International Journal of Business and Management; Vol. 17, No. 12; 2022
ISSN 1833-3850 E-ISSN 1833-8119
Published by Canadian Center of Science and Education

Information and Communication Technology (ICT) on Economic Growth in Asia: A Panel Data Analysis

Debbra Toria Nipo[1], Jaratin Lily[1], Sidah Idris[1], Saizal Pinjaman[1] & Imbarine Bujang[2]

[1] Faculty of Business, Economics, and Accountancy, Universiti Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia

[2] Faculty of Business and Management, Universiti Teknologi MARA Sabah Branch, Kota Kinabalu, Sabah, Malaysia

Correspondence: Debbra Toria Nipo, Faculty of Business, Economics and Accountancy, Universiti Malaysia Sabah, Jalan UMS, 88400, Kota Kinabalu, Sabah, Malaysia. E-mail: debbratoria@ums.edu.my

Received: September 17, 2022 Accepted: October 16, 2022 Online Published: November 1, 2022

doi:10.5539/ijbm.v17n12p18 URL: https://doi.org/10.5539/ijbm.v17n12p18

Abstract

Information and communication technology (ICT) plays an increasingly important role in driving economic growth and sustainability. Asia, being the most heterogenous region in terms of ICT development, consist of both most connected and least connected countries based on the global ICT Development Index 2017. Therefore, this study investigates the impact of ICT on economic growth for 20 Asian countries from year 2000 to 2020. Using the robust panel Fixed Effect model and Panel Feasible Generalized Least Squares method, findings revealed that fixed telephone subscriptions, mobile cellular subscriptions and Internet users are the ICT variables that have significant and positive effects on economic growth in Asia. Fixed telephone subscriptions however, emerged insignificant which could be due to its high cost and low practicality relative to other forms of ICT. Findings from this study benefit related parties such as firms and policymakers by encouraging adoption and usage of mobile phones and the Internet through provision of adequate infrastructure and affordable ICT services.

Keywords: ICT, economic growth, Asia, panel data

1. Introduction

The question of how ICT can affect a country's economic performance has been the subject of numerous research, partly because of Robert Solow (1957) whose work on growth accounting has produced significant landmarks and contributions to the economic growth theory. According to his findings using the Solow model in 1957, technical advancement was substantially responsible for the United States' economic growth in the 1950s and 1960s. Since Solow's fundamental work, there have been further studies around this topic, which are conducted at firm, industry, and national levels.

A handful of studies have focused on how ICT investment as capital input drives economic growth through the productivity channel (Oliner & Sichel, 2000; Schreyer, 2000). Farhadi, Ismail, Sarmidi and Kasimin (2013) meanwhile, presented a distinct perspective on ICT by examining the economic effects of ICT development as a system on economic growth. They defined ICT development as a concept that encompasses three key dimensions of ICT, namely: (i) ICT readiness (infrastructure and access), (ii) ICT use (intensity of using ICT), and (iii) ICT impact (ICT capability or skills). For instance, Farhadi, Ismail and Fooladi (2012) focused on the usage of ICT and looked at how ICT use affected economic growth in 159 countries across various regions of the world. They used an ICT use index that combines several measures of ICT (number of mobile subscriptions, fixed broadband internet subscribers and Internet users) and found a positive correlation between ICT use and the growth rate of real GDP per capita.

Farhadi and Ismail (2014) extended their previous work and computed an ICT access index consisting of fixed telephone lines per 100 inhabitants, mobile cellular telephone subscriptions per 100 inhabitants, international internet bandwidth per Internet user, percentage of households with a computer, and percentage of households with Internet access at home. Using the ICT access index as a proxy for ICT access, their findings revealed that access to ICT is significantly and positively correlated with real GDP for all 142 sample countries. Meanwhile, using the European Digitalization Development Index (EDDI), Evangelista, Guerrieri and Meliciani (2014) tested a set of variables covering various dimensions of the digitalization of society and economy (access, usage and

empowerment) against labor productivity growth, GDP per capita growth and employment growth in Europe. Their findings highlighted that the significance of ICT use is more pronounced for labour productivity.

