Impact of the Information and Communications Technology on Regional Development in Southeast Asia

Abstract

This study investigates the role of the information and communications technology on the regional economic development amongst Southeast Asian countries. The research utilizes panel data of the Association of Southeast Asian Nations (ASEAN) over the span of two decades (2000-2020) to measure the impact of the ICT sector indicators, together with control variables related to poverty, governance, education, and industry structure. The main findings are (1) ICT-related factors positively contribute to a country's GDP; (2) ICT positively impacts a country's growth under particular conditions such as good governance, reduced inequality and poverty, and presence of lower value-added sectors; (3) when independent variables are interacted with income dummies, medium and high-tech exports work better in lower income countries implying that ICT is particularly important in boosting up these countries' income level. In light of the new ASEAN Digital Master Plan 2025, the study provides insight into the current academic discussions as well as the practical field in terms of policy implications to stimulate development of the ICT sector in the Southeast Asian region.

Keywords: ASEAN, ICT, digitization, panel data, regional development.

1. Introduction

The role of information and communications technology (hereafter ICT) in economic development is unequivocal in transforming the dynamics of today's social, economic, and global landscape from the mid-20th century. Just as Jorgenson and Stiroh (2000) and Oliner and Sichel (2000) did, a number of studies recognize the importance of ICT as a key driver for the economy, and in these cases for the U.S. economy during the mid to late half of the 20th century. Colecchia and Schreyer (2002) discovered that even without an existing large ICT-producing industry, nine OECD countries examined in the study had strong, growing investment ICT capital drove economic growth, especially in the second half of the 1990s. Similarly, the World Bank (2012) stated that the rapid burgeoning of digital transformation in the 2000s and 2010s promised many economies the opportunity to boost productivity, reduce poverty, and achieve next-generation economic restructuring. Recently, the World Development Report 2020 (World Bank, 2020) greatly emphasizes the importance of ICT in developing countries in promoting trade, reducing transportation costs, and freeing the insular conditions of some states.

The fact remains many studies support for the positive influence of ICT on economic growth. For ASEAN5+3 countries (Malaysia, Thailand, Singapore, Indonesia, Philippines, China, Japan, and Korea), Ahmed and Ridzuan (2013) discovered supporting results, ICT, measured as telecommunications investment, has a positive effect on economic growth and that it defies the productivity paradox of Solow (1957). Other studies branch out to the impact of ICT to achieving sustainable development. For certain South Asian countries, ICT transpired beyond contributing to rapid economic growth and determined by Latif et. al (2017) that it has a positive relation with propelling sustainable economic development. Cioacă, Cristache, Vuță, Marin, and Vuță, (2020) confirm that positive effects of ICT on increasing productivity, fostering innovations, and

supporting fiscal systems that ultimately contribute to GDP growth amongst the countries in the European Union. Additionally, to consider its impact on the attainment of sustainable development, Cioacă et. Al (2020) established inequality of income distribution as a measure for sustainable development goal 10 – reduced inequalities. The results indicated that ICT does reduce income inequality.

Figure 1 South East Asian Region

Source: United Nations, author's contribution (indication of lower income ASEAN countries (Cambodia, Indonesia, Laos PDR, Myanmar, Philippines, Thailand, and Vietnam in green highlights)

The Association of Southeast Asian Nations (hereafter ASEAN), currently encompassing ten member states, is a powerful political and economic alliance in the Southeast Asian region. While successfully sustaining regional harmony and security (Tekunan, 2015), this multilateral alliance can be considered as heterogenous in terms of income levels. Based on each countries' GDP per capita (World Development Indicators, 2022), Table 1 further presents the income disparities amongst the countries while comparing them to that of EU member states. Amongst the EU states, the highest per capita GDP (Luxemburg) is approximately 13.33 times more than that of the lowest per capita GDP (Bulgaria). On the contrary, the highest per capita GDP in ASEAN (Singapore) is about 51.22 times that of the lower per capita GDP (Myanmar). According to Park (2000) and Raeskyesa (2020), despite the improved economic performance and growth of individual countries in ASEAN, as a whole, the group's income divergence has become more severe where higher-income countries are outperforming the lower-income countries. The degree of heterogeneity in economic development of the member countries between the two groups is attributable other non-economic factors such as political tendencies, geographical distances, and national priorities (Park 2000; Jetin, Petit 2018).

