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Linkage of Technological Innovation toward ICT base and Economic Output in CLMV Region

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ABSTRACT

The Fourth Industrial Revolution will change not only what we do but also who we are. It will affect our identity and all the issues associated with it (Schwab, 2016). The state of rising technological innovation and progress of the ICT-based era of modernization and globalization, particularly in developing countries, is driving the global economy into a new structure of transitional development and transformation. The paper examines the impacts of technological progress on economic output in the CLMV region from 1995 to 2016. The conventional estimation approaches of RE, MLE-RE, FE and FGLS estimation with/without robust standard error, provide accurate and consistent empirical outcomes. The crucial impact of technological progress, internet server connections and ICT and computer import products as proxies, is found to boost economic output and generate growth rate in the CLMV region. The findings suggest that policymakers should direct policy towards investment, trade in technology, and diversification to facilitate flows of capital, goods, and services, and support bringing business structures in line with technological innovation.

Keywords: Technological Innovation and Progress, Economic Output, Economic Significance Analysis, CLMV Region

JEL Classification: O3, C01

1. Background and Motivation

Technological innovation and progress towards greater information and communication technology (ICT) development can foster economic innovation, poverty reduction and robust economic growth by making accessible the empowering wealth of information available to people in both developed and developing countries. The act of transforming human behavior through digitalization and technological progress has placed the economy on a new path of transitional development. ICT has transformed many structures in the economy through reorganization of the economy, trade and foreign direct investment (FDI). However, despite increasing globalization, multinational enterprises (MNEs) have advantages through information asymmetry in market diversification as well as access to the latest innovations, such as big data and blockchain technology. So far, the internet technology is not yet the new frontier in Thailand, as access to internet connection and servers has yet to become a vital developing tool for the country.

The Fourth Industrial Revolution is a digital revolution that requires universal and reliable internet access; without stable and affordable access, many developing countries will not be able to fully participate in an increasingly mobile and digital-based economy. ICT plays a significant role in the development of each economic sector, particularly during liberalization process (Saidi, Hassen & Hammami, 2015). The theoretical framework suggests the crucial tool for a country to boost productivity via innovation in the factor production. The significant and positive relationship between ICT and economic growth is found in many empirical studies, both based developed and developing countries. Adak (2015), Alani (2012), Mefteh and Benhassen (2015), Çalışkan (2015), Farhadi, Ismail and Fooladi (2012), and Niebel (2014) confirmed the relationship by studying members of the OECD and the European Union (Edquist & Henrekson, 2006; Hanclova, Doucek, Fischer & Vltavska, 2015; Falk & Biagi, 2015). As suggested by Edquist and Henrekson (2006), with supporting evidence from Hagsten (2016), based on counting broadband-connections, the research stressed the importance of ICT for innovations and growth during the past three decades.

The primary of impacts of technological change are in promoting innovation, raising productivity and simulating economic growth and therefore economic well-being of human beings (Samimi, Ledary & Samimi, 2015). It has enabled enterprises and individuals to use technology more effectively and facilitate cost reductions and enhancing productivity, as well as increasing payoffs from investment (Çalışkan, 2015; Adak, 2015). More importantly, technology is an important factor for increasing the growth rate of the economy at the macro level, as well as profits and market shares of the firms at micro level (Çalışkan, 2015). In the study of Kuppusamy, Raman and Lee (2009) between private and government sectors, it confirmed that ICT investments made by the private sector seem to have contributed significantly to the country's growth compared to investments made by the government. In line with a large cross-sectional data, Mefteh and Benhassen (2015) and Farhadi et al. (2012) stated that the diffusion of new technology has accelerated the pace of economic growth. Hence, it is possible to conclude that ICT innovation and progress has a strong association with economic growth, particularly when the investment in new technologies is by the private sector.

The research question of this study is to find out what is the impact of technological innovation and progress on economic output in the CLMV region, and what recent progress has been made on technology development in CLMV region. Therefore, the main objectives of the study are firstly to examine the impacts of technological innovation and progress on economic output. Secondly, it is to measure the economic significance of technology innovation and progress to economic output through a proxy. The study is organized as follows: Section 1 introduced the backgrounds and motivations of the study, Section 2 presents the stylized facts of technological progress and innovation and economic output. Section 3 describes the methodology and data set. Section 4 discusses the empirical outcomes and technical observations, and section 5 makes some concluding remarks and highlights policy suggestions.

