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The Solow-Swan theories: An empirical evidence in various Indonesian Provinces

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ABSTRACT

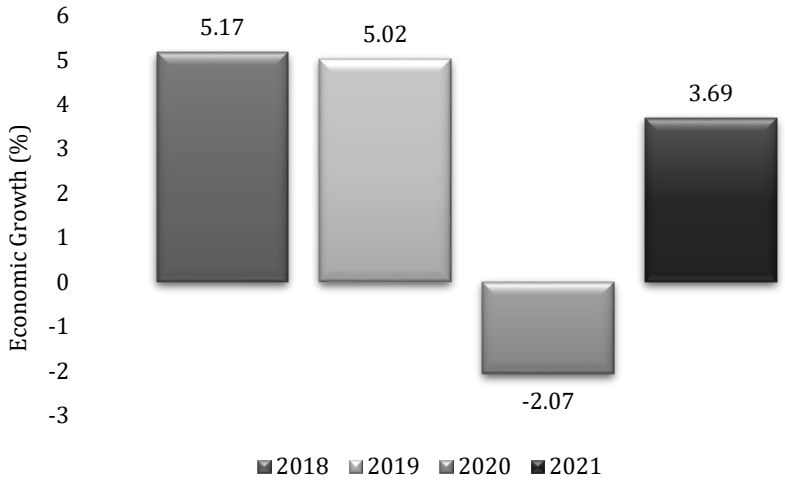
The digital ecosystem is a collection of integrated information technologies and entities. The development of the digital ecosystem in Indonesia has shown a positive trend and has significant impacts on the national economy. The penetration of Information and Communication Technology (ICT) has brought positive effects such as increased accessibility, business growth, and digital economic transformation. To assess the progress of this technology, the Solow-Swan approach is employed. This research aims to examine how investment, labor force, and technology, represented by the level of mobile phone usage and Base Transceiver Station (BTS) infrastructure, can influence the economy through Gross Regional Domestic Product (GRDP) in the 34 provinces of Indonesia. This paper aims to examine how investment, labor, and technology can affect the economy through the GRDP in 34 provinces in Indonesia. The data used is panel data from 2018 to 2021 for 34 provinces in Indonesia. The research results show that investment and technological progress have a significant positive impact. On the other hand, the labor force has no effect on the economy in 34 provinces in Indonesia. Overall, this research has not been able to validate the Solow-Swan theory in the context of 34 provinces in Indonesia for the 2018-2021 period.

Introduction

Cook & Davíðsdóttir (2021) stated that Sustainable Development Goals (SDGs) are a global campaign that provides a vision and global consensus for sustainable development and the future by 2030. This global campaign calls for all societies around the world to address challenges and threats related to the environment, economy, society, and institutions. Essentially, the SDGs aim to enhance the economic well-being of global society while ensuring sustainability in development. The goals are designed to promote sustainable development and guarantee long-term prosperity. Development can be understood as a multidimensional process involving various aspects of life, including social structures, attitudes towards accelerated economic growth, reducing income inequalities, and alleviating poverty (Todaro & Smith, 2012). The purpose of development is to

achieve well-being and prosperity through various economic advancements, one of which is promoting economic growth. Economic growth is a crucial aspect of a country's success in achieving the SDGs. This aligns with the statement by Estrada & Wenagama (2020) who found that the rate of economic growth is an indicator of development success. Since the end of World War II, most countries worldwide have targeted economic growth as a primary objective (Chen & Xu, 2022). The rate of economic growth is the eighth point out of the seventeen SDG goals, measured by the value added produced by a country, known as Gross Domestic Product (GDP), aimed at driving economic development.

The development of a country serves as an important indicator of its success. However, to achieve such success, all nations constantly strive to address potential challenges that may disrupt their economies, one of which is the global pandemic of Covid-19. Since the outbreak of the Covid-19 pandemic, which has affected countries worldwide, the economic progress of each nation has experienced contraction and slowdown. The restrictions imposed by governments on societal activities have hindered economic activities and led to a decline, including in Indonesia.



Source: Badan Pusat Statistik, 2022

Figure 1. Indonesia's Economic Growth Rate for 2018-2021 (y-o-y)

Figure 1 depicts the development of Indonesia's economic growth rate from 2018 to 2021, which remains positive despite experiencing a decline due to the Covid-19 pandemic. Post-pandemic, Figure 1 explains that Indonesia's economy has managed to rebound and show a positive growth rate of 3.69 percent year on year. However, the trend of economic growth from 2018 to 2021 has experienced a slowdown. The slowdown in economic growth during this period indicates the suboptimal development of regional economies. This is because national development is the result of aggregating economic development at the regional level across the 34 provinces in Indonesia. The ongoing process of digital transformation in the global economy is closely related to the concept of Industry 4.0 (Hizam-Hanafiah & Soomro, 2021) and is driven by innovative digital

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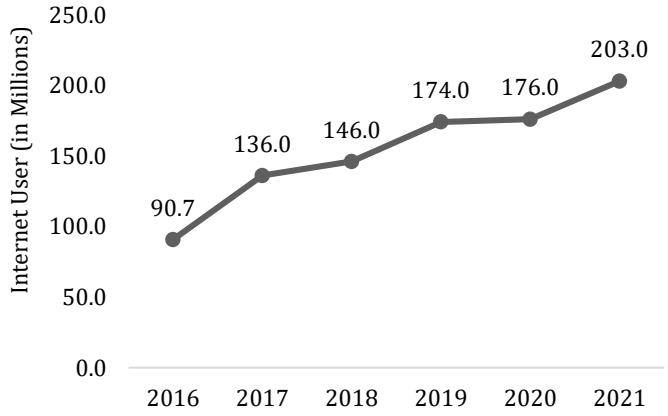
technologies (Schwab, 2016). In recent years, this process has gained momentum, encompassing almost every aspect of life. One of the utilizations of technological advancements in the economy is highlighted by Solow-Swan. The supporting role of economic growth proposed by Solow, as discussed in Munguía et al (2019) is that the dynamics of long-term economic growth are influenced by capital investment, labor, and emphasis on technological progress. Since the outbreak of the Covid-19 pandemic, society has been trying to fully adopt the benefits provided by technology (Aruleba & Jere, 2022).