Table 1. Income heterogeneity comparison between EU and ASEAN countries

EU Member States	Income Ratio	ASEAN Member States	Income Ratio
Bulgaria	1.00	Myanmar	1.00
Romania	1.40	Cambodia	1.08
Croatia	1.80	Lao PDR	2.00
Hungary	1.87	Vietnam	2.61
Poland	1.87	Philippines	2.64
Latvia	1.98	Indonesia	2.98
Slovak Republic	2.16	Thailand	4.85
Lithuania	2.18	Malaysia	8.38
Greece	2.27	Brunei Darussalam	23.16
Czech Republic	2.36	Singapore	51.22
Portugal	2.50		
Estonia	2.58		
Slovenia	2.98		
Spain	3.16		
Cyprus	3.34		
Malta	3.34		
Italy	3.80		
France	4.61		
Germany	5.13		
Belgium	5.16		
Austria	5.44		
Finland	5.60		
Netherlands	5.84		
Sweden	6.47		
Denmark	7.06		
Ireland	10.68		
Luxembourg	13.33		

Source: World Development Indicators (2022). **Notes:** Income ratio for all countries were calculated using GDP per capita (constant 2015 US$) for year 2021. For both groups, countries with the lowest GDP per capita were used as the base countries (for EU, Bulgaria; for ASEAN, Myanmar) and represented as 1, and based on that, the ratios were calculated by dividing the other country's GDP per capita to that of the base country.

This united yet diverse, independent, and unique Southeast Asian identity has become more prominent and integral to the global landscape, especially coupled with accelerated trends of massive digitization in almost every aspect of life. According to the ASEAN ICT Masterplan 2015 (2010), the member states have worked together since the early 2000s to develop a robust, accessible, and inclusive ICT foundation to aid the individual countries' growth and establish ASEAN as an international ICT hub.

As such, these previous studies (Ahmed and Ridzuan, 2013; Latif et. al, 2017; Chen and Kimura, 2020; Cioacă, Cristache, Vuță, Marin, and Vuță, 2020; Cioacă et. Al, 2020; Jorgenson and Stiroh, 2000; Oliner and Sichel, 2000; World Bank, 2012) highlight the importance of the ICT sector in

the context of the U.S., the European Union, the South Asian, and the East Asian economic, financial, and sustainable development. This paper aims to look deeper the impact of the ICT sector on the regional development of Southeast Asia, especially with a particular focus in the lower income countries. Using the most updated data available, this research investigates related policy and regulations while also expanding the scope to conducting regional analyses, by interacting income dummies within the ASEAN countries with ICT-related variables.

The structure of this paper is as follows. Section 1, the Introduction, provides a background and literature review of the topic. Section 2 details the data and methodology and Section 3 explores the empirical results of this study. Section 4 concludes this paper with policy implications and insights.