2. Stylized Facts of Technological Innovation and Economic Growth

Existing theories on the relation of capital, labor and technological innovation with economic growth have been long debated in seminal papers such as Solow (1956) and Romer (1990); while innovation and entrepreneurship are highlighted by Schumpeter (1983) as presented by Śledzik (2013), as the main drivers for sustainable economic growth. Technology as a factor is suggested to complement capital and labor in the sense that it brings productivity gains in production by introducing new knowledge and innovations (Solow, 1956; Romer, 1990; Gottfries, 2013). The literature treats technology in two ways: the neoclassical model of growth suggests that technology is an exogenous factor, and in this case, one should expect income to converge between countries over time because of every economy's constant access to technological progress. On the other hand, endogenous growth theory does not assume convergence since it attempts to explain how the level of technology varies. Both theories do support the characteristics of diminishing marginal returns on investments. Consequently, expectations about higher returns on investment where there are lower stocks of capital and labor are anticipated (Gottfries, 2013).

Recent empirical studies have investigated the impact of technological progress and investment of the ICT base on economic output via either cross-section or country level analysis. Das, Khan and Chowdhury (2016) stressed that ICT diffusion, through increased internet and mobile cellular phone subscriptions, can positively affect economic growth (Sassi & Goaied, 2013; Shahiduzzaman & Alam, 2014) in three different ways. Firstly, it can assist economy-wide technology diffusion and innovation. Secondly, it can improve the quality of decision making by economic agents. And finally, it can raise the output level by creating demand for goods and services and by lowering costs of production (Vu, 2005).

Waverman, Meschi and Fuss (2005) argued that an average of 10 additional mobile phones per 100 people would increase per capita GDP growth by approximately 0.59 percent in low income countries. Although the development of ICT infrastructure has been a major challenge, there has been a considerable rise in the number of Internet and mobile users in many developing countries in Asia. In few cases such as China, India and Sri Lanka, these numbers are as high as 80.76%, 69.92% and 91.63%, respectively (International Telecommunication Union, 2014). Interestingly, the number of mobile subscriptions in many Asian countries such as Indonesia, Korea, Malaysia, Philippines, Singapore and Thailand exceed their respective total population.

The empirical analysis of macro-level effects of technological progress on economic growth in developing and emerging countries examined the comparability and generalizability of estimated results. Niebel (2014) noted that investment in ICT is seen as a key driver of productivity growth. Kuppusamy et al. (2009) carried out research on data from both the private and public sector over the period 1992-2006 and found that ICT investments undertaken have paid off, albeit at different scales in different economic sectors. Those of private sector seem to have contributed mainly to the country's growth as opposed to the government's investment. Thus, investment in ICT resulting in benefit to social well-being due to greater ICT-enabled community will translate into higher economic growth. Adak (2015) found similarly that there was a significant impact of technological progress and innovation on economic growth in Turkey. Çalışkan (2015) stated that technological development made very important contributions to the economic and society. Additionally, Alani (2012) pointed out that growth in technological progress resulted in economic growth, regardless of whether it increased capital productivity or labor productivity.