The role of technology is crucial in enhancing a country's productivity. The world has recognized that technological advancements or digital growth have led to accelerated economic growth in a country (Bukht & Heeks, 2019). Understanding the positive effects of technological development on a country's economy, the use of internet technology has the potential and a positive influence on economic activities to drive productivity and efficiency. The advancement of internet technology provides new ways and innovations in conducting various activities, including economic activities (Amankwah-Amoah et al., 2018). These positive impacts are consistent with previous findings that highlight the positive relationship between technology, information, and communication usage with growth, welfare enhancement, and increased labor productivity (Solomon & Klyton, 2020). The development of internet usage worldwide shows a positive trend from year to year. The good acceleration of the internet in developing countries, particularly Indonesia, has the potential to expand the reach of businesses in enhancing digital products and services. This is in line with previous research stating that the role of digital technology has a positive impact on the economy through GDP (Irtyshcheva et al., 2021). Additionally, according to Awad & Albaity (2022) the role of digital technology enables the discovery of ways to improve quality in various aspects of life in Sub-Saharan Africa.

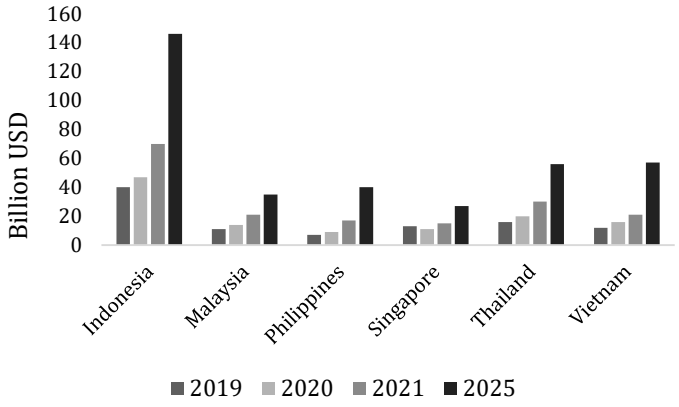


Source: We Are Social, 2022

Figure 2. Number of Indonesian Internet Users (In Millions)

Figure 2 that the number of internet users in Indonesia has been increasing from year to year, starting from 2016 to 2021. This indicates that Indonesia is a country with a promising digital

ecosystem worldwide, with more than 70 percent of the total domestic population using internet technology. The increasing internet usage in Indonesia reflects the development of massive technological advancements each year.



Source: Google et al (2021).

Figure 3. Digital Economy Valuation in Southeast Asia (In Millions)

The percentage of internet users is predicted to continue increasing in the following years, and it has the potential to drive the economy. With the massive use of domestic technology, Indonesia has the largest digital economy ecosystem in Southeast Asia. This was stated by Google et al (2021) in their report, as shown in Figure 3, which states that Indonesia's digital economy potential will reach USD 146 billion. The figure has experienced an increase of over 100 percent from the 2021 value, reaching USD 70 billion. The valuation of Indonesia's digital economy exceeds that of five other countries in Southeast Asia. Furthermore, by 2025, the projected valuation of Indonesia's digital economy is nearly three times larger than Vietnam's, which has the second-highest valuation in 2025. This valuation has the potential to make Indonesia the largest digital economy in ASEAN.

Since the 1990s, the use of mobile telecommunications has become increasingly popular, especially in developing countries (Ward & Zheng, 2016). The emergence of smartphones and tablet computers for accessing the internet signifies the dramatic impact of technology. Magomedov et al (2020) explain that the most prominent characteristic of modern society is the increasing influence of digital technology on people's lifestyles and work. This is due to the rapid development of microelectronics, information, and telecommunications technology. Therefore, it can be concluded that the "digitization" of public life is an objective and inevitable progressive movement. The use of smartphones or mobile phones is a key driver of economic growth in developing countries (Bahrini & Qaffas, 2019). Additionally, the use of mobile phone technology has a significant impact on the living standards of communities (Chavula, 2013). The indicator of mobile phone usage is intended to measure the population's ability to access technology, which has the potential to support the country's economic development efforts. The higher the percentage of the population that has access to the internet through mobile phones, the easier it is for individuals to lead their lives and

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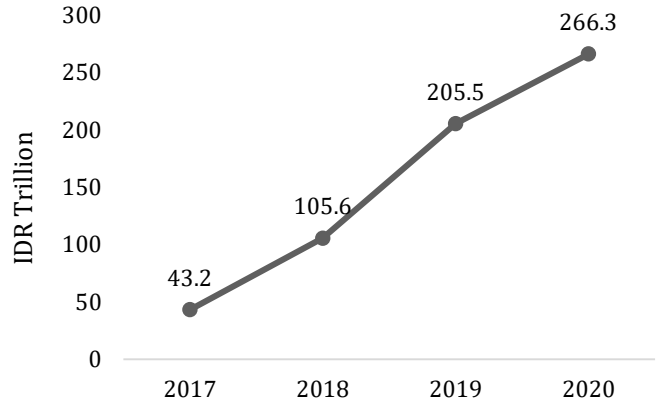
promote efficiency through digitalization. Furthermore, according to Evangelista et al (2014) digitalization is essential for creating resource efficiency, driving productivity, and making a positive contribution to economic growth in both developing and developed countries (Myovella et al., 2020). The positive impact of internet technology has been experienced by many countries worldwide, and Indonesia is no exception. The positive influence of digitalization is also felt in Indonesia's economy. Digital financial transactions have a positive impact on economic development through regional economies (He et al., 2022). This positive impact can be seen in the increasing value of e-commerce transactions, even during the COVID-19 pandemic.