2. Data and Methodology

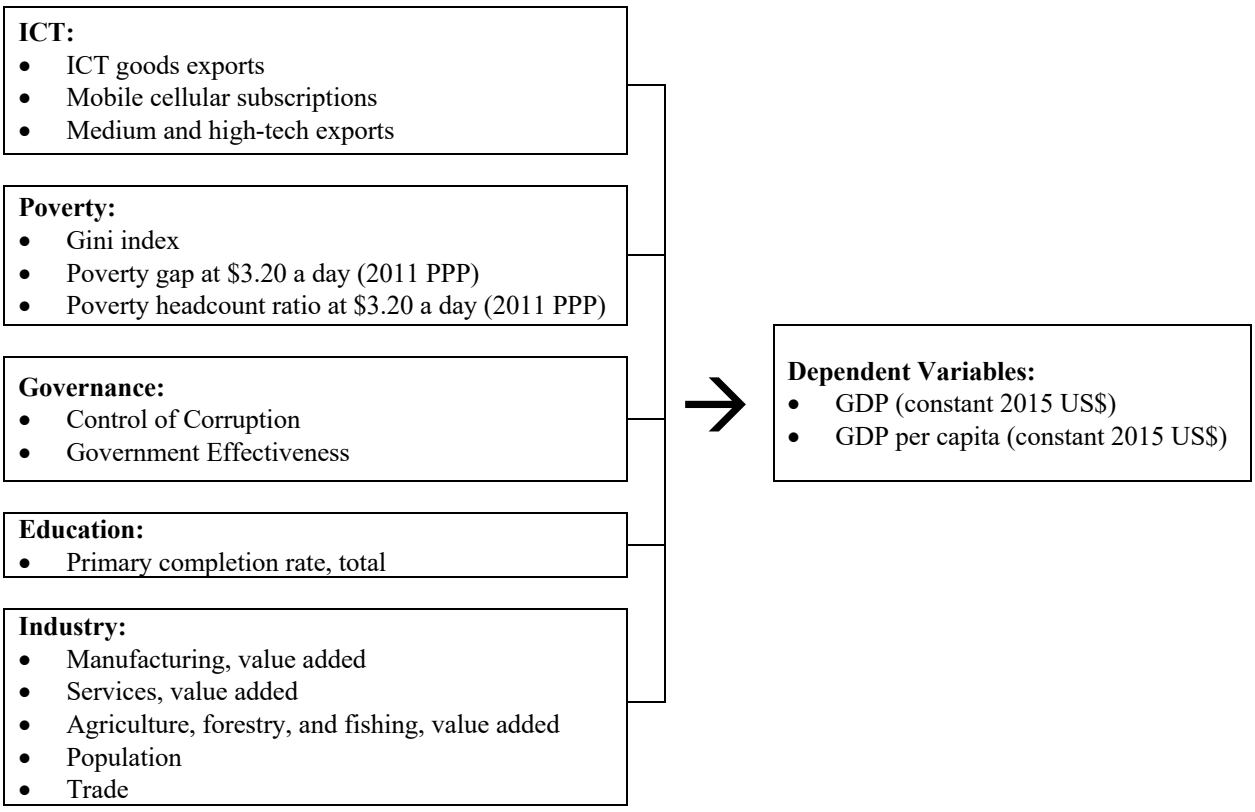
This paper utilizes panel data from 10 ASEAN countries (Brunei Darussalam, Cambodia, Indonesia, Myanmar, Lao PDR, Malaysia, Philippines, Singapore, Thailand, and Vietnam) over the span of 21 years from 2000 to 2020 to evaluate the impact of the ICT sector on regional development in Southeast Asia. Particular attention will be paid to lower income countries (Cambodia, Indonesia, Myanmar, Lao PDF, Philippines, Thailand, and Vietnam), as depicted in Figure 1, by creating a dummy variable entailing this factor. Descriptive statistics for all variables are available in Table 2, which are categorized based on the analytical framework in Figure 2. All data are extracted from the World Bank World Development Indicators. Constant prices and purchasing power parity (hereafter PPP) adjusted data are utilized to neutralize inflation effects.

Table 2 Descriptive Statistics for dependent, independent, and control variables

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
GDP (constant 2015 US$) (Log)	210	25.194	1.521	22.329	27.679
GDP per capita (Log)	210	8.269	1.376	5.736	11.021
Mobile cellular subscriptions (Log, Lag)	205	3.688	1.798	-3.552	5.227
ICT goods exports (Lag)	182	17.52	16.738	0.013	54.974
Medium and high-tech exports (Lag)	199	40.71	29.262	0	87.413
Gini index (Log)	65	3.642	0.116	3.353	3.865
Poverty gap at $3.20 a day (2011 PPP) (Log, Lag)	65	1.172	1.856	-2.303	3.357
Poverty headcount ratio at $3.20 a day (2011 PPP) (Log, Lag)	65	2.499	1.679	-1.204	4.346
Control of Corruption: Estimate	200	-0.264	1.004	-1.673	2.326
Government Effectiveness: Estimate	200	0.117	1.01	-1.618	2.437
Primary completion rate, total	143	94.883	11.92	51.284	121.658
Manufacturing, value added	208	19.493	6.22	7.453	31.953
Services, value added	201	46.273	10.253	25.251	70.948
Agriculture, forestry, and fishing, value added	209	15.345	12.075	0.03	57.14
Population (Log)	210	16.925	1.798	12.716	19.427
Trade (Log)	196	4.698	0.628	2.473	6.081

Notes: Variables marked with (Log) are log-transformed and (Lag) is lagged 1 year in empirical analysis.

Figure 2 Analytical Framework of the Impact of ICT on Development of ASEAN Countries



Most variables are log-transformed, and some are lagged by one year to tackle any potential endogeneity or reverse causality issues. The Variance Inflation Factor (hereafter VIF) test indicates that the variables do not exhibit high multicollinearity. The Hausman Test indicates that the difference in coefficients is not systematic, which allows the use of both fixed and random effects.