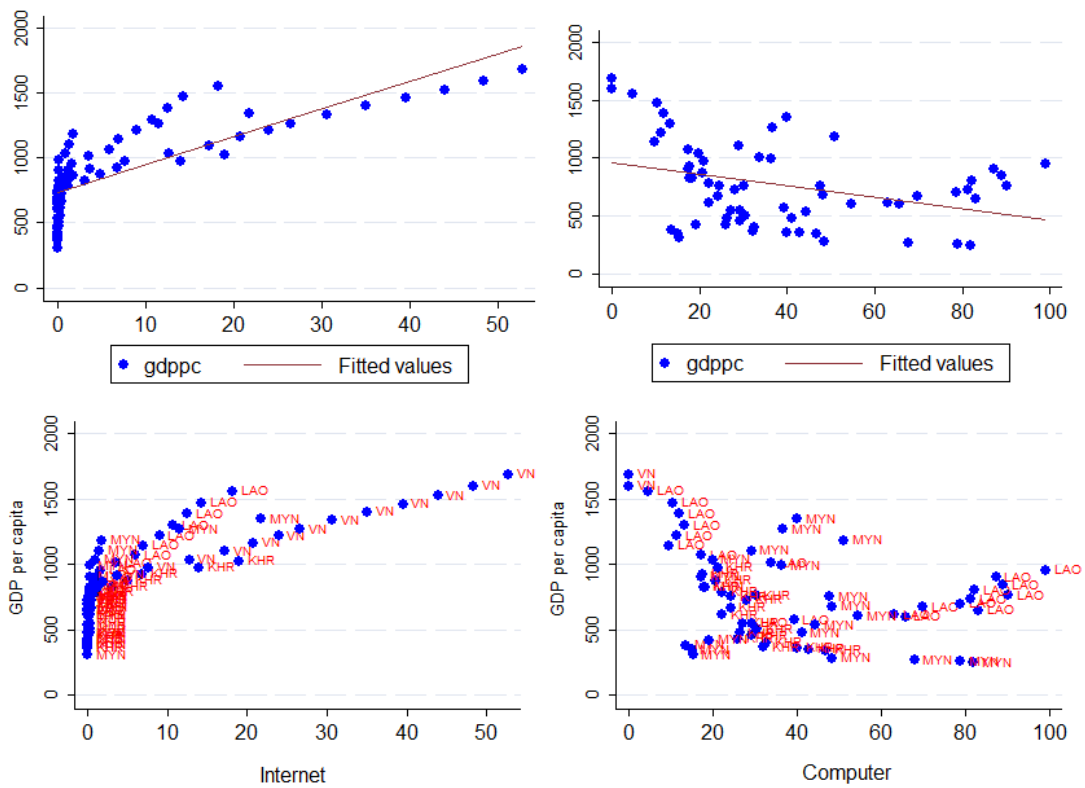
With a large cross-section of 50 ICT goods importing countries, ICT investment has had a significant impact on economic growth not only as traditional investment, but also as a tool to boost efficiency in growth. In addition, it is proposed that a higher level of ICT capital stock per capita will allow an economy to achieve a higher growth rate for given levels of growth in labor and capital inputs. Farhadi et al. (2012) applied dynamic GMM based on panel data from 159 countries over the period 2000 to 2009 and found that there is a positive relationship between growth rate of real GDP per capita and ICT. Similarly, with 43 countries over the period 1995-2011, Mefteh and Benhassen (2015) suggest a positive and significant relationship. Based on a sample of 101 countries in the period 1995-2015, using an augmented Cobb-Douglas production function with GDP growth as dependent variable, Liljevern and Karlsson (2017) divided the sample into four income groups- high, upper middle, lower middle and low, to account for income disparities across countrie bs and show that there are only significant contributions to growth in the top-three richest countries, with exception for the middle-income countries when controlling for fixed effects.

3. Methodology and Data Collection

3.1. Data calculation and source

The data was obtained from the World Bank's World Development Indicators (WDI). The study uses GDP per capita growth rate as the proxy of explained variable, representing economic output. Internet server connection (% radio of population) and computer, communication and ICT (% of export) are the explanatory variable, denoted as a proxy for technological progress. To capture the causal relationship in the system equation, other controlled variables such trade openness, FDI and CPI (as the proxy of inflation rate) are included in our analysis. The sample observations are converted into natural log form. The descriptive statistics are presented in the Appendix 1. The figure below provides a graphic illustration of the relationship between GDP per capita and internet connections, and with import of computers and related products.

Figure 1. Scatter graphic of real GDP per capita to internet and computer as explanatory variables



Source: Authors' illustration based on WDI data.