E-commerce transactions in Indonesia have continued to experience positive growth, Figure 4 shows reaching a value of IDR 266.3 trillion at the end of 2020. The transaction value increased by 29.6 percent and has consistently increased from 2017, 2018, and 2019 with transaction values of IDR 43.2 trillion, IDR 105.6 trillion, and IDR 205.5 trillion, respectively. This upward trend is likely to continue, especially considering the projection that the digital economy valuation in Indonesia will become the largest in Southeast Asia in the future.



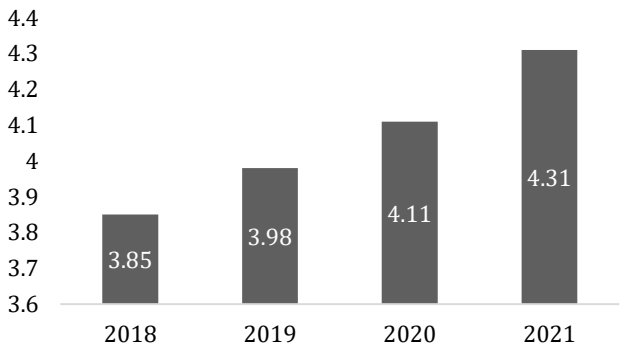
Source: Bank Indonesia, 2021

Figure 4. Nominal E-Commerce Transactions in Indonesia for 2017-2020

The use of digital technology needs to consider the aspect of available resources. Sufficient resources, both in terms of human resources and infrastructure, play a crucial role in supporting the utilization of technology. With the use of technology accompanied by additional capital for technology infrastructure development and the availability of a skilled labor force, it presents an opportunity to drive the economy in the digital sector and potentially enhance economic development. This aligns with previous findings that the economic growth performance in developing countries depends on several factors, including Technology, Information, and Communication (ICT), as well as the role of relevant investments in driving the economy of a country (Dunne & Masiyandima, 2017).

The influence of technological advancement on economic growth can be observed through several aspects, one of which is the development of infrastructure. Well-optimized investments will

have an impact on the development of ICT infrastructure. This condition will stimulate the progress in accessing higher levels of ICT, increase employment opportunities, and have a positive effect on the country's economic growth (Pradhan et al., 2021). High economic growth leads to a more extensive demand for technological advancements due to the need to reach expanding markets and improve productivity. ICT influences economic growth through productivity, efficiency, and the consumption of economic stakeholders in accessing resources, knowledge, and markets (Arvin et al., 2021). One of the ICT infrastructures that drive the progress of mobile telecommunications is the Base Transceiver Station (BTS) infrastructure. As more people use mobile phones to access the internet through cellular networks, the development of BTS infrastructure plays a vital role in supporting reliable and efficient mobile connectivity. BTS infrastructure plays a role in expanding the coverage of cellular networks. Strategic placement of BTS allows telecommunications operators to reach broader areas and serve a larger number of active users. Well-established and widely distributed BTS infrastructure also enables better communication accessibility for individuals and businesses. With reliable mobile connectivity, people can access telecommunications services, supporting business communication, access to information, and various other economic activities. BTS infrastructure also plays a crucial role in improving access to online transactions and financial services, especially through mobile-enabled financial technology (Fintech). Therefore, BTS infrastructure plays an important role in facilitating business growth and economic interactions.



Source: Badan Pusat Statistik, 2022

Figure 5. Indonesian DI-ICT Disparity in 2018-2021

The massive use of the internet in the digital era presents significant opportunities for Indonesia in the future and has a positive impact on the economy. However, on the other hand, there has been a slowdown in economic growth in recent years, and the influence of technology and supporting infrastructure has not been able to maximize Indonesia's economic growth. Furthermore, the availability of supporting ICT infrastructure development remains a challenge faced by Indonesia. The limitations and disparities in ICT development in some regions will hinder all economic activities, including buying and selling transactions and other transactions by the public. The disparity in ICT development in Indonesia continues to increase from year to year. As shown in

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Figure 5, ICT development is concentrated in Java Island, particularly in DKI Jakarta and DI Yogyakarta, while the development of ICT outside Java, especially in Papua and Maluku, is poor. This has led to a gap in ICT development in Indonesia. Therefore, researchers suspect that the disparity in ICT development in several regions of Indonesia has been a hindrance to the country's economy from 2018 to 2021. The researchers' hypothesis is based on previous findings that explain how the digital divide in each region leads to imbalanced socio-economic development and affects the country's economy (Wang et al., 2021). Furthermore, although the Solow-Swan theory has been the dominant approach in modeling the performance of technological advancement and the economy, there are still some studies on the relationship between technology and the economy that are inconsistent. There is a positive impact of technology on the economy through digital transformation Other literature studies have also found that digital transformation, such as mobile phones and ICT investments, has not been able to drive the economy through GDP (Donou-Adonsou, 2019; Ishida, 2015). Based on the explanation provided, there is still inconsistency in previous research. Therefore, this study aims to investigate and examine the influence of investment, labor force, and technological advancement on the economy of Indonesia across 34 provinces. In line with the Solow-Swan theory, which explains that long-term economic growth can be enhanced by increasing investment, improving the efficiency of capital and labor utilization, and fostering technological innovation. The massive use of ICT in Indonesia still faces several issues that need to be addressed. With the challenges arising from the massive use of ICT, it is crucial for Indonesia to formulate policies to tackle these issues and optimize its digital economic potential. Therefore, the focus of this research is to investigate the role of technology in enhancing Indonesia's economy and to validate the Solow-Swan theory of economic growth.