Additionally, a number of studies focused on certain types of ICT where their impacts on growth are individually assessed. For instance, Lee, Levendis and Gutiérrez (2009) examined the link between mobile phones and economic growth in sub-Saharan Africa and discovered a positive significant relationship between the two variables for year 2000 to 2006. Lee et al. (2009) also noted that the contribution of cellular phones to economic growth is related to the fact that cellular phones are portable and less expensive to install than land-line phones, whose up-front infrastructure costs are comparably more expensive. A study by Andrianaivo and Kpodar (2012) also revealed findings that are consistent with those of Lee et al. (2009), whose findings similarly highlight the significant influence that mobile phone development has on the economic growth of African countries. The impact of ICT on the economic growth of the ASEAN5+3 nations was also examined by Ahmed and Ridzuan (2013), where they found that investments in labour, capital, and telecommunications are all positively correlated with GDP.

Past evidence on the relationship between ICT and economic growth largely come from either industry-level studies (Basant, Commander, Harrison & Menezes-Filho, 2006; Spiezia, 2012) or country-level studies (Crepon & Heckel, 2002; Kim, 2003). Regional studies that investigate the impacts of ICT on economic indicators in specific regions remain scarce. Moreover, ICT variables used in past studies are combined into a single-measure index (Farhadi & Ismail, 2014; Evangelista et al., 2014; Farhadi et al., 2012) where the distinct impact of each type of ICT could not be ascertained. Therefore, this study attempts to fill this literature gap by investigating the relationship between ICT and economic growth of countries in Asia. The first contribution of this study is by testing 4 different measures of ICT variables against economic growth, when studies in the past mostly used an ICT index representing various ICT variables. Testing for individual impact of each measure of ICT provides richer evidence on the relationship between ICT and economic growth, by determining the varying degree of influence each form of ICT has on economic growth. Secondly, this study is conducted specifically for countries in Asia. According to the global ICT Development Index (IDI) 2017, Asia is the most diverse region in terms of IDI performance as this region includes countries that sat on top of the most cost connected countries, while some are ranked as least connected countries (International Telecommunication Union, 2017). In consideration of such heterogeneous levels of ICT development in Asia, studying the impact of different forms of ICT could help in identifying which forms of technology are more impactful and rewarding to all.

2. Data and Methodology

2.1 Data

This study uses a sample of 20 Asian countries over a 21-year period from 2000 to 2020. The dependent variable is measured by GDP per capita growth, representing economic growth. Variables measuring ICT comprise of four different forms of technologies: (i) fixed broadband subscriptions, (ii) fixed telephone subscriptions, (iii) mobile cellular subscriptions and (iv) individuals using the Internet. Instead of a joint estimation, each of these ICT variables is tested separately against the economic growth indicator. In addition, control variables consisting of total labor force participation rate and gross fixed capital formation are also included in the regression models. Table 1 below shows all the variables used in the study, including their measurements and the sources from which the data were collected.

Table 1. Measurement of variables

Variable	Indicator	Measurement	Data Source
Dependent variable	GDP per capita	Measured by annual percentage growth rate of GDP per capita based on constant local currency	World Bank: World Development Indicators
Independent variables	Fixed broadband subscriptions	Measured by the number of fixed broadband subscriptions (per 100 people)	
	Fixed telephone subscriptions	Measured by the number of fixed telephone subscriptions (per 100 people)	
	Mobile cellular subscriptions	Measured by the number of mobile cellular subscriptions (per 100 people)	
	Internet users	Measured by the percentage of individuals using the Internet (% of population)	
Control variables	Labor force	Labor force participation rate, total (% of total population ages 15+) (modeled ILO estimate)	
	Capital stock	Measured by gross fixed capital formation (annual % growth)	

2.2 Model Specification

To examine the relationship between ICT and economic growth, this study improvises the standard endogenous growth model as defined in Andrainavo and Kpodar (2012) by removing the lagged dependent variable and adding three other ICT variables. The regression model of the study, thus takes the following form:

$$GDP_{i,t} = \beta_0 + \beta_1 ICT_{i,t} + \beta_2 LAB_{i,t} + \beta_3 CAP_{i,t} + \varepsilon_{i,t} \quad (1.0)$$

where *GDP* is the dependent variable measuring economic growth in country *i* in year *t*; *ICT* represents various ICT variables as measured by fixed broadband subscriptions (FBB), fixed telephone subscriptions (FTEL), mobile cellular subscriptions (MOB) and Internet users (INTR) in country *i* in year *t*; *LAB* is total labour force participation rate in country *i* in year *t*; and *CAP* is gross fixed capital formation in country *i* in year *t*. β_0, β_1, β_2, and β_3 represent the parameters to be estimated, while $\varepsilon_{i,t}$ represents the error term.

