Asian Economic and Financial Review
ISSN(e): 2222-6737
ISSN(p): 2305-2147
DOI: 10.55493/5002.v13i9.4824
Vol. 13, No. 9, 621-634.

URL: www.aessweb.com

The effect of information and communication technology on economic growth high-income countries

Alpon Satrianto[1+]
Akmil Ikhsan[2]

[1,2]*Economics Department, Universitas Negeri Padang, Padang City, Indonesia.*
[1]*Email: alponsatrianto@fe.unp.ac.id*
[2]*Email: akmilikhsan@gmail.com*

(+ Corresponding author)

Article History
Received: 27 March 2023
Revised: 23 May 2023
Accepted: 9 June 2023
Published: 4 July 2023

Keywords
Economic growth
Financial development
Financial institution depth
Financial market depth
Fixed broadband subscription
Fixed telephone subscription
High-income countries
ICT
Internet user
Mobile cellular telephone subscription.

JEL Classification:
O3; O4; G2; C1.

ABSTRACT

This study analyzes the influence of information and communication technology (ICT) and financial developments on the economic growth in high-income countries. This research uses the panel data regression method with a random effects model (REM) approach. The data were sourced from the World Bank and the International Telecommunication Union publications from 2001–2020. The results show that ICT (fixed telephone subscriptions, mobile/cellular telephone subscriptions, internet users and fixed broadband subscriptions) had no significant effect on economic growth. On the other hand, financial development (domestic credit to the private sector and stock market capitalization) had a significant effect on economic growth. Thus, indicators of financial development are better at promoting economic growth in high-income countries. Domestic credit to the private sector has a greater influence on economic growth compared to stock market capitalization. The research implications show that it is necessary to increase the contribution of financial development, such as facilitating access to credit to the real sector and increasing access to the capital market for economic actors to increase economic growth.

Contribution/Originality: There is still little research that examines ICT and financial development on economic growth in high-income countries. This study adds fixed telephone subscriptions, mobile/cellular telephone subscription, internet users and fixed broadband subscriptions as indicators of ICT.

1. INTRODUCTION

Economic growth is largely determined by output over a certain period. These factors are driven by human and natural resources, workforce skills, and information and communication technology (ICT) (Ngozi & Chiamaka, 2019). ICT advances that have taken place in the last 30 decades have supported various economic activities to achieve progress in knowledge and productivity levels. The endogenous growth theory states that ICT is the basis of economic growth through processes, product forms and business models (Czernich, Falck, & Falck, 2009). In addition, ICT encourages economic growth through increasing production inputs so that production costs become more efficient (Erumban & Das, 2016).

Farhadi and Fooladi (2012) define ICT as a concept that includes computer hardware and software as well as information instruments that include electronics and communications among others. Pradhan, Nair, Mittal, and

Norman (2017) revealed that information and communication technology infrastructure includes digital telephone network facilities, cell phones, internet servers, fixed networks and other technologies. Therefore, ICT can combine connected and integrated electronics, telecommunications, network, and computer workstations; this system will have a direct impact on companies, industry, and other economic sectors that continue to drive a more dynamic digital transformation across the country.

Another view of ICT suggests the importance of ICT as a means of storing, collecting and publishing data, including images, audio, and visuals presented on computer or telecommunication devices. To achieve economic growth, there are several reasons that ICT is very important. First, ICT is able to transmit data at high speeds. Second, it can reduce production costs to a minimum. Third, it is not limited to trading between specific countries. Fourth, it increases transparency from the bureaucratic side (Niebel, 2018).

ICT provides ample scope for a faster communication, access to financial markets, lower cost of capital, and increased revenue and productivity. In addition, the use of ICT, especially internet access, can develop a sustainable economic sector thereby reducing information asymmetry and reducing costs (Stanley, Doucouliagos, & Steel, 2018). ICT has been able to increase business efficiency with improvements in supply chain management, the development of new business ideas, and access to inputs (Thompson Jr & Garbacz, 2011).

From the research of several authors who have focused on ICT (Ahmed & Ridzuan, 2013; Erumban & Das, 2016; Pradhan, Arvin, Nair, Hall, & Bennett, 2021; Seifallah & Mohamed, 2013; Toader, Firtescu, Roman, & Anton, 2018; Vu, 2011), there are four pathways for ICT to encourage economic growth. First, the production of goods and services will have a higher added value; second, input will increase the production of goods and services; third, increased productivity can be driven from the ICT sector; and fourth, increased efficiency and effectiveness will drive economic growth.

The resources available in ICT are more profitable and can be developed competitively so that they have value that can boost the country's economy (Kpodar & Andrianaivo, 2011). Viewed from a broader perspective, a more vital contribution to economic growth is not only through ICT but also from the financial sector. Financial development acts as a support to drive the economy by allocating resources efficiently for activities that can increase investment, such as credit, insurance, increasing savings and risk management (Allen, Bartiloro, Gu, & Kowalewski, 2018; Beck & Feyen, 2013; Ruiz, 2018). Literature on financial development and financial growth should refer back to early works by Gurley and Shaw (1967); McKinnon (1973); Schumpeter (1934) and Shaw (1973), who argue that financial development is encouraged through financial institutions in carrying out their functions, such as banking activities, which aim to provide financial resources that are effective and capable of increasing efficiency and effectiveness in the productive sector.

Financial development is believed to play a major role in economic growth through efficient financial resources, various productive activities, increased savings, insurance, and reducing business risks (Allen et al., 2018; World Bank, 2016). In addition, financial development from the side of financial institutions and markets provides services in return on investment, whose implementation can be achieved in the long term (World Bank, 2016).

Table 1. Date economic growth high-income countries (%).