Method

This research employs a descriptive quantitative approach. According to Sugiyono (2016) the quantitative approach is defined as a statistical analysis process that utilizes systematic and measurable numerical research data. This study utilizes quantitative secondary data sourced from the 34 provinces in Indonesia. The secondary data used in this research is obtained from Badan Pusat Statistik (BPS). This study utilizes two types of variables, namely the dependent variable and the independent variable. The research samples statistical data sourced from national official websites such as the Badan Pusat Statistik (BPS), which include Gross Regional Domestic Product (GRDP), Gross Fixed Capital Formation (GFCF), labor force, mobile phone usage rates, and Base Transceiver Station (BTS) infrastructure in the 34 provinces of Indonesia from 2018 to 2021.

The data analysis method used in this research consists of panel regression analysis and descriptive analysis. Panel regression analysis is a statistical method that combines time series and

cross-sectional data to analyze the relationship between a dependent variable and independent variables. In this case, panel data regression analysis is used to determine the extent to which independent variables such as GFCF, labor force, mobile phone usage rate, and the number of BTS (Base Transceiver Stations) influence the dependent variable, which is the value of GRDP in the 34 provinces of Indonesia. On the other hand, descriptive analysis is used to interpret and provide an overview of the influence of independent variables on the dependent variable. The panel regression analysis is conducted using supportive software called Eviews 9. The following is the equation model used in this study.

$$LnGRDP_{it} = \alpha + \beta_1 LnGFCF_{it} + \beta_2 LnLF_{it} + \beta_3 MPU_{it} + \beta_4 LnBTS_{it} + \mu_{it} \quad (1)$$

Where $LnGRDP$ is the Gross Regional Domestic Product (in Millions IDR); $LnGFCF$ is the Gross Fixed Capital Formation (in Millions IDR); $LnLF$ is the Labor Force (Workers); MPU is the Mobile Phones Usage (percent); $LnBTS$ is the Base Transceiver Station (Unit); α is constanta; β_1, β_2, β_3 and β_4 is the coeffiecient; i for cross-section; t for time-series and μ_{it} is the disturbance error for panel data. To facilitate the interpretation of estimation results and standardize the unit of variables, this study utilizes logarithmic transformations (Ln). Additionally, the use of logarithms also reduces the likelihood of issues with classical assumption tests.

Results and Discussion

Table 1 presents descriptive statistics for several indicators that have an impact and contribute to the economy. The economy is proxied by GRDP as the dependent variable. The independent variables used include labor force, Gross Fixed Capital Formation (GFCF), and technology factors represented by internet usage rates and BTS infrastructure. First, the average value of the economy proxied by GRDP is 18.88 percent, with a variability of 1.14 percent. GRDP can reach a maximum value of 21.34 percent and a minimum value of 17.04 percent. Second, the accumulation of capital proxied by GFCF has an average value of 17.73 percent, with a variability of 1.13 percent. GFCF can reach a maximum of 20.43 percent with a minimum value of 15.79 percent. Third, the labor force has an average value of 14.61 percent, with a variability of 1.02 percent. The labor force can reach a maximum value of 17.02 percent and a minimum value of 12.71 percent. Fourth, the technology factor represented by mobile phone usage rates has an average value of 63.49 percent, with a variability of 8.11 percent. Mobile phone usage rates can reach a maximum of 81.83 percent with a minimum value of 38.50 percent. Another technology factor, BTS infrastructure, has an average value of 6.58 percent, with a variability of 0.83 percent. BTS infrastructure has a maximum value of 8.48 percent and a minimum value of 5.19 percent. For data panel there are Estimation can be conducted using three approaches. These three approaches aim to determine the best model for

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this research. The first estimation approach is the Chow test. The Chow test is used to determine the best model between the Common Effect Model (CEM) or the Fixed Effect Model (FEM).

Table 1. Descriptive Statistics

Variables	Obs	Mean	Std. Dev	Min	Max
LnGRDP	136	18.88	1.14	17.04	21.34
LnGFCF	136	17.73	1.13	15.79	20.43
LnLF	136	14.61	1.02	12.71	17.02
MPU	136	63.49	8.11	38.50	81.83
LnBTS	136	6.58	0.83	5.19	8.48

Source: data processed

Table 2 shows the preliminary best model according to the Chow test is the FEM. This is indicated by the Chi-square probability test value falling below α or 0.05. After selecting the best model through the Chow test, the next step is to perform the Hausman test. The Hausman test is used to determine the best model between the FEM and Random Effect Model (REM). Based on the Hausman test results, the cross-section probability value is 0.0000. This value is below the chosen significance level α, indicating that the FEM is the appropriate regression model. After selecting the best model using both the Chow test and Hausman test, the analysis of the FEM regression results can be continued without performing the Lagrange Multiplier test.

Table 2. Best Model Selection Estimation Results

Chow Test	Statistics	d.f	Prob
Cross-Section Chi-Square	592.671	33.0000	0.0000
Hausman Test	Statistics	d.f	Prob
Cross-Section Random	76.528	4.0000	0.0000

Source: data processed

The approach used in this research model is the FEM or LSDV. In the panel data regression model using FEM, the initial step is to test the classical assumptions. The first assumption test to be conducted is the test for multicollinearity. The multicollinearity test is used to assess the interrelationships among the independent variables.