As the study aims to investigate the individual effect of each ICT variable, the model specification as expressed in Equation (1.0) above is replicated by substituting the ICT variable with fixed broadband subscriptions (FBB), fixed telephone subscriptions (FTEL), mobile cellular subscriptions (MOB) and Internet users (INTR), into Equations (1.1) to (1.4) respectively. The model specifications are expressed as below:

$$GDP_{i,t} = \beta_0 + \beta_1 FBB_{i,t} + \beta_2 LAB_{i,t} + \beta_3 CAP_{i,t} + \varepsilon_{i,t} \quad (1.1)$$

$$GDP_{i,t} = \beta_0 + \beta_1 FTEL_{i,t} + \beta_2 LAB_{i,t} + \beta_3 CAP_{i,t} + \varepsilon_{i,t} \quad (1.2)$$

$$GDP_{i,t} = \beta_0 + \beta_1 MOB_{i,t} + \beta_2 LAB_{i,t} + \beta_3 CAP_{i,t} + \varepsilon_{i,t} \quad (1.3)$$

$$GDP_{i,t} = \beta_0 + \beta_1 INTR_{i,t} + \beta_2 LAB_{i,t} + \beta_3 CAP_{i,t} + \varepsilon_{i,t} \quad (1.4)$$

2.3 Methodology

This study employs the static panel data regression analysis based on the robust Fixed Effect (FE) model and Panel Feasible Generalized Least Squares (PFGLS) method. Before proceeding with the main model estimations, the Breusch-Pagan Lagrange Multiplier (BP LM) test is first conducted to test for poolability of data and followed by the Hausman test to determine the suitability of using a random effect model versus fixed effect model. Next, diagnostic testing for multicollinearity, autocorrelation and heteroskedasticity issues within the models are also performed. In the event where the models are found to be plagued by autocorrelation and/or heteroskedasticity issues, the standard errors need to be corrected to ensure reliability of parameter estimates. Hence, the static panel data analysis in this study primarily employed both the (i) Fixed Effects (FE) model with robust standard errors, and (ii) Panel Feasible Generalized Least Squares (PFGLS) method that allows estimation when first-order autocorrelation exist within panels, and when cross-sectional correlation and heteroskedasticity exist across panels.

Regression of models specified in Section 2.2 is performed separately for each ICT variable. Therefore, the static panel data analysis is conducted four times since there are 4 different measures of ICT variables used in the study, namely fixed broadband subscriptions (FBB), fixed telephone subscriptions (FTEL), mobile cellular subscriptions (MOB) and Internet users (INT).

3. Results and Discussion

Table 1 below shows the static panel data analysis results for investigating the relationship between ICT and economic growth in Asia. Diagnostic tests indicated that all model specifications did not appear to suffer from multicollinearity problem, based on their small VIF values. However, the significant p-values of Modified Wald Test and Wooldridge Test suggest that the models suffer from heteroskedasticity and autocorrelation problems. Thus, robust FE model and PFGLS estimator are used to overcome these problems accordingly.