No	Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	Chile	3.3	3.11	4.09	7.21	5.74	6.32	4.91	3.53	-1.6	5.84	6.11	5.32	4.05	1.77	2.3	1.71	1.19	3.95	1.05	2.04
2	France	1.98	1.14	0.82	2.83	1.66	2.45	2.42	0.25	-2.9	1.95	2.19	0.31	0.58	0.96	1.11	1.1	2.29	1.79	1.51	1.14
3	Germany	1.68	-0.2	-0.7	1.18	0.73	3.82	2.98	0.96	-5.7	4.18	3.93	0.42	0.44	2.21	1.49	2.23	2.6	1.27	0.56	1.78
4	Japan	0.41	0.12	1.53	2.2	1.66	1.42	1.65	-1.1	-5.4	4.19	-0.1	1.5	2	0.37	1.22	0.52	2.17	0.32	0.65	0.87
5	The Republic of Korea	4.85	7.73	3.15	5.2	4.31	5.26	5.8	3.01	0.79	6.8	3.69	2.4	3.16	3.2	2.81	2.95	3.16	2.91	2.04	2.11
6	Norway	2.07	1.45	0.91	3.97	2.63	2.4	2.99	0.48	-1.7	0.7	0.98	2.7	1.03	1.97	1.97	1.07	2.32	1.29	1.15	1.23
7	Singapore	-1.1	3.91	4.54	9.82	7.36	9.01	9.02	1.87	0.12	14.5	6.34	4.46	4.84	3.94	2.99	3.24	4.34	3.44	0.73	3.66
8	Spain	3.93	2.73	2.98	3.12	3.65	4.1	3.6	0.89	-3.8	0.16	-0.8	-3	-1.4	1.38	3.84	3.03	2.97	2.43	1.95	0.79
9	Switzerland	1.31	0.16	0.04	2.78	3.12	3.99	4.11	2.15	-2.2	3	1.69	1.01	1.85	2.45	1.33	1.72	1.8	2.75	0.93	1.84
10	United States	1	1.74	2.86	3.8	3.51	2.85	1.88	-0.1	-2.5	2.56	1.55	2.25	1.84	2.53	2.91	1.64	2.37	2.93	2.16	2.12

The World Bank (2016) shows that the development of ICT in the contribution of total input factors to gross domestic product (GDP) has the same channel in lower-, middle-, and high-income countries. GDP is generally defined as the result of the production of goods and services in one year in a country and is used as a basis for determining economic growth. However, high-income countries can enjoy the potential of ICT advances, but lower-income countries and middle-income countries do not show significant potential for ICT advancements, especially since the use of ICT services is not evenly distributed. From a broader perspective, the ITU (2020) presents a report on the potential for the digital economy to grow to 15.5% of GDP globally and grow two and a half times faster than global GDP from 2003 to 2018. For this reason, this study focuses on high-income countries by analyzing the variables that can drive economic growth through ICT and financial development. By using several countries in the sample, the results can add to the empirical literature and can provide a broader understanding.

Data on economic growth in high-income countries can be seen in Table 1 above. It shows that the economic growth of high-income countries as a whole has a fluctuating trend from year to year. In 2009, almost all countries recorded negative economic growth due to the global financial crisis, except for the Republic of Korea and Singapore, but the growth rate in these countries did not reach 1%, which indicates that these countries were affected by the crisis even though growth was not negative.

If you look at the context of each country, France experiences stagnant economic growth every year, which only grows between 1–2%. In addition, other European countries, such as Spain and Switzerland, have fluctuating growth rates by an average of 2%. Economic growth in Norway after the crisis in 2009 has not changed, where it can be seen that growth did not reach 1%, in contrast to Germany, which experienced an improvement in growth after the crisis, which reached an average of 3%. The Republic of Korea recorded high economic growth between 2001 and 2005 with an average of 4%. However, at the end of the research period, economic growth experienced a decline. This condition was the same in Japan, which experienced an average decline of 1%, in contrast to Singapore, which experienced an increase in economic growth at the end of the research period that grew an average of 3%. The United States experienced stable economic growth conditions at the end of the research period, in contrast to Chile, which experienced a decline. However, at the beginning of the research period, the economic growth rate in Chile was higher than in other countries.

2. LITERATURE REVIEW

Many empirical studies have focused on ICT, financial development, and economic growth and reached the relevant conclusion that ICT and financial development are strong foundations for achieving economic growth. In the 1990s and 2000s, it was found that ICT is capable of spurring economic growth in developed countries (Bagchi, Kirs, & López, 2008; Cronin, Colleran, Herbert, & Lewitzky, 1993; Cronin, Parker, Colleran, & Gold, 1991; Inklaar, O'Mahony, & Timmer, 2005; Jorgenson & Vu, 2005; Oliner & Sichel, 2000; Van Ark, O'Mahony, & Timmer, 2008).

Research on ICT management has been conducted by Bojnec and Ferto (2012) and Lee, Levendis, and Gutierrez (2012), explaining that ICT can be a driver of economic activity with advances in internet technology, which has increased investment in developed countries, but this has not been achieved in developing countries. Other research from Maradana et al. (2019); Nath and Liu (2017); Perez-Trujillo and Lacalle-Calderon (2020) and Saito (2017) makes it clear that ICT contributes to innovation, productivity and economic growth.

Vu (2011) carried out a study to determine if internet indicators, cellular phones and personal computers can expand access to the use of telecommunications networks to achieve significant economic growth in 102 countries. Lam and Shiu (2010) argue that, in the short and long terms, economic growth is driven by the ICT sector as an effort to drive the economy. Research by Yousefi (2011) found evidence that economic growth in developed countries could not be achieved with the development of the ICT sector. However, developing countries achieved economic growth with a faster growing ICT sector. Research by Dahl, Kongsted, and Sørensen (2011) found that, in European countries, the IT sector is a major factor in spurring economic growth in the long term.