3.2. Empirical methodology

Due to increasing numbers of internet connections and usage in the CLMV region, and based on the existing body of literature, the study derives the specification function of the impact of technological innovation/progress and economic output towards the controlled variables as follows:

$$\log(y_{i,t}) = \alpha + \beta \log(Tech_{i,t}) + \varphi W'_{i,t} + \mu_{i,t} \qquad (1)$$

Where,

- $y_{i,t}$ is per capita GDP growth rate at time t for country i
- $Tech_{i,t}$ denotes technological p innovation and progress, proxied by internet connections and computer and ICT imports as % of total import
- $W'_{i,t}$ is the matrix of controlled variables, containing variables such as foreign direct investment (FDI) as the percentage of GDP (%), trade openness and inflation rate (CPI)
- $\mu_{i,t}$ is an error (disturbance) term which is assumed to be a Gaussian distribution, with mean and variance, $N(0, 1)$

The baseline model including and excluding control variable is employed. The other models incorporate dummy variables and interaction with the proxy for technological innovation and progress to examine the different effects in the countries of interest, namely Cambodia, Lao PDR, Myanmar and Vietnam. To examine the effect from individual country and time dummy, a binary variable which takes the value of 0 or 1 is employed. The study subscripts its function as follows: consider country dummy $CD_r = 1$ where r is the evaluated country, e.g. $CD_r = 1$ if $r = cambodia$ and 0 otherwise. As the result, we denote as follows:

$$\text{Country dummy } = \theta_{rt} CD_r \qquad (2)$$

Where, country dummy, (CD_r) and $r = 1, \dots, R$ is dummy variable taking number 1 for country r, and 0, otherwise. It is calculated by multiplying with the country dummy variable. With regard to time dummy, let's denote $\tau_j T_j$ as the time trend effect or time dummy where τ_j is the parameters of time trend,

T_j. It equals to 1 on year j and 0 otherwise. For any given year j, denote the function by setting $T_j = 1$ for j equates to determined period and 0 otherwise. As the result, we get an expression as follows:

$$\text{Time dummy} = \sum_{j=1}^{T-1} \tau_j T_j \tag{3}$$

From equation (1), (2) and (3), we can write a new specification function of technological p innovation/progress and economic output in CLMV region as follows:

$$\log(y_{i,t}) = \alpha + \beta \log(Tech_{i,t}) + \theta_{rt}CD_r + \sum_{j=1}^{T-1} \tau_j T_j + \varphi W'_{i,t} + \mu_{i,t} \tag{4}$$

Equation (4) will be estimated using panel data methods, namely fixed effect (FE) and random effect (RE) models, MLE-RE and FGLS estimation. A brief description of panel data model is explained as follows. Consider an explained variable, $(y_{i,t})$ and a set of explanatory variables, $(x'_{i,t})$ at time (t) and cross-section (i). Control variable $(w'_{i,t})$ is incorporated into the regression equation. Accordingly, we get the regression equation for panel data analysis as follows:

$$y_{i,t} = \alpha + \eta x'_{i,t} + \psi w'_{i,t} + v_i + \varepsilon_t \tag{5}$$

Where, α is constant term and $\mu_{i,t} = v_i + \varepsilon_t$ is a random effect across the country. From equation (5), Hsiao (2014) discloses that the pooled OLS estimator takes into account the country specific effect; accordingly, panel data models based on FE and RE estimators are used to eliminate those problems by considering the assumptions as follows. FE assumes that the slopes are common and differ in intercept and allows for unobservable country heterogeneity whereas the RE estimator considers unobservable country heterogeneity effect but flexible of variation across countries. Unlike FE, the RE estimator incorporates these effects into error term which is assumed to be uncorrelated with the dependent variable (Hsiao, 2014). It is worth noting that, since time-invariant variables such as distance and common languages as well as religions were removed in FE estimator for which leads it to be less efficient. Accordingly, to eliminate that issue, RE estimator takes these factors into account. To select whether FE or RE estimator is appropriate, based on Hausman (1978), the null hypothesis is that difference in coefficients not systematic and vice versa for the alternative one.

Moreover, it is worth noting that the OLS estimator is biased, inconsistent and inefficient due to autocorrelation, or serial correlation (Greene, 2012). The empirical result is thus theoretically not reliable. Accordingly, other estimators take into account these issues. In the presence of heteroskedasticity of error term, the FGLS estimator uses weighted least squares (WLS) to correct for consistency and efficiency in the presence of heteroskedasticity and can be applied to a linearized model. FGLS, in contrast to RE or FE estimator, assumes orthogonality between explanatory variables and the unobserved heterogeneity (Baltagi, 2008). In empirical studies it is revealed that it is fitted perfectly to small sample size, meaning that it is sensitive to small sample size observations, and has the lowest bias. Consequently, it is perfectly fitted to our study where it consists of only 4 cross-sections with a sample of 79 observations. The method applies a weighted matrix to estimate the parameter errors of heteroskedasticity. For the weighted matrix, $\Omega_{i,j}$ to be parameterized to model cross-sectional correlation, they must be square (balanced panels). Our dataset is strongly balanced. According to Imbens and Wooldridge (2009), FGLS weighs the observations in line to the square root of their variance. It is given by:

$$\hat{\beta}_{FGLS} = (x^{-1}\Omega^{-1}x)^{-1}y = \left(\sum_{i=1}^{n} x'_i \sum x_i{}^{-1}\right) \sum_{i=1}^{n} x'_i \sum x_i{}^{-1} \quad (6)$$

It can be showed that even if the weights used in FGLS estimation are biased (resulting in a biased estimation of the residuals variance), FGLS would still provide consistent estimates due to the variance matrix of the error terms applied transformation technique (Manning, 1998). Equations (1) and (4) will be estimated using FGLS, FE, RE and MLE-RE estimators with a diagnostic test of Breusch-Pagan/Cook-Weisberg to test for heteroskedasticity. MLE-RE is also employed to check the robustness of standard error (SE) in increasing an accuracy of estimation. Lastly, it will also capture more detail of panel data approach, they can be found in Hsiao (2014), Hausman (1978), Baltagi (2008), Imbens and Wooldridge (2009), Manning (1998) and Greene (2012).

4. Empirical Results and Discussions

In this section, the study aims to discuss the empirical outcomes from the baseline regression model. Four estimators, namely RE, MLE-RE, FE and FGLS are used to estimate equations (1) and (4) in line with controlling dummy variables of cross-section term. The variables are multiplied by cross-section to test technological innovation and progress. The empirical results are shown in Table 1, 2 and 3, 4 for estimation of MLE-RE and FE without robust SE and RE and FE with robust SE respectively, and Table 5 shows the results of FGLS estimation.

4.1. Preliminary results

The overall statistical significance of the estimation is supported by the F-statistics for all models. This suggests that the proposed estimation models are econometrically and methodologically justified. Table 1 reports models (1), (2) and (3), the study estimating technological innovation and progress through a proxy of internet server connections with and without controlled and dummy variables. Models (4), (5) and (6) of the study uses import of computer and ICT product as the proxy variables. It is estimated with and without controlled and dummy variables similar models (1), (2) and (3). Models (1), (2) and (3) reveal a statistically significant positive relationship between internet server connections and economic output. This can be interpreted as a 1% change of internet server connections, leads to an increase of 0.10%, 0.05% and 0.038% in economic output in CLMV countries. It supports the idea of rising investment in ICT through increasing connections to the internet in the recent period. Models (4), (5) and (6) conversely show a negative relationship. A possible reason is due to the fact that CLMV countries, particularly Cambodia and Myanmar, have had trade deficits for the last decade. Thus, a big amount of import results in decreasing economic output if government expenditure or population is exclusive. Looking closely at controlled variables such as FDI, trade and CPI, they are positively associated with economic growth and are statistically significant. Simply, this reflects the sense of rising capital flows into CLMV region as well as other developing world after the global financial crisis in 2009. Year-on-year, FDI approximates nearly 18% contributing to ASEAN. CPI is negatively related to economic output, potentially due to rising world fuel price which caused increases in the price level. Nevertheless, the inflation rate has not caused decreased economic growth since in CLMV countries the gap of the overall price level is relatively and comparatively modest, approximated at an annual average of 3.5%. It potentially indicates a better destination for investment and trade compared to nearby neighbors.

Turning to FE results, it is similar to those of Table 1. It shows a statistical significance at 1% for all proposed models. The statistical significance of explaining economic output remains the same. Internet server connections is positively related to economic output at 1% level of significance. It reflects what the World Bank stated in 2017 that progress is possible. Effective ICT policy reform can trigger greater private investment in broadband infrastructure and make internet access more affordable. The import of computers is negatively associated with growth. Control variables are positively correlated with economic output. More importantly, with respect to the dummy effect interaction with country and technological progress variables, the model indicates a negative relationship with economic output. A few variables are dropped due to the correlation.