Table 2. Static panel data regression results

	FBB		**FTEL**		**MOB**		**INTR**	
	FE	**PFGLS**	**FE**	**PFGLS**	**FE**	**PFGLS**	**FE**	**PFGLS**
FBB	0.2046**	0.1158***						
	(0.0763)	(0.0050)						
FTEL			0.1180	0.0247***				
			(0.1181)	(0.0009)				
MOB					0.0332***	0.0291***		
					(0.0112)	(0.0016)		
INTR							0.0677***	0.0515***
							(0.0232)	(0.0014)
LAB	0.1063	0.0318***	0.1762**	0.0102**	0.0551	0.0523***	0.0011	0.0284***
	(0.0616)	(0.0078)	(0.0678)	(0.0048)	(0.0072)	(0.0072)	(0.1000)	(0.0092)
CAP	0.1508***	0.1387***	0.1708***	0.1446***	0.1376***	0.1276***	0.1422***	0.1364***
	(0.0433)	(0.0022)	(0.0409)	(0.0018)	(0.0416)	(0.0043)	(0.0431)	(0.0021)
Constant	1.4544	0.9913*	1.3692**	1.8589***	1.8979	1.8142***	1.8567	2.2048***
	(2.0214)	(0.5741)	(2.0602)	(0.3334)	(2.8735)	(0.4053)	(2.5922)	(0.6988)
BP LM test	9.34***		2.86**		7.51***		6.61***	
	[0.0011]		[0.0453]		[0.0031]		[0.0051]	
Hausman	16.88***		12.16***		16.46***		17.46***	
Test	[0.0007]		[0.0069]		[0.0009]		[0.0006]	
VIF	1.04		1.03		1.06		1.05	
Modified	6687.57***		3446.93***		3185.49***		5725.25***	
Wald Test	[0.0001]		[0.0001]		[0.0001]		[0.0001]	
Wooldridge	24.114***		22.803***		21.359***		24.204***	
Test	[0.0001]		[0.0001]		[0.0002]		[0.0001]	
No. of countries	20		20		20		20	

Notes. Values in parentheses are standard errors and values in brackets are p-values, where ***, ** and * indicate significance at 1%, 5% and 10% significance levels, respectively. FE represents robust Fixed Effect model and PFGLS represents Panel Feasible Generalized Least Squares.

Results show that nearly all ICT variables are significantly correlated with GDP per capita, except fixed telephone subscriptions. This supports findings from previous studies (Farhadi & Ismail, 2014; Evangelista et al., 2014; Andrianaivo & Kpodar, 2012; Farhadi et al., 2012; Lee et al., 2009) who similarly found significant relationship between ICT and economic growth. Notably in this study, fixed broadband subscriptions revealed to have the largest positive coefficient values among all ICT variables, suggesting that a 1% increase in the number of fixed broadband subscriptions leads to a 0.2% increase in GDP per capita growth. This is followed by mobile cellular subscriptions and Internet users who both emerged with significant and positive coefficients, indicating that a 1% increase in mobile phone subscriptions and Internet users are associated with a 0.03% and 0.06% increase in GDP per capita growth, respectively.

On the other hand, fixed telephone subscriptions emerged insignificant under the FE model analysis when robust standard errors are obtained. This is in line with findings by Nurlela, Aliasuddin and Dawood (2021) who also showed that fixed-line phones do not render any significant influence on economic growth in Indonesia from 2011

to 2019. One reason behind this could be due to the fact that fixed telephones are relatively more costly and less practical compared to other forms of ICT such as mobile cellular that are more efficient. This finding also corresponds well with the gradually declining rate of fixed telephone adoption particularly in more developed countries in Asia, whilst mobile cellular continue to grow and dominate the market. Importance of mobile cellular is further validated by the findings of this study, implying that mobile phones are preferred over fixed telephones in engaging in productive activities, and thus promoting economic growth.

Moving to findings for control variables, it appears that capital stock is strongly correlated with GDP per capita. This indicates that raising the level of capital stock would promote growth in GDP per capita of Asian countries. This finding is consistent with Ahmed and Ridzuan (2013) who found positive effects of labour, capital and telecommunications investment on GDP in ASEAN countries from year 1975 to 2006. However, labor force in this study only appeared significant in the model specification when fixed telephone is treated as the sole ICT variable. This suggests that increase in the labor force participation leads to increase in economic activities and thus GDP, through higher employment and labor productivity. Nevertheless, findings shown by Bryant et al. (2004) demonstrated that the proportional increase in GDP between new and existing workers may differ; new workers is likely to have greater impact than existing workers. The study also pointed out that significant capital investment is required for the extra workers to reach the expected productivity levels.

4. Conclusion and Recommendation

This study investigates the impact of various ICT variables on economic growth in Asia for the period 2000 to 2020. Using static panel data analysis approaches, empirical evidence found in this study pointed to the significant role played by fixed telephone, mobile cellular and the Internet in promoting economic growth in Asia. In particular, fixed broadband emerged with the largest significant positive coefficient value, which goes to show that access to more advanced forms of technology prove to be the most impactful in the region. This study however, failed to establish a significant relationship between fixed telephone and economic growth, which may be attributable to the declining adoption rate of fixed telephone due to its high cost and low practicality.