As such, the econometric model suggests the following hypotheses: (1) the role of the ICT sector is a significant contributing factor to growth amongst ASEAN countries, (2) the role of the ICT sector may work conditionally only for countries with good political governance, (3) lower value-added sectors (manufacturing, agriculture, low-skilled service industry) may trigger growth in lower income economies, supporting World Development Report 2020 and previous studies.

$$Y_{it} = \beta 0 + \beta 1(ICT_{it}) + \beta 2(Poverty_{it}) + \beta 3(Governance_{it}) + \beta 4(Education_{it}) + \beta 5(Industry_{it}) + \beta 6\,(Income_i) + \beta 7(ICT_{it} \times Income_i) + \varepsilon_{it} \quad (1)$$

The regression model is proposed as the equation above; (i) refers the country, (t) refers the year, ICT variables are ICT goods exports (ICTE), mobile cellular subscription (MCS), and medium and high-tech exports (TECHE). Other variables are categorized as poverty, governance, education, and industry as provide in Figure 2. Poverty includes poverty gap at $3.20 (PGAP), poverty headcount ratio at $3.20 (PHCR), Gini Index (GINI); governance includes control of corruption (COC), government effectiveness (GOV); education includes primary completion rate (PCR); and industry includes population (POP), trade in value added (TRD), agriculture in value added (AGRI), manufacturing in value added (MFT), and services in value added (SER); lastly, ε is the

error term. In addition to this, the ICT variables are interaction with the income dummy variable which is time invariant (1 refers to Brunei, Malaysia, Singapore; 0 are Cambodia, Indonesia, Myanmar, Lao PDF, Philippines, Thailand, and Vietnam).

3. Empirical Results

Equation (1) has been estimated for two dependent variables with pooled OLS. Given the equation, the results are provided in Table 2 below.

Table 3 Pooled OLS Estimation

	GDP (Log)				GDP per capita (Log)		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
ICT goods exports	0.035***	-0.007**	-0.000	-0.014***	-0.019***	-0.018***	-0.024***
	(0.007)	(0.003)	(0.001)	(0.002)	(0.003)	(0.003)	(0.003)
Mobile subs. (Log)	0.204***	0.308***	0.115***	-0.043	0.038	0.034	0.155***
	(0.073)	(0.044)	(0.032)	(0.044)	(0.048)	(0.045)	(0.054)
Medium, high-tech	0.009**	0.016***	-0.002*	0.005***	0.014***	0.013***	0.023***
	(0.004)	(0.003)	(0.001)	(0.001)	(0.003)	(0.003)	(0.002)
Poverty gap (Log)					-0.137***		
					(0.022)		
Headcount ratio (Log)						-0.129***	
						(0.021)	
Gini Index (Log)							-0.426
							(0.528)
Corruprtion				0.342***			
				(0.089)			
Governance				0.717***			
				(0.095)			
Primary completion				0.038***			
				(0.004)			
Population (Log)		0.600***	0.825***	0.898***			
		(0.051)	(0.014)	(0.015)			
Trade		0.003***	0.002***				
		(0.000)	(0.000)				
Manufacturing		0.049***	0.007				
		(0.010)	(0.005)				
Agriculture			-0.095***				
			(0.003)				
Services			-0.008***				
			(0.003)				
Income					0.781***	0.801***	1.028***
					(0.063)	(0.062)	(0.087)
Constant	23.519***	11.926***	12.239***	6.596***	7.867***	7.699***	8.259***
	(0.314)	(0.799)	(0.197)	(0.321)	(0.308)	(0.276)	(1.848)

Notes: ***, **, and * respectively notes significance levels at 1%, 5%, and 10%. The dependent variable is log transformed GDP (constant 2015 US$) for (1)-(4) and log-transformed GDP per capita for (5)-(7). Some independent variables (mobile cellular subscriptions; population; poverty gap; poverty headcount ratio; and Gini index) are log transformed. The White heteroskedasticity-consistent standard errors are in parenthesis. Income is a dummy variable where high-income countries (Brunei, Malaysia, and Singapore) are 1 and low-income countries (Cambodia, Indonesia, Myanmar, Lao PDR, Philippines, Thailand, and Vietnam) are 0. Variables marked with (Log) are log transformed and (Lag) is lagged 1 year in empirical analysis to avoid endogeneity issues.