4.2. Robustness checks

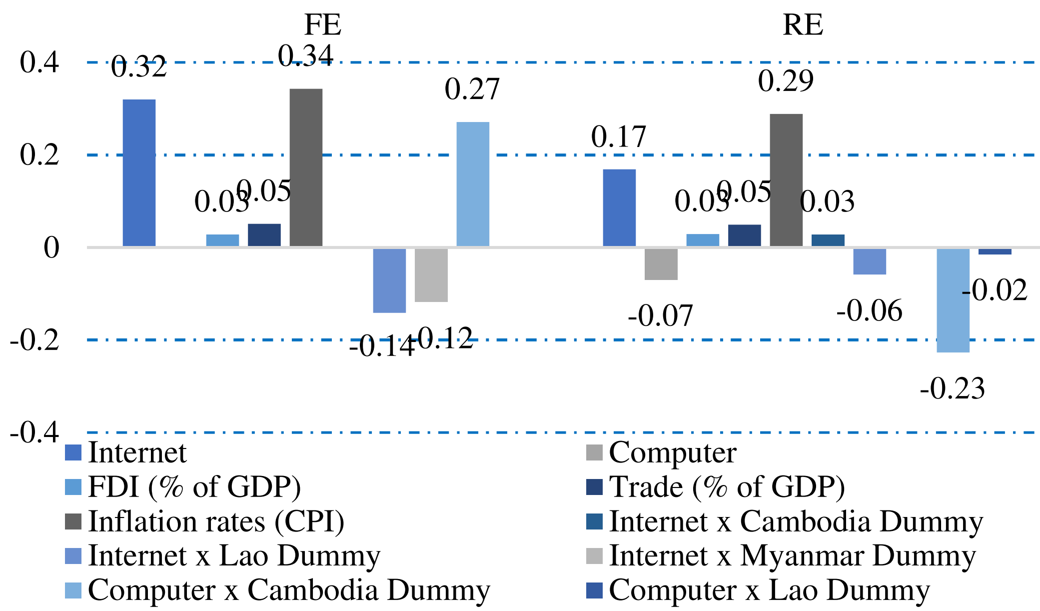
The study now reports the empirical outcomes of robust standard error (SE) in Tables 3 and 4. Table 3 shows internet server connections is positively and statistically significant in explaining economic output. Control variables lost their explanatory power if we estimate the baseline regression equation separately between technological progress and explained variable. Conversely, it is significant estimating with the full specification function. Our key variables of interest are internet server connections since the central objective of the study is to examine the impacts of technological innovation and progress on economic output.

More importantly, control variables such as FDI, trade openness and CPI are jointly related in explaining economic output as well. Furthermore, the estimated magnitudes of the parameters tend to be stable across different model specifications. These findings are encouraging since it indicates the robustness of our estimated parameters, and hence, a lower risk that our estimates are biased (Estrada, 2010). Overall, our evidence fits perfectly in line with the empirical literature, which suggests that technological progress measured by internet server connections and importation of computer and communication plays a significant and essential role in boosting economic output and growth.

4.3. Economic significance analysis

Next, the study measures the estimated regression of the significant factors. It is calculated from multiplying the estimated coefficient of the variable and its standard deviation (SD). The largest and smallest impacts are presented in Figure 2. Economic output is largely driven by internet-based technology followed by FDI, trade and inflation rate. This suggests the important role of the adoption and transformation through usage ICT both in trade and investment by firms. Furthermore, it finds that these countries posted strong growth in internet user numbers over the past 12 months, with users in Laos up an impressive 83% year-on-year versus January 2016. Cambodia – also at the lower end of the regional rankings, posted strong growth with internet users growing by 43% over the course of 2016 to reach 45% penetration in January 2017 (Kemp, 2017).

Figure 2. Economic significance of technological innovation/progress regression: Fixed effect model with robust standard error



Source: Author's estimates.

5. Concluding Remarks

The empirical analysis yields evidence that is strongly supportive of the positive linkage between technological innovation and progress measured as internet connection and economic growth. Our findings indicate that overall technology investment exerted a significant and positive effect on real per capita GDP growth in the CLMV region during the observed period. The evidence is robust and consistent across different specifications for cross-sectional analysis, and while using dummy variables to measure the interaction between cross-section and the determinant variable. There are a number of key messages which emerged from our empirical analysis for CLMV countries policymakers. Above all, it suggests that technological progress and innovation will be a key ingredient of the region's medium and long-run growth. Another important means of furthering technology investment is to improve the investment climate and trade via technological means in addition to augmenting the supply of investment in ICT by foreign investors to bring in new technology and management, thus boosting the domestic economy's productivity and efficiency.