Table 3. Multicolinearity Test

	LnGFCF	LnLF	MPU	LnBTS
LnGFCF	1.000	0.868	0.279	0.655
LnLF	0.868	1.000	-0.011	0.869
MPU	0.279	-0.011	1.000	-0.151
LnBTS	0.655	0.869	-0.151	1.000

Source: data processed

Table 3, it indicates that the data used in this research is affected by multicollinearity issues. This is reflected in the independent variables that have values exceeding 0.8 in the multicollinearity test. Next, it is necessary to perform the heteroscedasticity test in the subsequent classical assumption test. The heteroscedasticity test is conducted to detect variance inequality issues. Panel data need to conduct the heteroscedasticity test to evaluate the variance of the data used in this model.

Table 4. Heteroskedasticity Test

F-Stat	8.101	Prob F (4, 131)	0.000
Obs*R-Squared	26.970	Prob Chi-Square (4)	0.000
Scaled Explained SS	27.860	Prob Chi-Square (4)	0.000

Source: data processed

Table 4, it indicates that the data used in this research has heteroscedasticity issues. This is reflected in the processed data values of the heteroscedasticity test, which tend to be below α or below 0.05. Based on the results of the classical assumption tests conducted, it can be observed that the research model still violates the classical assumption tests, namely, experiencing multicollinearity and heteroscedasticity issues. To address these classical assumption problems, in this study, the researcher applies Cross-section Weights with the Generalized Least Squares (GLS) estimation model.

Table 5. Robust Estimation Result with the Fixed Effect Model (FEM)

Variables	Coefficient
Constant	11.860
	(9.358)***
LnGFCF	0.321
	(7.808)***
LnLF	0.028
	(0.370)
MPU	0.005
	(4.872)***
LnBTS	0.096
	(4.000)***
Diagnostic Tools	
Adj R-Squared	0.999
F-stat	23516.360***

Noted: *, **, *** significance at level 10%, 5% and 1% respectively

Table 5 it can be observed that the constant term has a positive value of 11.8604. This value indicates that every increase in the independent variables will positively influence the economy through GRDP by approximately 11.86 percent. The Adjusted R-squared value in the model used is 0.999845, which means that approximately 99 percent of the variation in the dependent variable (GRDP) can be explained by the independent variables. The remaining 1 percent is explained by other variables outside the model. Another results, all the independent variables, namely Gross Fixed Capital Formation (GFCF), labor force, mobile phone users, and Base Transceiver Station (BTS) infrastructure, show a positive relationship with the dependent variable, GRDP. The GFCF variable has a positive and significant coefficient of 0.3210, with a probability value of 0.0000. This indicates that a one percent increase in GFCF will lead to a 0.32 percent increase in the economy reflected by GRDP. This suggests that an increase in GFCF investment will contribute to economic growth in the 34 provinces of Indonesia. This finding is consistent with previous research that highlights the positive and significant impact of capital stock or investment on economic growth (Osei & Kim, 2020; Kahouli & Chaaben, 2022).

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The positive and significant impact of GFCF on the economy through GRDP indicates that GRDP investment plays a crucial role in driving the regional economy. This is because government expenditure on capital goods or investment can stimulate the local economy and has the potential to improve the standard of living for the people in the 34 provinces of Indonesia. Thus, this research supports the Solow-Swan theory, which states that investment factors, proxied through GFCF, have an influence on the economy through GRDP. The labor force variable has a positive coefficient but is not significant, with a value of 0.0277 and a probability value of 0.7123. This indicates that a one percent increase in the labor force will lead to a 0.02 percent increase in the economy through GRDP. This suggests that an increase in the labor force can contribute to the economic performance in the 34 provinces of Indonesia. These results align with previous research that highlights the positive impact of the labor force on economic growth (Baerlocher et al., 2021; Li & Li, 2022; Solarin, 2020). Given these findings, this study has not been able to support the Solow-Swan theory which states that labor force factors influence the economy through GRDP. Table 5 shows that labor force variable does not have a significant influence on the economy through GRDP in 34 provinces in Indonesia during the years 2018-2021. It happen that the labor force does not have a significant impact on economic growth. One of the reasons is the quantity of the labor force not being accompanied by an improvement in the quality of the labor force in Indonesia in general. Based on the data, the quality of the Indonesian labor force from the perspective of completed education is still relatively low during the years 2018-2021. The Indonesian labor force is still dominated by low-skilled workers or individuals with education below primary school level (SD). The following is a breakdown of the labor force based on completed education.

Table 6. Labor Force Based on Education

Completed Highest Education	Year			
	2018	2019	2020	2021
Never Attended School	2.63	2.78	1.38	1.05
Have not Finished Primary School	12.44	12.00	9.96	11.05
Primary School	24.54	23.89	26.16	24.46
Junior High School	17.94	17.75	18.15	17.75
General High School	18.47	18.78	19.54	19.40
Vocational High School	11.75	12.36	12.42	13.54
Diploma	2.79	2.71	2.32	2.63
University	9.43	9.74	9.66	10.12

Source: Badan Pusat Statistik (2022)

Table 6 explains that during the years 2018-2021, the education level of the labor force is still predominantly comprised of individuals who have never attended school, have not completed primary education, primary education (SD), and lower secondary education (SLTP), accounting for more than 50 percent. Especially, the labor force with primary education (SD) contributes the largest proportion, with over 20 percent during the years 2018-2021. This has the potential to

impact the quality and quantity of goods and services produced if the available labor force is not accompanied by quality skills. Efforts to improve skills need to be considered and are crucial. Skill improvement can be done through vocational training that is tailored to the needs of the job market, industrial apprenticeships, and optimizing the role of the Vocational Training Center (BLK).