Calculation (1), which is the most elementary form of the analyses, all ICT-related factors such as ICT goods exports, mobile cellular subscriptions, and medium, high-tech exports positively contribute to GDP; 1% increase of each variable is expected to increase GDP by 0.035%, 0.204%, and 0.009%, respectively. However, as shown in Calculations (2) and (3), when controlled by trade, agriculture, manufacturing, and services activities, only mobile cellular subscriptions remain significant, and ICT good exports are ruled out as a significant factor in the regional development of Southeast Asia. Medium and high-tech exports turn out to be a significantly positive contributing factor in a country's per capita GDP. This should be a very important finding that can be linked to policy implications. At the same time, further analysis is required to determine whether this works to all the countries. Calculation (4) indicate that when controlled by governance-related factors, such as government effectiveness and control of corruption, and education-related factors, the primary completion rate, ICT good exports, and medium and high-tech exports remain significant while mobile cellular subscriptions became an insignificant factor.

In terms of the relationship between ICT-related variables and GDP per capita, another proxy for regional economic development, indicated in Calculations (5), (6), and (7) separately that poverty and inequality related variables, poverty gap at $3.20 and poverty headcount ratio at $3.20 negatively affect GDP per capita. While the Gini index also affects regional development negatively, it is deemed insignificant, partially due to lack of data availability.

Table 4 Panel Regression

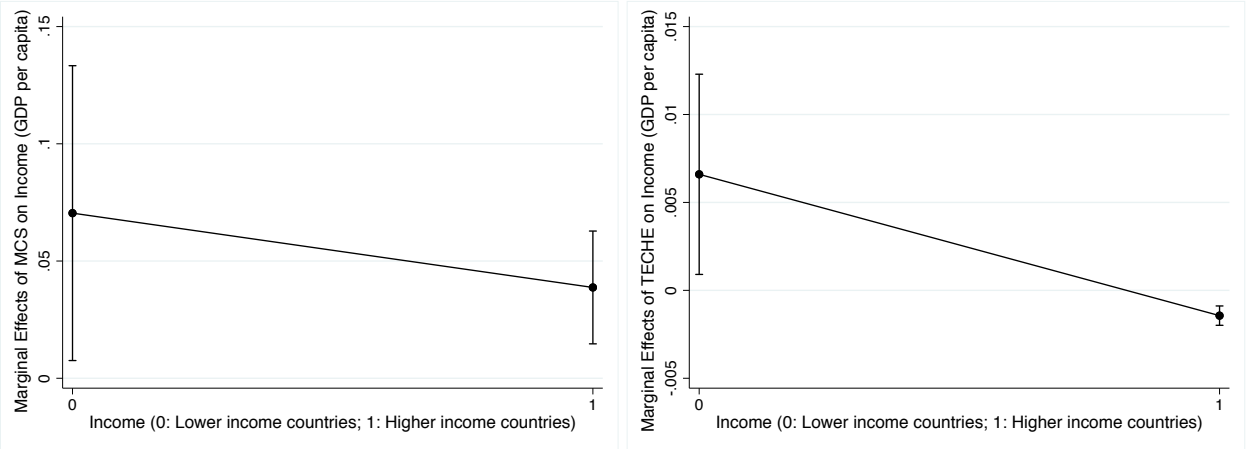
	GDP (Log)			**GDP per capita (Log)**			
	FE (1)	**FE (2)**	**FE (3)**	**FE (4)**	**FE (5)**	**RE (6)**	**RE (7)**
Mobile subs. (Log) (Lag)	0.217***	0.053	0.036	0.161***	0.152***	0.070**	
	(0.023)	(0.032)	(0.036)	(0.032)	(0.027)	(0.032)	
Medium, high-tech (Lag)	0.002	-0.002	-0.001	0.011***	0.011***		0.007**
	(0.004)	(0.001)	(0.001)	(0.002)	(0.002)		0.003
Poverty gap (Log) (Lag)				-0.056**			
				(0.016)			
Headcount ratio (Log) (Lag)					-0.063**		
					(0.018)		
Corruprtion			-0.140				
			(0.079)				
Governance			0.022				
			(0.140)				
Primary completion rate			0.009**				
			(0.003)				
Population (Log)		2.246***	2.729***				
		(0.441)	(0.503)				
Trade		0.001					
		(0.001)					
Manufacturing		-0.019**				-0.033***	-0.040***
		(0.008)				(0.007)	(0.005)
Agriculture		-0.030***				-0.035***	-0.045***
		(0.009)				(0.008)	0.004)
Services		-0.010**				0.003	0.007
		(0.003)				(0.004)	(0.006)
Income						2.031***	2.060***
						(0.419)	(0.316)
Income*Mobile subs. (Log) (Lag)						-0.032	
						(0.026)	
Income*Medium, high-tech (Lag)							-0.008***
							(0.003)
Constant	24.505***	-11.686	-21.426**	7.054***	7.024***	8.496***	8.689***
	(0.185)	(7.432)	(8.187)	(0.183)	(0.138)	(0.356)	(0.390)