Table 1. Estimation of impact of technological progress on economic growth (MLE-RE model)

Economic output	**Baseline regression equation, MLE – RE**					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
FDI		0.078***	0.066***	0.117**	0.120***	0.043*
		(3.88)	(3.98)	(3.02)	(3.5)	(2.55)
Trade		0.018	0.021*	0.053**	0.065***	0.024*
		(1.53)	(2.06)	(2.62)	(3.76)	(2.4)
CPI		0.353***	0.380***	0.393***	0.381***	0.364***
		(7.56)	(8.73)	(11.45)	(12.36)	(5.77)
Internet server connections	*0.107****	*0.051****	*0.038****			*0.054****
	(18.33)	*(6.85)*	*(6.18)*			*(3.82)*
Internet x Cambodia			0.055***			0.024*
			(6.0)			(2.08)
Internet x Lao			-0.005			-0.054***
			(-0.43)			(-3.94)
Internet x Myanmar			0.005			
			(0.57)			

Table 1. (Continued)

Economic output	**Baseline regression equation, MLE – RE**					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Computer				*-0.079**	*-0.059*	*-0.105****
				(-2.03)	*(-1.55)*	*(-4.33)*
Computer x Cambodia					-0.220***	-0.146***
					(-8.25)	(-10.05)
Computer x Lao					-0.016	-0.009
					(-0.62)	(-0.74)
Constant	6.763***	5.062***	4.962***	4.918***	5.122***	5.540***
	(97.43)	(22.46)	(22.81)	(16.71)	(25.18)	(19.17)
Time dummy	Yes	Yes	Yes	Yes	Yes	Yes
Cross–sectional dummy	Yes	Yes	Yes	Yes	Yes	Yes
Fitted model	124.56***	175.19***	208.67***	83.12***	115.75***	177.77***
Observations	73	72	72	57	57	51

Note: t-statistics in parentheses and *** p<0.01, ** p<0.05 and * p<0.1.
Source: Author's estimates.

Table2. Estimation of impact of technological progress on economic growth (FE model)

Economic output	**Baseline regression equation, FE**					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
FDI		0.0796***	0.0674***	0.120**	0.107**	0.042*
		(3.82)	(3.82)	(2.96)	(3.29)	(2.36)
Trade		0.02	0.022*	0.057**	0.049**	0.025*
		(1.63)	(2.06)	(2.69)	(2.88)	(2.40)
CPI		0.356***	0.383***	0.393***	0.350***	0.433***
		(7.37)	(8.33)	(10.99)	(11.58)	(5.39)
Internet server	*0.107****	*0.051****	*0.093****			*0.102****
connections	*(18.07)*	*(6.56)*	*(9.37)*			*(5.26)*
Internet x Lao			-0.06***			-0.131***
			(-4.82)			(-5.47)
Internet x Myanmar			-0.05***			-0.064**
			(-4.35)			(-3.38)
Internet x Vietnam			-0.0548***			
			(-5.63)			

Table 2. (Continued)

Economic output	**Baseline regression equation, FE**					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Computer				*-0.0799*	*-0.706****	*-0.056*
				(-1.97)	*(-5.74)*	*(-1.15)*
Computer x Cambodia						0.174
						(1.05)
Computer x Lao					0.618***	-0.094
					(4.98)	(-1.51)
Computer x Myanmar					0.808***	
					(5.47)	
Constant	6.760***	5.037***	4.938***	4.895***	5.674***	4.819***
	(391.13)	(24.15)	(23.75)	(20.11)	(23.36)	(11.69)
Time dummy	Yes	Yes	Yes	Yes	Yes	Yes
Cross – sectional dummy	Yes	Yes	Yes	Yes	Yes	Yes
Adjust r square	0.7534	0.6673	0.7242	0.3254	0.3880	0.0390
Fitted model	326.53***	194.18***	176.95***	49.56***	57.13***	124.35***
Observations	73	72	72	57	57	51

Note: t-statistics in parentheses and *** $p<0.01$, ** $p<0.05$ and * $p<0.1$.
Source: Author's estimates.