Albiman and Sulong (2017); Beuermann and Vakis (2012) and Lee et al. (2012) found evidence that ICT has led to economic growth in Sub-Saharan Africa over the past few years, where the ICT sector has grown faster and more dynamically. Hopestone (2014) encourages African countries to develop the ICT sector, because this sector has proven capable of achieving sustainable economic growth. Haftu (2019) suggests that economic growth in African countries cannot be achieved if they only rely on the ICT sector to drive the economy.

Pradhan and Norman (2015) found that ICT and financial development have a major role in driving economic growth in 21 Asian countries. Seifallah and Mohamed (2013) put forward findings that ICT is able to achieve steady conditions to encourage economic growth in Middle East and North Africa (MENA) countries. With extensive use of the internet, access to economic activities can be expanded.

Pradhan, Arvin, Norman, and Bele (2014) showed that there is evidence in the G20 countries of the importance of ICT as a tool for expanding access and providing telecommunications facilities to contribute to economic growth. Toader et al. (2018) showed that ICT can be effective in the technology sector in European countries and plays a major role in achieving economic growth.

Research by Nchofoung and Asongu (2022) in Sub-Saharan Africa shows that ICT has a significant influence on economic growth. Myovella, Karacuka, and Haucap (2020) carried out research in Sub-Saharan Africa and the Organization for Economic Cooperation and Development (OECD). Their results show that the use of the internet and digitalization can be a factor driving economic growth in both the short and long terms. Research by Donou-Adonsou (2019) in Sub-Saharan Africa showed that the use of the internet and cell phones provides broad access for users of the digital economy to support economic growth.

Das, Chowdhury, and Seaborn (2018) showed that ICT has a positive effect in low-income countries but this was not the case in middle-income countries. Ishida (2015) found that ICT has a significant impact on economic growth in Japan. Latif et al. (2018) presented results to show that ICT is the basis of economic growth in BRICS countries (Brazil, Russia, India, China and South Africa). Lee and Brahmasrene (2014) showed that ICT plays an important role in economic growth in the Association of Southeast Asian Nations (ASEAN) region.

Cheng and Lee (2021) conducted a study on 72 countries and found that economic growth is achieved when ICT and financial development grow and develop adequately in the long term. These results are evidence of the importance of ICT and the financial sector in providing resources as a major factor for economic growth. Salahuddin and Alam (2016) provide evidence that ICT has a significant and positive influence on economic growth in Organization for Economic Cooperation and Development (OECD) countries. Ward and Zheng (2016) show that ICT helps economic growth in China in the long run. These results prove that the role of ICT in China has reached a more advanced stage than other countries and that expanding ICT sector services can be a driving force for economic growth.

3. METHOD

This empirical study investigates the impact of ICT and financial development on economic growth in high-income countries (Chile, France, Germany, Japan, The Republic of Korea, Norway, Singapore, Spain, Switzerland and the United States) from 2001 to 2020 using the panel data method. The source of the data used in this research is from the World Bank and the International Telecommunication Union.

To analyze economic growth, the variables used are ICT indicators (fixed telephone subscriptions, mobile/cellular telephone subscriptions, internet users, and fixed broadband subscriptions). The indicators of financial development are domestic credit to the private sector and stock market capitalization. Table 2 contains the descriptions and sources of the research variables.

Table 2. Descriptions of the variables.

Variable type	Variable	Indicator	Unit	Source
Dependent variable	Economic growth	GDP constant prices growth annual	%	World Bank, World Development Indicators
Independent variables	Information and communication technology	Fixed telephone subscriptions	%	International Telecommunication Union
	Information and communication technology	Mobile/cellular telephone subscriptions	%	International Telecommunication Union
	Information and communication technology	Internet users	%	International Telecommunication Union
	Information and communication technology	Fixed broadband subscriptions	%	International Telecommunication Union
Explanatory variables	Financial institution depth	Domestic credit to the private sector to GDP	%	World Bank, World Development Indicators
	Financial market depth	Stock market capitalization	%	World Bank, World Development Indicators

Economic growth is a condition that indicates an increase in the production of goods and services based on GDP in a country at a given time.

Fixed telephone subscriptions refer to the number of active fixed telephone line numbers for analogue, voice-over internet protocol (VoIP) subscriptions, fixed wireless local loop (WLL), integrated services digital network (ISDN) voice line equivalent, and fixed public telephones.

Mobile/cellular telephone subscriptions are subscriptions to a public cellular telephone service that provides access to a public switched telephone network (PSTN) using cellular technology. The indicators include the number of postpaid subscriptions and active prepaid account numbers. This activity applies to all mobile subscriptions that offer direct or indirect voice communication.

Internet users are individuals who have used the internet network for a long period of time for a range of activities. The internet can be used via computers, cellphones, personal digital assistants, gaming machines, and digital television sets.

Fixed broadband subscriptions are for high-speed access to the broad public internet. Forms of this service include a cable modem, digital subscriber line (DSL), fiber-to-the-home/building, and other fixed broadband subscriptions, such as satellite wireless broadband.

Domestic credit to the private sector is a financial resource provided by financial institutions for the needs of the private sector to meet investment amounts in the form of loans, purchases of non-equity securities, and trade credits and other receivables, which specify payment terms within a certain period of time.

Stock market capitalization is the total market value of shares traded on the outstanding stock market at a given time. Stock market movements can determine the size of a company in terms of sales or total assets.