Notes: ***, **, and * respectively notes significance levels at 1%, 5%, and 10%. The dependent variable is log-transformed GDP (constant 2015 US$) for (1)-(3) and log-transformed GDP per capita for (4)-(7). Some independent variables (mobile cellular subscriptions; population; poverty gap; poverty headcount ratio; income*mobile cellular subscriptions) are log transformed while some variables (mobile cellular subscriptions; medium, high-tech exports, poverty gap, poverty head count ratio; income*mobile cellular subscriptions; income*medium, high-tech exports are lagged. The White heteroskedasticity-consistent standard errors are in parenthesis. Income is a dummy variable where high-income countries (Brunei, Malaysia, and Singapore) are 1 and low-income countries (Cambodia, Indonesia, Myanmar, Lao PDR, Philippines, Thailand, and Vietnam) are 0. Unable to use income dummy variable for fixed and interaction effect analysis because it is time invariant Variables marked with (Log) are log-transformed and (Lag) is lagged 1 year in empirical analysis to avoid endogeneity issues.

As a sensitivity test, this study re-examines the dataset with panel regression. Although fixed effect tis used with priority given its efficiency in handling endogeneity issues, random effect is used as a supplementary when dealing with income dummy (1 refers to Brunei, Malaysia, Singapore; 0 are Cambodia, Indonesia, Myanmar, Lao PDF, Philippines, Thailand, and Vietnam), which is time-invariant. Overall, the results presented in Table 4 are similar to Table 3, confirming the robustness of the previous findings. Unlike the previous analysis this one interacts the income dummy with ICT-related variables, mobile cellular subscription in (6) and medium high-tech exports in (7) that provides interesting findings; both of them positively contribute to GDP per capita on their own, but their interaction with the dummy turned out to be negative when industry structure, such as manufacturing, agriculture, and service are controlled.

This provides important policy implications given that although the ICT factors positively contributes to ASEAN economies, they are particularly of importance to lower income countries.

Figure 3 Marginal Effects of ICT Factors on GDP per Capita



Notes: The figure on the left illustrates the marginal effects of mobile cellular subscriptions on GDP per capita, while the right one is for medium and high-tech exports on GDP per capita.

The significance of the income dummy can be investigated in depth with the marginal effect by differentiating the dependent variable, GDP per capita (denoted as y) in Equation (1) with respect to each ICT variable (Yoon and Moon, 2014). As a result, equation (2) is constructed as follows

$$\frac{\partial y_{it}}{\partial ICT_{it}} = \alpha + \beta \times Income_i \quad (2)$$

where the marginal effect of ICT is α for lower income countries (with dummy 0) and α + β for higher income countries (with dummy 1) (Yoon and Moon, 2014; Lee and Oh, 2021). For example, based on Column (6), α is 0.070 and $\alpha + \beta$ is $0.070 - 0.032 = 0.048$. Interestingly, Column (7) finds that the marginal effect turns out to be opposite where α is 0.007 and $\alpha + \beta$ is $0.007 - 0.008 = -0.001$. Figure 3 provides a visual illustration of the graph on the left side from Model (6) illustrates the marginal effect changing from 0.07 to 0.048 and the one on the right side from Model (7) depicts the changes in its signs, from 0.007 to -0.001, as explained above. This implies that a certain ICT factor, like medium and high-tech exports is a positive contributor to growth only in lower income countries. It is critical for policy makers and leadership in lower income countries to pay special attention to the ICT industry to boost their economies.