The variable of mobile phone users has a significant positive coefficient of 0.0046 with a probability value of 0.0000. This value indicates that if mobile phone users increase by one percent, the economy, as measured by the GRDP, will increase by 0.0046 percent. This suggests that an increase in mobile phone users will drive economic performance in the 34 provinces of Indonesia. Thus, in general, this research supports the Solow-Swan theory, which states that technological factors have an impact on the economy through the GRDP. The positive role of technology, specifically mobile phones, aligns with previous findings by Bahrini & Qaffas (2019) explained that mobile phones integrated with the internet serve as drivers of the economy in developing countries. Other studies by Chavula (2013) also found that the penetration of mobile phones and the internet has a significant impact on improving the standard of living for individuals and can stimulate economic growth. Amankwah-Amoah et al (2018) stated the flow of globalization and technology has led to the transformation of conventional economic sectors into a digital economy, known as the fourth industrial revolution. This transformation has created new opportunities and expanded market reach for businesses. Furthermore, the adoption of technology in the financial sector has also been felt in terms of financial transactions, making them more effective and efficient. This has brought positive impacts to economic development through regional economies (He et al., 2022).

Table 7. Mobile Phone User Based on Age

Mobile Phone User Levels Based on Age	Year			
	2018	2019	2020	2021
5-12 years old	5.69	7.93	9.55	13.32
13-15 years old	8.72	7.86	7.42	7.23
16-18 years old	11.21	9.66	8.83	8.12
19-24 years old	20.23	18.72	17.13	15.26
25-49 years old	47.54	48.33	48.24	46.55
50+ years old	6.61	7.51	8.83	9.53

Source: Badan Pusat Statistik (2022)

The findings in this study are supported by the data presented in Table 7, which states that the benefits of mobile phone usage on the economy in the 34 provinces of Indonesia are predominantly seen among the population within the productive age range.

Table 8. Mobile Phone User Based on Activity

Mobile Phone User Levels Based on Activity	Year			
	2018	2019	2020	2021
Schooling	58.86	64.88	70.18	85.82
Working	44.58	52.54	58.53	62.58
Taking Care of Household	32.18	40.99	46.85	54.19
Others	46.11	50.94	57.35	64.09

Source: Badan Pusat Statistik (2022)

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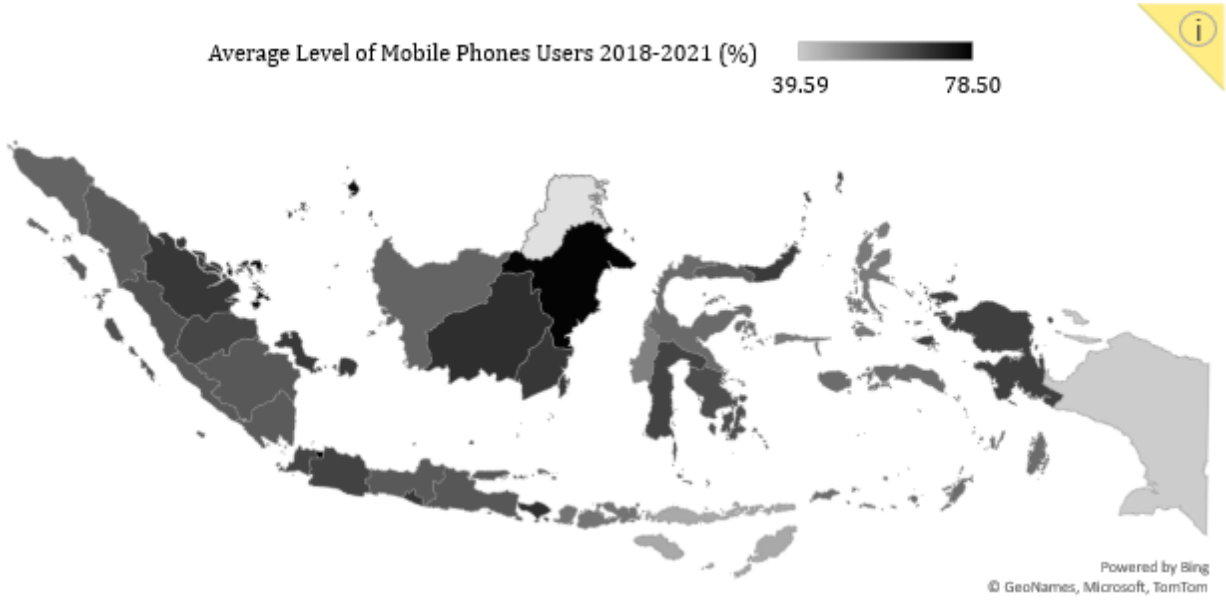
Table 8 shows the level of mobile phone users is dominated by the productive age group of 16-49 years old during the years 2018-2021. The utilization of mobile phones by the productive age group can be for work purposes as well as entertainment, leading to online economic activities through the utilization of internet technology via mobile phones. This aligns with the available data, which indicates an increasing trend in the utilization of internet technology through mobile phones each year, whether for educational or work purposes, to drive economic growth. The widespread use of the internet through mobile phones has great potential to drive the economy in the 34 provinces of Indonesia. However, despite the positive impact of internet usage through mobile phones, the ease of access to the internet via mobile phones remains an issue. Disparities in the development of internet technology infrastructure and mobile phone coverage are believed to be challenges, leading to an economic slowdown in Indonesia during the years 2018-2021. This is supported by data that explains that the accessibility of internet technology is easily available to people in the western and central regions of Indonesia. Meanwhile, in the eastern region, the supporting infrastructure for internet technology and mobile phone coverage is still relatively lacking compared to the western and central regions of Indonesia. This hinders the effective utilization of internet technology through mobile phones to drive the economy. Here is the average level of mobile phone users during the years 2018-2021 in the 34 provinces of Indonesia.