Panel data combines a time series and a time (cross section) which includes observations on the same variable from several periods (Studenmund, 2016). The panel data regression equation can be addressed as follows in Equation 1:

$$Y_{it} = \alpha_i + \beta_1 X_{it} + \varepsilon_{it} \quad (1)$$

Where Y is the dependent variable, β is the variable coefficient, X is the independent variable, i denotes a country (where i = 1, 2,…, N), t is the time period (where t = 1,2,…, N), and ε is the error term. Based on Equation 1, the panel data regression equation model in this study can be written as follows in Equation 2:

$$EG_{it} = \beta_0 + \beta_1 FIX_{1it} + \beta_2 MOB_{2it} + \beta_3 INTE_{3it} + \beta_4 FBS_{4it} + \beta_5 DCPS_{5it} + \beta_6 SMC_{6it} + \varepsilon_{it} \quad (2)$$

Description (Equation 2):

EG = Economic Growth.

FIX_1 = Fixed Telephone Subscriptions.

MOB_2 = Mobile Cellular Telephone Subscriptions.

$INTE_3$ = Internet User.

FBS_4 = Fixed Broadband Subscriptions.

$DCPS_5$ = Domestic Credit to the Private Sector.

SMC_6 = Stock Market Capitalization.

t = Year unit (2001–2020).

i = Chile, France, Germany, Japan, The Republic of Korea, Norway, Singapore, Spain, Switzerland and the United States.

β_0 = Constant.

$\beta_1 \ldots \beta_6$ = Variable Coefficient *FIX*, *MOB*, *INTE*, *FBS*, *DCPS*, *SMC*.

ε_{it} = Error Term.

The common effects model (CEM) combines time series data and cross sectional data and is the first approach in the panel data method. In addition, the data is assumed to be the same so it does not show the time dimension. The fixed effects model (FEM) is the second approach in the panel data method and assuming that the data between countries can be accommodated as an intercept. In this approach, the dummy variable technique can be used to determine if there are differences in the results obtained. The random effects model (REM) is the last approach in the panel data method. In this approach, the model handles the possibility that the data between countries is related, so the results of the analysis can be accommodated by intercepts and errors from each country studied.

In panel data method there are three stages to finding the right approach. First, the Chow test is carried out to select between the common effects model and the fixed effects model {H0 = common effects model and H1 = fixed effects model}; second, the Hausman test is used to choose between the fixed effects model or the random effects model {H0 = random effects model and H1 = fixed effects model}; and third, the Lagrange multiplier test is conducted to select between the common effects model or the random effects model {H0 = common effects model and H1 = random effects model}.

4. RESULTS AND DISCUSSION

4.1. Results

The results presented below are from the selected approaches in the panel data method.

4.1.1. Chow Test

The results of Chow test, presented in Table 3, show that the fixed effects model (FEM) was more appropriate than the common effects model (CEM). This can be seen from the Chi-square probability value of 0.000, which is less than 0.05.

Table 3. Chow test.

Effect test	Statistic	d.f.	Probability
Cross-section F	6.469	(9.148)	0.000
Cross-section Chi-square	54.986	9	0.000

4.1.2. Hausman Test

The results of Hausman test, presented in Table 4, show that the random effects model (REM) was chosen over the FEM. This can be seen from the Chi-square probability value of 0.584, which is greater than 0.05.

Table 4. Hausman test.

Test summary	Chi-sq. statistic	Chi- sq d.f.	Probability
Cross-section random	4.690	6	0.584

4.1.3. Lagrange Multiplier Test

The results of Lagrange multiplier test, presented in Table 5, indicate that the REM was a better option than the CEM. This can be seen from the Chi-square probability value of 0.000, which is less than 0.05.

Table 5. Lagrange multiplier test.

Null hypotheses: No effects Alternative hypotheses: Two-sided (Breusch–Pagan) and One-sided (All others)	Test hypothesis		
	Cross-section	Time	Both
Breusch–Pagan	39.696 (0.000)	105.624 (0.000)	145.321 (0.000)
Honda	6.300 (0.003)	10.277 (0.000)	11.722 (0.000)
King–Wu	6.300 (0.003)	10.277 (0.000)	11.016 (0.000)
Standardized Honda	9.898 (0.000)	10.796 (0.000)	10.173 (0.000)
Standardized King and Wu (1997)	9.989 (0.000)	10.796 (0.000)	10.192 (0.000)
Gourieroux, Monfort, and Trognon (1984) Pseudo maximum likelihood method	--	--	145.321 (<0.01)

4.2. Panel Data Estimation Results

In this study, the variables used for information and communication technology (ICT) are fixed telephone subscriptions (FIX), mobile/cellular telephone subscriptions (MOB), internet users (INTE), and fixed broadband subscriptions (FBS). The financial development variables of domestic credit to the private sector (DCPS) and stock market capitalization (SMC) are the independent variables, and economic growth (EG) is used as the dependent variable. Table 6 contains the results of the panel data estimation using the REM approach.

Table 6. Panel data estimation results.

Variable	Coefficient	Std. error	t-statistic	Probability
Economic growth (EG)	8.421	1.555	5.415	0.000
Fixed telephone subscriptions (FIX)	-0.028	0.018	-1.598	0.112
Mobile/cellular telephone subscriptions (MOB)	-0.017	0.011	-1.504	0.134
Internet users (INTE)	-0.011	0.019	-0.549	0.584
Fixed broadband subscriptions (FBS)	0.024	0.026	0.891	0.374
Domestic credit to the private sector (DCPS)	0.044	0.008	5.590	0.000
Stock market capitalization (SMC)	0.027	0.006	4.672	0.000

Based on the results in Table 6, the panel data regression equation is as follows:

$$EG_{it} = 8.421109 - 0.028045FIX_{it} - 0.016936MOB_{it} - 0.010659INTE_{it} + 0.023510FBS_{it} + 0.0443601DCPS_{it} + 0.026689SMC_{it} + \varepsilon_{it} \quad (3)$$

Based on Equation 3, fixed telephone subscriptions have a regression coefficient of -0.8696. This shows that there is a negative influence on economic growth, i.e., a 1% increase in fixed telephone subscriptions will reduce economic growth by -0.028045. Mobile/cellular telephone subscriptions have a regression coefficient of -

0.016936. This shows that there is a negative effect on economic growth, i.e., if there is a 1% increase in mobile/cellular telephone subscriptions, it will reduce economic growth by -0.016936. Internet users have a regression coefficient of -0.010659, which shows that there is a negative influence on economic growth, i.e., if there is an increase of 1% in internet users, it will reduce economic growth by -0.010659. Fixed broadband subscriptions have a regression coefficient of 0.023510. This shows that there is a positive influence on economic growth, i.e., if fixed broadband subscriptions increase by 1%, economic growth will increase by -0.023510.

