to use in the estimation between fixed effect model and random effect model by using Hausman test. The results suggest us to use fixed effect model. However, in some regressions in the estimation, we will not only use the result from the panel model determining, but also will use both FEM and REM for comparative reasons and to enable result robustness.

The overall estimation results provide the positive and strong association between TI and economic growth in provincial level in Indonesia. The results except from the fixed telephone are positive which imply that TI give strong and positive impact toward economic growth in Indonesia. Regarding the negative impact from fixed telephone, we can propose an explanation which is the decreasing condition of fixed telephone subscriber in Indonesia. On the other hand, cellular telephone subscriber and internet subscriber increased dramatically in the last decade.

The estimation result suggest that the internet give the biggest impact towards economic growth. In the results, internet has the biggest coefficient compare to cellular telephone and fixed telephone. When considering regional division, the internet also becomes the most significant TI variable in the regression results. Using one period of lag, the internet and cellular telephone have different results especially when using regional division consideration.

These results suggest that to achieve better economic performance, the government should consider improving the infrastructure especially TI which is believed to have bigger impact compare to other types of infrastructures.

Nowadays the growth of broadband becomes very rapid in Indonesia. However, this paper is not included broadband in the research. Therefore, further research is needed to examine thoroughly with all the types of TI.

Appendices

Appendix 1
Sample table

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Notes