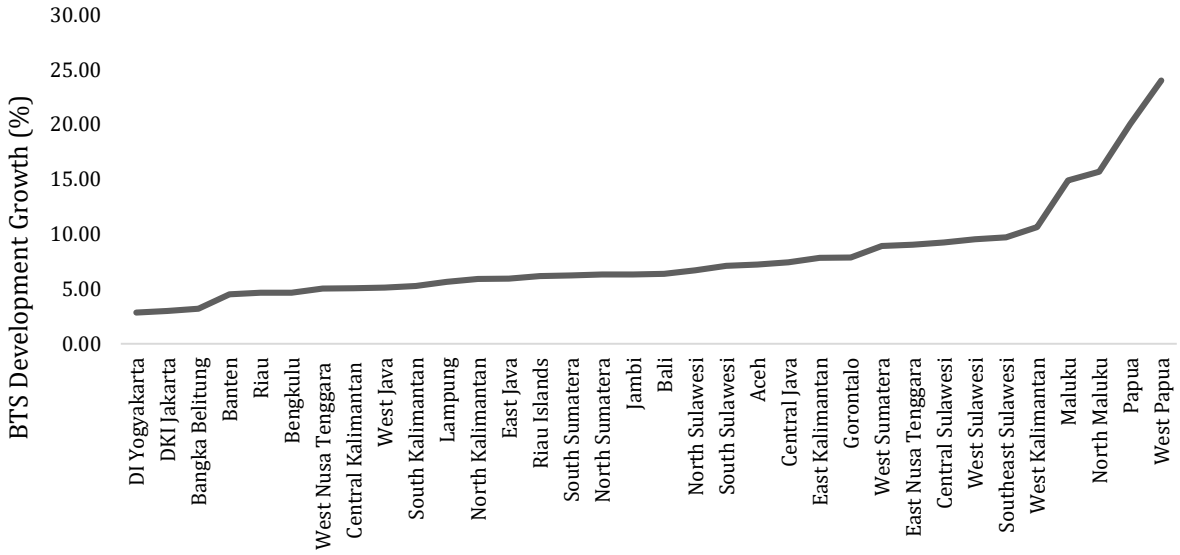


Source: Badan Pusat Statistik, 2022 (processed)

Figure 6. Average Level of Mobile Phones Users 2018-2021

Figure 6 shows there is still a disparity in the use of internet technology through mobile phones. This can be seen from the average mobile phone users in the 34 provinces of Indonesia during the years 2018-2021, which are still dominated by the population in the western and central regions of Indonesia. DKI Jakarta province remains the province with the highest average level of mobile

phone users during the years 2018-2021, at 78.50 percent. Other provinces such as East Kalimantan, Riau Islands, North Kalimantan, and Bali rank second to fifth as provinces with the highest average level of mobile phone users during the years 2018-2021. Meanwhile, eastern regions of Indonesia such as Papua province have the lowest average level of mobile phone users, at 39.59 percent during the years 2018-2021. Other provinces like East Nusa Tenggara (NTT), West Sulawesi, North Maluku, and West Nusa Tenggara (NTB) rank second to fifth with the lowest level of mobile phone users during the years 2018-2021. The existence of a disparity in the accessibility of mobile phone technology is a problem in Indonesia. The disparity in the accessibility of internet technology through mobile phones is believed to be closely related to the issue of expensive internet tariffs, particularly in the eastern regions of Indonesia. According to Prasmasari (2021) stated the difference in internet tariffs is caused by the absence of regulations that set limits on internet tariffs for each internet service provider. In this regard, the government needs to regulate internet tariff limits to address the disparity in tariffs across different regions in Indonesia. This would enable people to maximize the positive impact of internet technology through mobile phones, particularly in driving regional economic growth through GRDP.



Source: Badan Pusat Statistik, 2022 (processed)

Figure 7. Average BTS Construction Growth for 2018-2021

The infrastructure variable in the form of Base Transceiver Stations (BTS) has a significant positive coefficient of 0.0964 with a probability value of 0.0001. This value indicates that when the provision of BTS infrastructure increases by one percent, the economy, as measured by GRDP, experiences a growth of 0.0964 percent. This suggests that an increase in the availability of BTS infrastructure will drive the performance of the economy in the 34 provinces of Indonesia. Thus, overall, this research supports the Solow-Swan theory, which states that technological factors, such as BTS infrastructure, have an impact on the economy through GRDP. The findings of this study are

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supported by data that explain the growth of BTS development in the 34 provinces during the years 2018-2021. The growth of BTS development has provided greater opportunities for people to access the internet through mobile phones. Figure 7 shows that has been growth in BTS infrastructure during the period of 2018-2021, particularly in the eastern regions of Indonesia. Eastern regions such as Maluku, North Maluku, Papua, and West Papua have experienced greater growth in BTS infrastructure compared to other regions in Indonesia. This can be attributed to the efforts of the government, particularly the Ministry of Communication and Information Technology of the Republic of Indonesia (Kominfo), in accelerating the development of BTS infrastructure in the eastern regions of Indonesia to facilitate mobile communication access. The construction of BTS infrastructure aligned with regional development plans, there is potential to achieve development targets in each region. The findings of this study are consistent with previous research by Evangelista et al (2014) and Pradhan et al (2021) which emphasize the importance of digital empowerment through ICT infrastructure and its positive impact on the economy as a whole. Furthermore, to harness the positive impact of technology, it is necessary to increase the penetration of mobile phones and ICT infrastructure in each province to drive the economy through GRDP. The acceleration of BTS infrastructure development is not only focused on quantity. The development of BTS infrastructure should also be in line with strong signal speed and extensive coverage area. Strong signals will support digital economic activities by the community in each region and have a positive impact on the economy. Additionally, the placement and arrangement of BTS need to be considered so that every region in Indonesia can be covered by BTS transmitter signals. Although infrastructure development is being accelerated in the eastern regions of Indonesia, the quality of signals produced by BTS transmitters is still relatively slow compared to other areas. The availability of BTS infrastructure in a region does not necessarily guarantee mobile phone signals. This is influenced by various factors such as BTS tower transmit power, height, geographical location, and terrain.