Based on the outcome of Equation 3, domestic credit to the private sector has a regression coefficient of 0.044360, which shows that there is a positive influence on economic growth. That is, if there is a 1% increase in domestic credit to the private sector, it will increase economic growth by 0.044360. Stock market capitalization has a regression coefficient of 0.026689, which shows that there is a positive influence on economic growth. That is, if there is a 1% increase in stock market capitalization, it will increase economic growth by 0.026689.

4.3. Discussion

Based on the results of Equation 3, fixed telephone subscriptions have a negative effect on economic growth. This means that an increase in fixed telephone subscriptions will not increase or decrease the economic growth of high-income countries. This is because fixed telephones only have a limited number of users, so this condition does not have a large effect on economic growth. These results are in line with research by Albiman and Sulong (2017) in middle-income and lower-to-low-income countries. The results of the study show that economic growth is not driven by the ICT sector, as evidence shows that this sector is unable to support the economy. These results also provide clear evidence that in middle-income countries increased ICT is not able to encourage efforts to increase economic activity broadly, so ICT is not an important factor in economic growth. This is also the case with low-income countries, where changes or progress in the IT sector have not been able to impact the progress of economic growth. Research by Nchofoung and Asongu (2022) in 140 countries shows that high economic growth that cannot be obtained from fixed broadband subscriptions, both from institutions and the ICT sector. The expansion of fixed telephone subscriptions as one of the indicators of ICT has so far not made a significant contribution to increasing economic growth.

Mobile/cellular telephone subscriptions have a negative effect on economic growth. This means that an increase in mobile/cellular telephone subscriptions will not have an impact on the increase or decrease in the economic growth of high-income countries. This is because the expansion of mobile/cellular telephone subscriptions has not fully reached individuals or households. The results of this study are in line with research by Vu (2011), who showed that the economic growth achieved by 102 countries was not supported by the IT sector in providing optimal resources to maintain economic growth. The development of mobile/cellular telephone subscription innovations in developed and developing countries to increase the efficiency and effectiveness of resource allocation was not able to significantly affect economic growth. Belloumi and Touati (2022) provide evidence that economic growth that is maintained every year is not contributed to by the ICT sector in spurring existing resources to meet the need for available, wide-scale technology services in Arab countries. Priority allocation of resources from ICT can ensure the adoption and transfer of technology and the provision of a superior workforce in their fields. However, this does not impact economic growth.

Internet users have a negative effect on economic growth. This means that an increase in internet users will not have an impact on the increase or decrease in the economic growth of high-income countries. This is because the use of internet users is still limited to personal needs, but not fully for business needs in a wider scope. These results are in accordance with the research of Pradhan, Mallik, and Bagchi (2018), which shows that G20 economic growth is not proven to be influenced by internet users. Expansion of internet users should be a priority because ICT can catalyze communication and decision making for companies and households. However, so far, its contribution has not been seen in economic growth. Research from Pradhan, Arvin, Mittal, and Bahmani (2016) in

11 countries also shows that internet users have not been able to increase economic growth. Internet user instruments and services can increase demand for the internet. This condition reflects the increasingly integrated quality of ICT, which can generate benefits for companies and households. However, the economic growth that has been achieved so far has not come from the contribution of internet users.

Fixed broadband subscriptions have a negative effect on economic growth. This means that an increase in fixed broadband subscriptions will not have an impact on the increase or decrease in the economic growth of high-income countries. This is because the use of fixed broadband subscriptions has not reached usage levels evenly, so the demand for and supply of technological products is not high. These results are in line with research by Singh and Siddiqui (2023), which shows that the economic growth of developed countries is not significantly affected by fixed broadband subscriptions but they do have a significant effect in developing countries. The results of this study imply that economic growth in developed countries has not been driven through innovation, while in developing countries it has been driven through trade. In the case of developed countries, technological innovation should have developed rapidly and inclusively in the long term. However, this study reveals that this is not the case and further study is required. In developing countries, growth occurs over a long period of time with an unequal cycle of competition in various economic sectors. This is an obstacle to achieving economic growth. Research by Toader et al. (2018) in European countries suggests that fixed broadband subscriptions have not had a significant impact in achieving better economic growth. ICT is an important driver of economic growth and emphasizes the development of ICT infrastructure to spur innovation, investment, and access to technology so that it can become a vital factor in driving economic growth. However, economic growth has not reached a high level every year.

Domestic credit to the private sector has a positive effect on economic growth. This means that an increase in domestic credit to the private sector will increase the economic growth of high-income countries. This is because the distribution of domestic credit to the private sector can facilitate increased investment in the economic sector, which is useful for spurring the production of goods and services so that economic growth can be achieved. This result is in line with Sharma and Kautish (2020), who found that economic growth in South Asian countries was driven by the financial sector through domestic credit distributed by financial institutions, which had a significant influence. Anetor (2020) also found similar results in Sub-Saharan Africa, which proved that economic growth can be supported by increased performance of financial institutions in channeling domestic credit to the productive sector.