4. Policy Implications & Conclusion

The empirical findings of the study extrapolate on the importance of the development of ICT in the regional development of ASEAN countries, especially for economies with relatively low income. Firstly, the general correlation between ICT related factors and GDP and GDP per capita support the hypothesis that the role of the ICT sector is a significant contributing factor to growth amongst ASEAN countries. Secondly, encouraging good governance within each ASEAN member states would be crucial to fully experiencing the impact of the ICT sector. Moreover, the industry structure, in terms of lower value-added sectors such as manufacturing, agriculture, low-skilled service industry, plays an important role for relatively low-income countries (Brunei, Cambodia, Indonesia, Myanmar, Lao PDR, Philippines, Thailand, Vietnam).

According to the ASEAN Digital Integration Framework and the ASEAN Digital Integration Index Report 2021 (2021), the integration of digital transformation has accelerated over the years, especially in the midst of the COVID-19 crisis when many activities were restricted by the pandemic and its consequential restrictions in human interaction. In terms of social, economic, and even political activities, many of those have managed to cross over the physical barrier and became digitalized which allowed for new formations of connectivity amongst the general population (ASEAN, 2021). As such, the ASEAN Digital Integration Index (ADII) evaluates the progress of ASEAN's digitalization efforts (ASEAN, 2021). The findings of the report concluded that while ASEAN has managed to make strides in its digital integration efforts, compared to other countries in the Asia-Pacific region, ASEAN lacks in performance, capacity, and skills, which may be attributed to the heterogeneous nature of ASEAN member states in terms of development levels (ASEAN, 2021). Thus, such findings further imply the importance of the much-needed growth of the ICT sector within lower-income ASEAN countries.

In line with the ASEAN Digital Masterplan 2025 (ASEAN, 2015), it is without doubt that the ASEAN ICT industry is paving its way to become a potent digital community by encouraging investments in the field, incorporating ICT into other sectors for better inclusion and efficiency of services, and expanding as the global ICT hub it aspires to be in the near future. As such, digitization of various social, economic, and even political activities in terms of investments, management, production, and distribution of goods and services are encouraged to be endorsed by the involved parties, ranging from individual consumers to manufacturing firms to government officials as suggested by the findings of the study.

A myriad of efforts is to be expected from the ASEAN to boost the ICT sector for the growth of the ASEAN, both as individual member states and as a region. It is recommended that ASEAN member states primarily to increase the volume of medium and high technology exports. Medium and high technology exports are integral to a country's industrial development because it allows for structural digital transformation to occur. Moreover, the particular emphasis on medium and high technology exports is expected to greatly contribute to strengthening high-value industries, which are knowledge-intensive, skilled, and competitive. That being so, the growth of such industries will further play a part in accelerating the industrial growth of the economies. In addition, such improvements will inherently bring about other changes as a chain of events, including fostering technological innovations, increasing employment, and decreasing costs for the required changes to occur (World Bank 2020).

While furnishing the groundworks for technological development is important, another fundamental aspect of successful digitization is capacity building. The composition of ASEAN member countries varies with respect to each of the country's development levels. This indicates that while a united objective to have in mind is fully utilizing ICT for industrial development, the approach to such goal may come in different forms for each of the countries. On top of that, it is also recommended that while shaping digital and physical infrastructures, implementing regulations in the marketplace, and bolstering ICT industries on the macro-level and on the micro-level, individuals should be considered in the course of change. Basic access to mobile and internet technology should be granted as accessible, affordable, and safe by all, if not most of the population. This will provide a common ground where people will be able to become inspired to innovate and connect with others. Overall, going back up to the macro-level, every piece of digital connection, linkage, and interaction will augment the digital framework within each country and as these interactions expand beyond the national boundaries to the Southeast Asian region.

In hindsight, the limitations of the study suggest the need for follow-up studies. One shortcoming is that the proxies for measuring the impact of the ICT sector are rather elliptical considering the rapid advancements of technology in the present day. Another major caveat is missing data for some countries (mostly Brunei, Laos, Myanmar, and Singapore) during certain years (especially in the 2000s) for certain variables (Gini index, poverty gap at $3.20 a day (2011 PPP), poverty headcount ratio at $3.20 a day (2011 PPP)). Further research utilizing precise data pertaining to the presence of ICT in a given country may be necessary to supplant the paucity of research of the role of the ICT sector in the ASEAN region and will be reserved for future research.

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