Table 9 shows the eastern regions of Indonesia still face issues with low-quality mobile phone signal reception compared to other areas in the years 2020-2021. This situation has the potential to disrupt regional development plans in driving the economy through digital transformation. The disparity in mobile phone signal reception quality among regions will also negatively impact Indonesia's overall economy and hinder the full benefits provided by digital technology. Here is the signal reception quality in each region in Indonesia. The gap in quality between BTS signal transmitter speed and signal coverage remains a challenge in the development of the digital ecosystem in Indonesia. This issue will hinder digital transformation by the public, especially in the field of economy. Therefore, the government needs to make efforts in infrastructure development that go beyond merely focusing on quantity. The quality of BTS infrastructure needs to be enhanced

to address the issues of low signal speed and limited coverage of mobile phone signals. These improvements are expected to support digital activities, particularly economic endeavors, in order to drive regional economies through GRDP growth.

Table 9. Quality of Mobile Phone Signal Reception

Province	Year					
	2020			2021		
	Strong	Poor	No Signal	Strong	Poor	No Signal
Sumatera	77.53	20.70	1.77	77.06	21.55	1.39
Kalimantan	59.30	33.82	6.88	59.53	34.07	6.40
Jawa	89.54	10.32	0.14	90.63	9.33	0.04
Balinusra	68.38	29.16	2.46	68.03	30.60	1.37
Sulawesi	70.29	25.11	4.60	69.70	26.09	4.21
Maluku Papua	31.80	27.14	41.06	33.35	28.53	38.12

Source: Badan Pusat Statistik (2022)

The estimation results of Fixed Effects Model (FEM) assume that there are differences in intercepts among individuals or cross-sections at the same time intersection (see Appendix). Intercepts analysis is conducted to determine the differences in coefficients among provinces in Indonesia. Based on the FEM Cross-section estimation, it can be observed that several provinces have different intercept values. A higher intercept value indicates a higher economic condition through GRDP when assuming that all independent variables such as GFCF, labor force, mobile phone users, and BTS have no influence. Conversely, if the intercept value is low, it can be inferred that the economic condition through GRDP is also low, assuming that the independent variables have no influence. From the FEM Cross-section estimation results, it is evident that several provinces in Java Island, namely DKI Jakarta, East Java, West Java, and Central Java, have high intercept values compared to other provinces. On the other hand, the provinces with the lowest intercept values are North Maluku, Maluku, Gorontalo, Bengkulu, and West Sulawesi. Here are the intercept results for the 34 provinces in Indonesia.

Conclusion

The findings of this research indicate that capital and technology factors have a significant positive influence on the economic level in the 34 provinces of Indonesia. These findings support previous research that emphasizes the importance of capital and technological advancement in driving the economy. On one hand, the workforce factor has an influence, but it is not statistically significant on the economy in the 34 provinces of Indonesia. This finding aligns with previous research that indicates the workforce does not have a significant impact on the economy. Overall, this research has not been able to validate the Solow-Swan theory in improving the economy of the 34 provinces in Indonesia. In light of these findings, the following suggestions can be made: (1) Local governments in each province are expected to increase physical investment. This is crucial to enhance productivity, stimulate regional economic growth, and contribute to national

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development. (2) There is a need for enhancing the skills and quality of the labor force through vocational training programs tailored to the needs of the job market, industrial internships, and optimizing the role of Vocational Training Centers. By improving the skillset of the labor force, it can contribute to driving the regional economy through GRDP. (3) It is important to establish and regulate internet tariff limits to address the disparities in tariffs across regions in Indonesia. This is aimed at maximizing the role of internet technology, particularly through mobile phones, in economic activities. By setting standardized internet tariffs, it can facilitate economic activities and promote the use of digital technology for economic development. (4) Efforts should be made to improve the quality of BTS infrastructure, not only focusing on the quantity of BTS in different regions of Indonesia. The quality of BTS can be measured by its transmission power speed and expanding the coverage area that can receive mobile signals. By enhancing the quality of BTS infrastructure, it is expected to facilitate and improve digital activities in society, particularly in economic activities, thereby driving the regional economy through GRDP.

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APPENDIX

Province	Cross-section effects	Intersept
DKI Jakarta	1.589342	13.449742
East Java	1.395413	13.255813
West Java	1.346712	13.207112
Central Java	1.031200	12.891600
East Kalimantan	0.764766	12.625166
Riau	0.704497	12.564897
North Sumatera	0.697153	12.557553
Banten	0.628128	12.488528
South Sumatera	0.347236	12.207636
South Sulawesi	0.325079	12.185479
Lampung	0.199502	12.059902
Papua	0.110018	11.970418
Jambi	0.074319	11.934719
West Sumatera	0.057300	11.917700
Riau Islands	0.049747	11.910147
Bali	-0.039280	11.821120
South Kalimantan	-0.050399	11.810001
West Kalimantan	-0.095008	11.765392
Central Sulawesi	-0.146890	11.713510
DI Yogyakarta	-0.194635	11.665765
Aceh	-0.198903	11.661497
West Nusa Tenggara	-0.368217	11.492183
West Papua	-0.368570	11.491830
Central Kalimantan	-0.382105	11.478295
Southeast Sulawesi	-0.412147	11.448253
North Sulawesi	-0.431968	11.428432
North Kalimantan	-0.515920	11.344480
Bangka Belitung	-0.542255	11.318145
East Nusa Tenggara	-0.654499	11.205901
West Sulawesi	-0.856404	11.003996
Bengkulu	-0.863932	10.996468
Gorontalo	-1.020214	10.840186
Maluku	-1.025054	10.835346
North Maluku	-1.154012	10.706388

Source: Data Processed, 2022