Stock market capitalization has a positive effect on economic growth. This means that an increase in stock market capitalization will have an impact on increasing the economic growth of high-income countries. This is because stock market movements moving in a positive direction can provide a reference for decision making as well as increased risk and encourage liquidity so that the stock market can become one of the supporting factors of economic growth. These results are in line with Masoud and Hardaker (2012), who provide evidence that economic growth can be achieved if stock market capitalization is able to improve stock trading conditions to support increased investment for households and companies in emerging markets. The results of this study confirm that stock market capitalization affects economic growth through stock trading, liquidity, investment flows and financial risk reduction. Research by Fufa and Kim (2018) shows that to achieve economic growth in high-income countries, stock market capitalization has become a trigger for stock market movements to have a large share in channeling investment. In line with this, for middle-income countries, economic growth can also be achieved by capitalizing the stock market. The results also indicate that the economic conditions in each country greatly influence how the stock market impacts the long-term sustainability of economic growth. In addition, flexible stock trading is expected to be able to respond to market challenges related to risks that are always faced by the economic sector.

5. CONCLUSION

Based on the research findings in the previous section, it was concluded that ICT has no significant effect on the economic growth of high-income countries. However, it was found that financial development has a significant effect on the economic growth of high-income countries.

The variables that do not have a significant effect are ICT variables with indicators of fixed telephone subscriptions, mobile/cellular telephone subscriptions, internet users and fixed broadband subscriptions. The results of this study are also supported by previous research that found that ICT in the countries studied also did not show a significant impact on economic growth. Although many other studies provide evidence that ICT does not have a significant effect on economic growth, in this context, in the future it is hoped that ICT will contribute to increasing the rate of economic growth. For this reason, efforts to improve ICT infrastructure can be expanded in the future.

In order to achieve economic growth, it is necessary to increase financial development contributions to the economies in high-income countries. This can be done with regulations to facilitate the distribution of credit access to the real sector as well as increasing access to the stock market for economic actors.

Funding: This study received no specific financial support.
Institutional Review Board Statement: The Ethical Committee of the Universitas Negeri Padang, Indonesia has granted approval for this study (Ref. No. 1286/UN35.13/LT/2023).
Data Availability Statement: Upon a reasonable request, the supporting data of this study can be provided by the corresponding author.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: Define and elaborate topics, data, methods, discussions, conclusions, A.S.; data processing, empirical analysis, and layout, A.I. Both authors have read and agreed to the published version of the manuscript.

REFERENCES

Ahmed, E. M., & Ridzuan, R. (2013). The impact of ICT on East Asian economic growth: Panel estimation approach. *Journal of the Knowledge Economy*, *4*(4), 540-555. https://doi.org/10.1007/s13132-012-0096-5

Albiman, M. M., & Sulong, Z. (2017). The linear and non-linear impacts of ICT on economic growth, of disaggregate income groups within SSA region. *Telecommunications Policy*, *41*(7-8), 555-572. https://doi.org/10.1016/j.telpol.2017.07.007

Allen, F., Bartiloro, L., Gu, X., & Kowalewski, O. (2018). Does economic structure determine financial structure? *Journal of International Economics*, *114*, 389-409. https://doi.org/10.1016/j.jinteco.2018.08.004

Anetor, F. O. (2020). Financial development threshold, private capital inflows and economic growth: Evidence from Sub-Saharan African countries. *International Journal of Development Issues*, *19*(1), 77-92.

Bagchi, K., Kirs, P., & López, F. (2008). The impact of price decreases on telephone and cell phone diffusion. *Information and Management*, *45*(3), 183–193. https://doi.org/10.1016/j.im.2007.12.005

Beck, T., & Feyen, E. (2013). *Benchmarking financial systems: Introducing the financial possibility frontier*. Retrieved from World Bank Policy Research Working Paper, No. 6615.

Belloumi, M., & Touati, K. (2022). Do FDI inflows and ICT affect economic growth? An evidence from Arab countries. *Sustainability*, *14*(10), 6293. https://doi.org/10.3390/su14106293

Beuermann, C. M., & Vakis, R. (2012). Mobile phones and economic development in rural Peru. *The Journal of Development Studies*, *48*(11), 1617–1628. https://doi.org/10.1080/00220388.2012.709615

Bojnec, Š., & Ferto, I. (2012). Broadband availability and economic growth. *Industrial Management & Data Systems*, *112*(9), 1292-1306. https://doi.org/10.1108/02635571211278938

Cheng, M. S. C., & Lee, C. C. (2021). ICT diffusion, financial development, and economic growth: An international cross-country analysis. *Economic Model*, *94*, 662–671. https://doi.org/10.1016/j.econmod.2020.02.008

Cronin, F. J., Colleran, E. K., Herbert, P. L., & Lewitzky, S. (1993). Telecommunications and growth. The contribution of telecommunications infrastructure investment to aggregate and sectoral productivity. *Telecommunications Policy, 17*(9), 677–690. https://doi.org/10.1016/0308-5961(93)90039-6

Cronin, F. J., Parker, E. B., Colleran, E. K., & Gold, M. A. (1991). Telecommunications infrastructure and economic growth. An analysis of causality. *Telecommunications Policy, 15*(6), 529–535. https://doi.org/10.1016/0308-5961(91)90007-X

Czernich, N., Falck, O., & Falck, O. (2009). *Broadband infrastructure and economic growth.* Retrieved from Cesifo Working Paper, 2861, 39.