Given these findings, policymakers should encourage adoption and usage of mobile phones and the Internet. Providing adequate infrastructure and affordable ICT services allows firms, households and individuals to make the most out of the opportunities and benefits offered by the technologies. Moreover, similar emphasis should be placed on digital literacy development as individuals need sufficient knowledge and skills to use ICT effectively. This can be done by embedding ICT in important sectors such as education and health, as well as by cultivating a digital culture in schools and firms alike.

For limitation, this study focuses on the relationship between ICT and economic growth where the direction of causality is hypothesized to run from ICT to economic growth only. Future researchers can investigate other causality channels and whether there is a bidirectional causality between ICT and economic growth. Additionally, this study involves only countries within the Asia region. Thus, the sample countries can be expanded to include other country groups from certain regions or development levels for future research.

Acknowledgments

The authors would like to thank the Ministry of Education (MOE) Malaysia and Universiti Malaysia Sabah for supporting this work under the Fundamental Research Grant Scheme for Research Acculturation of Early Career Researchers (RACER/1/2019/SS08/UMS/2).

References

Ahmed, E., & Ridzuan, R. (2013). The Impact of ICT on East Asian Economic Growth: Panel Estimation Approach. *Journal of the Knowledge Economy*, *4*(4), 540-555.

Andrianaivo, M., & Kpodar, K. (2012). ICT, financial inclusion, and growth evidence from African countries. *International Monetary Fund Working Paper 11/73*.

Basant, R., Commander, S. J., Harrison, R., & Menezes-Filho, N. (2006). Adoption and Productivity in Developing Countries: New Firm Level Evidence from Brazil and India. *IZA Discussion Paper No. 2294*.

Bryant, J., Jacobsen, V., Bell, M., & Garrett, D. (2004). Labour Force Participation and GDP in New Zealand, *New Zealand Treasury Working Paper No. 04/07*.

Crepon, B., & Heckel, T. (2002). Computerisation in France: An evaluation Based on Individual Company Data. *Review of Income and Wealth*, *48*(1).

Evangelista, R., Guerrieri, P., & Meliciani, V. (2014). The Economic Impact of Digital Technologies in Europe. *Economics of Innovation and New Technology*, *23*(7/8), 802-824.

Farhadi, M., & Ismail, R. (2014). The Impact of Information and Communication Technology Availability on Economic Growth. *Research Journal of Applied Sciences, Engineering and Technology*, *7*(7), 1226-1231.

Farhadi, M., Ismail, R., & Fooladi, M. (2012). Information and Communication Technology Use and Economic Growth. *PLoS ONE*, *7*(11), e48903. http://doi.org/10.1371/journal.pone.0048903

Farhadi, M., Ismail, R., Sarmidi, T., & Kasimin, H. (2013). The Role of Information and Communication Technology (ICT) Development in economic Growth: A Dynamic Panel Data Approach. *Advances in Information Sciences and Service Sciences*, *5*(12).

International Telecommunication Union (ITU). (2017). Measuring the Information Society Report. Place des Nations CH-1211 Geneva, Switzerland.

Kim, S. J. (2003). Information Technology and its Impact on Economic Growth and Productivity in Korea. *International Economic Journal*, *17*(3), 55-75.

Lee, S. H., Levendis, J., & Gutiérrez, L. (2009). Telecommunications and economic growth: an empirical analysis of sub-Saharan Africa. *Applied Economics*, *44*(4), 461-469.

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*, 3-22.

Schreyer, P. (2000). The Contribution of Information and Communication Technology to Output Growth: A Study of the G7 Countries. *OECD/DSTI Working Paper*, 2000/2.

Solow, R. M. (1957). Technical Change and the Aggregate Production Function. *Review of Economics and Statistics*, *39*(3), 312-20.

Spiezia, V. (2012). ICT investments and productivity: Measuring the contribution of ICTS to growth. *OECD Journal: Economic Studies*, *1*. http://dx.doi.org/10.1787/eco_st udies-2012-5k8xdhj4tv0t