Dahl, C. M., Kongsted, H. C., & Sørensen, A. (2011). ICT and productivity growth in the 1990s: Panel data evidence on Europe. *Empirical Economics, 40*(1), 141-164. https://doi.org/10.1007/s00181-010-0421-4

Das, A., Chowdhury, M., & Seaborn, S. (2018). ICT diffusion, financial development and economic growth: New evidence from low and lower middle-income countries. *Journal of the Knowledge Economy, 9*(3), 928-947. https://doi.org/10.1007/s13132-016-0383-7

Donou-Adonsou, F. (2019). Technology, education, and economic growth in Sub-Saharan Africa. *Telecommunications Policy, 43*(4), 353–360. https://doi.org/10.1016/j.telpol.2018.08.005

Erumban, A. A., & Das, D. K. (2016). Information and communication technology and economic growth in India. *Telecommunications Policy, 40*(5), 412-431. https://doi.org/10.1016/j.telpol.2015.08.006

Farhadi, R. I., & Fooladi, M. (2012). Information and communication technology use and economic growth. *PLoS One, 7*(11), 1-7. https://doi.org/10.1371/journal.pone.0048903

Fufa, T., & Kim, J. (2018). Stock markets, banks, and economic growth: Evidence from more homogeneous panels. *Research in International Business and Finance, 44*, 504-517. https://doi.org/10.1016/j.ribaf.2017.07.120

Gourieroux, A. C., Monfort, A., & Trognon, A. (1984). Pseudo maximum likelihood methods: Applications to poisson models published. *The Econometric Society Stable, 52*(3), 701–720.

Gurley, J. G., & Shaw, E. S. (1967). Financial structure and economic development. *Economic Development and Cultural Change, 15*(3), 257-268.

Haftu, G. G. (2019). Information communications technology and economic growth in Sub-Saharan Africa: A panel data approach. *Telecommunications Policy, 43*(1), 88-99. https://doi.org/10.1016/j.telpol.2018.03.010

Hopestone, C. K. (2014). The role of ICTs in agricultural production in Africa. *Journal of Development and Agricultural Economics, 6*(7), 279-289. https://doi.org/10.5897/jdae2013.0517

Inklaar, R., O'Mahony, M., & Timmer, M. (2005). ICT and Europe's productivity performance: Industry-level growth account comparisons with the United States. *Review of Income and Wealth, 51*(4), 505-536. https://doi.org/10.1111/j.1475-4991.2005.00166.x

Ishida, H. (2015). The effect of ICT development on economic growth and energy consumption in Japan. *Telematics and Informatics, 32*(1), 79-88. https://doi.org/10.1016/j.tele.2014.04.003

ITU. (2020). *Measuring digital development. Facts and figures 2020. In ITU Publications.* Retrieved from https://www.itu.int/en/mediacentre/Documents/MediaRelations/ITU Facts and Figures 2019 - Embargoed 5 November 1200 CET.pdf

Jorgenson, D. W., & Vu, K. (2005). Information technology and the world economy. *The Scandinavian Journal of Economics, 107*(4), 631-650.

King, M. L., & Wu, P. X. (1997). Locally optimal one-sided tests for multiparameter hypotheses. *Econometric Reviews, 16*(2), 131–156. https://doi.org/10.1080/07474939708800379

Kpodar, K., & Andrianaivo, M. (2011). ICT, financial inclusion, and growth evidence from African countries. *IMF Working Papers, 11*(73), 1. https://doi.org/10.5089/9781455227068.001

Lam, P.-L., & Shiu, A. (2010). Economic growth, telecommunications development and productivity growth of the telecommunications sector: Evidence around the world. *Telecommunications Policy, 34*(4), 185-199. https://doi.org/10.1016/j.telpol.2009.12.001

Latif, Z., Latif, S., Ximei, L., Pathan, Z. H., Salam, S., & Jianqiu, Z. (2018). The dynamics of ICT, foreign direct investment, globalization and economic growth: Panel estimation robust to heterogeneity and cross-sectional dependence. *Telematics and Informatics, 35*(2), 318-328. https://doi.org/10.1016/j.tele.2017.12.006

Lee, J., & Brahmasrene, T. (2014). ICT, CO2 emissions and economic growth: Evidence from a panel of ASEAN. *Global Economic Review, 43*(2), 93–109. https://doi.org/10.1080/1226508x.2014.917803

Lee, S. H., Levendis, J., & Gutierrez, L. (2012). Telecommunications and economic growth: An empirical analysis of Sub-Saharan Africa. *Applied Economics, 44*(4), 461-469. https://doi.org/10.1080/00036846.2010.508730

Maradana, R. P., Pradhan, R. P., Dash, S., Zaki, D. B., Gaurav, K., Jayakumar, M., & Sarangi, A. K. (2019). Innovation and economic growth in European economic area countries: The Granger causality approach. *IIMB Management Review, 31*(3), 268-282. https://doi.org/10.1016/j.iimb.2019.03.002

Masoud, N., & Hardaker, G. (2012). Emerald Article: The impact of financial development on economic growth: Empirical analysis of emerging market countries. *Studies in Economics and Finance, 29*(3), 148-173. https://doi.org/10.1108/10867371211246830

McKinnon, R. (1973). *Money, and capital in economic development.* Washington: Brookings Institution.

Myovella, G., Karacuka, M., & Haucap, J. (2020). Digitalization and economic growth: A comparative analysis of Sub-Saharan Africa and OECD economies. *Telecommunications Policy, 44*(2), 101856. https://doi.org/10.1016/j.telpol.2019.101856

Nath, H. K., & Liu, L. (2017). Information and communications technology (ICT) and services trade. *Information Economics and Policy, 41*, 81-87. https://doi.org/10.1016/j.infoecopol.2017.06.003

Nchofoung, T. N., & Asongu, S. A. (2022). ICT for sustainable development: Global comparative evidence of globalisation thresholds. *Telecommunications Policy, 46*(5), 102296. https://doi.org/10.1016/j.telpol.2021.102296

Ngozi, A., & Chiamaka, E. (2019). Evaluation of ICT development and economic growth in Africa. *Netnomics, 20*, 31–53. https://doi.org/10.1007/s11066-019-09131-6

Niebel, T. (2018). ICT and economic growth–comparing developing, emerging and developed countries. *World Development, 104*(14), 197-211. https://doi.org/10.1016/j.worlddev.2017.11.024

Oliner, S. D., & Sichel, D. E. (2000). The resurgence of growth in the late 1990s: Is information technology the story? *Journal of Economic Perspectives, 14*(4), 3-22. https://doi.org/10.1257/jep.14.4.3

Perez-Trujillo, M., & Lacalle-Calderon, M. (2020). The impact of knowledge diffusion on economic growth across countries. *World Development, 132*, 104995. https://doi.org/10.1016/j.worlddev.2020.104995

Pradhan, M. B. A., Nair, M., Mittal, J., & Norman, N. R. (2017). Telecommunications infrastructure and usage and the FDI–growth nexus: Evidence from Asian-21 countries. *Information Technology for Development, 23*(2), 235–260. https://doi.org/10.1080/02681102.2016.1217822

Pradhan, M. B. A., & Norman, N. R. (2015). The dynamics of information and communications technologies infrastructure, economic growth, and financial development: Evidence from Asian countries. *Technology in Society, 42*, 135–149. https://doi.org/10.1016/j.techsoc.2015.04.002

Pradhan, R. P., Arvin, M. B., Mittal, J., & Bahmani, S. (2016). Relationships between telecommunications infrastructure, capital formation, and economic growth. *International Journal of Technology Management, 70*(2-3), 157-176.

Pradhan, R. P., Arvin, M. B., Nair, M. S., Hall, J. H., & Bennett, S. E. (2021). Sustainable economic development in India: The dynamics between financial inclusion, ICT development, and economic growth. *Technological Forecasting and Social Change, 169*, 120758. https://doi.org/10.1016/j.techfore.2021.120758

Pradhan, R. P., Arvin, M. B., Norman, N. R., & Bele, S. K. (2014). Economic growth and the development of telecommunications infrastructure in the G-20 countries: A panel-VAR approach. *Telecommunications Policy, 38*(7), 634-649.

Pradhan, R. P., Mallik, G., & Bagchi, T. P. (2018). Information communication technology (ICT) infrastructure and economic growth: A causality evinced by cross-country panel data. *IIMB Management Review, 30*(1), 91-103.

Ruiz, J. L. (2018). Financial development, institutional investors, and economic growth. *International Review of Economics & Finance, 54*, 218-224. https://doi.org/10.1016/j.iref.2017.08.009

Saito, Y. (2017). Effects of patent protection on economic growth and welfare in a two-R&D-sector economy. *Economic Modelling*, *62*(January), 124-129. https://doi.org/10.1016/j.econmod.2017.01.015

Salahuddin, M., & Alam, K. (2016). Information and communication technology, electricity consumption and economic growth in OECD countries: A panel data analysis. *International Journal of Electrical Power & Energy Systems*, *76*, 185-193. https://doi.org/10.1016/j.ijepes.2015.11.005

Schumpeter, J. (1934). *The theory of economic development*. Cambridge, Massachusetts, United States: Harvard University Press.

Seifallah, S., & Mohamed, G. (2013). Financial development, ICT diffusion and economic growth: Lessons from MENA region. Financial development, ICT diffusion and economic growth. *Telecommunications Policy*, *37*(4–5), 252-261. https://doi.org/10.1016/j.telpol.2012.12.004

Sharma, R., & Kautish, P. (2020). Linkages between financial development and economic growth in the middle-income countries of South Asia: A panel data investigation. *Vision*, *24*(2), 140-150. https://doi.org/10.1177/0972262920923908

Shaw, E. (1973). *Financial deepening in economic development*. London, England: Oxford University Press.

Singh, P., & Siddiqui, A. A. (2023). Innovation, ICT penetration, trade and economic growth in developing and developed countries: a VECM approach. *Competitiveness Review: An International Business Journal*, *33*(2), 395-418. https://doi.org/10.1108/CR-05-2021-0074

Stanley, T. D., Doucouliagos, H., & Steel, P. (2018). Does ICT generate economic growth? A meta-regression analysis. *Journal of Economic Surveys*, *32*(3), 705-726. https://doi.org/10.1111/joes.12211

Studenmund. (2016). *Using econometrics: A practical guide* (7th ed.). Boston, United States: Pearson.

Thompson Jr, H. G., & Garbacz, C. (2011). Economic impacts of mobile versus fixed broadband. *Telecommunications Policy*, *35*(11), 999-1009. https://doi.org/10.1016/j.telpol.2011.07.004

Toader, E., Firtescu, B. N., Roman, A., & Anton, S. G. (2018). Impact of information and communication technology infrastructure on economic growth: An empirical assessment for the EU countries. *Sustainability*, *10*(10), 3750. https://doi.org/10.3390/su10103750

Van Ark, B., O'Mahony, M., & Timmer, M. P. (2008). The productivity gap between Europe and the United States: Trends and causes. *Journal of Economic Perspectives*, *22*(1), 25–44. https://doi.org/10.1257/jep.22.1.25

Vu, K. M. (2011). ICT as a source of economic growth in the information age: Empirical evidence from the 1996–2005 period. *Telecommunications Policy*, *35*(4), 357-372. https://doi.org/10.1016/j.telpol.2011.02.008

Ward, & Zheng, S. (2016). Mobile telecommunications service and economic growth: Evidence from China. *Telecommunications Policy*, *40*(2–3), 89–101. https://doi.org/10.1016/j.telpol.2015.06.005

World Bank. (2016). World development report 2016: Digital dividends. In (pp. 359): Washington, United States: World Development Report.

Yousefi, A. (2011). The impact of information and communication technology on economic growth: Evidence from developed and developing countries. *Economics of Innovation and New Technology*, *20*(6), 581–596. https://doi.org/10.1080/10438599.2010.544470