Table 3. Estimation of impact of technological progress on economic growth (RE model with robust standard errors)

Economic output	**Baseline regression equation, RE**					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
FDI		0.021	0.007		0.120**	0.043***
		(0.40)	(0.14)		(3.03)	(4.86)
Trade		-0.019	-0.015		0.065*	0.024***
		(-0.61)	(-0.51)		(2.07)	(7.08)
CPI		0.126	0.091		0.381**	0.364***
		(0.70)	(0.40)		(2.68)	(3.84)
Internet server	*0.107****	*0.10**	*0.074***			*0.054***
connections	*(5.61)*	*(2.15)*	*(2.82)*			*(2.81)*
Internet x Cambodia			0.097***			0.024**
			(5.01)			(2.58)
Internet x Lao			0.035			-0.054***
			(1.12)			(-7.06)
Internet x Myanmar			0.034			
			(1.34)			

Table 3. (Continued)

Economic output	**Baseline regression equation, RE**					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Computer				*-0.271****	*-0.059*	*-0.105****
				(-4.38)	*(-1.38)*	*(-4.63)*
Computer x Cambodia					-0.220***	-0.146***
					(-6.59)	(-31.61)
Computer x Lao					-0.016	-0.009*
					(-0.40)	(-2.38)
Constant	6.763***	6.263***	6.438***	7.440***	5.122***	5.540***
	(88.21)	(7.17)	(6.02)	(37.01)	(6.98)	(10.87)
Time dummy	Yes	Yes	Yes	Yes	Yes	Yes
Cross – sectional dummy	Yes	Yes	Yes	Yes	Yes	Yes
Adjust r square	0.7534	0.7517	0.8119	0.1075	0.8688	0.9694
Observations	73	72	72	62	57	51

Note: Robust t-statistics in parentheses and *** $p<0.01$, ** $p<0.05$ and * $p<0.1$.
Source: Author's estimates.

Table 4. Estimation of impact of technological progress on economic growth (FE model with robust standard errors)

Economic output	**Baseline regression equation FE base**					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
FDI		0.0796**	0.0674*		0.107	0.0421*
		(6.51)	(5.84)		(2.82)	(8.68)
Trade		0.0195	0.0224*		0.0493	0.0247*
		(2.53)	(4.95)		(3.14)	(5.75)
CPI		0.356*	0.383*		0.350	0.433
		(3.50)	(3.77)		(2.79)	(3.49)
Internet server	*0.107**	*0.0505*	*0.0927***			*0.102**
connections	*(5.54)*	*(2.59)*	*(8.24)*			*(6.59)*
Internet x Lao			-0.0600**			-0.131*
			(-6.92)			(-6.81)
Internet x Myanmar			-0.0500**			-0.0639*
			(-7.16)			(-6.76)
Internet x Vietnam			-0.055***			
			(-32.85)			

Table 4. (Continued)

Economic output	**Baseline regression equation FE base**					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Computer				*-0.277*	*-0.706**	*-0.0564*
				(-4.17)	*(-5.43)*	*(-1.82)*
Computer x Cambodia						0.174*
						(5.05)
Computer x Lao					0.618*	-0.0935
					(8.81)	(-1.75)
Computer x Myanmar					0.808*	
					(4.48)	
Constant	6.760***	5.037**	4.938**	7.462***	5.674*	4.819*
	(858.25)	(11.44)	(11.41)	(32.35)	(8.13)	(8.71)
Time dummy	Yes	Yes	Yes	Yes	Yes	Yes
Cross – sectional dummy	Yes	Yes	Yes	Yes	Yes	Yes
Adjust r square	0.7534	0.6673	0.7242	0.1075	0.3880	0.0390
Observations	73	72	72	62	57	51

Note: Robust t-statistics in parentheses and *** $p<0.01$, ** $p<0.05$ and * $p<0.1$.
Source: Author's estimates.

Table 5. Estimation of impact of technological progress on economic growth (FGLS model)

Economic output	**Baseline regression equation, FGLS**					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
FDI		0.0796***	0.0674***	0.120**	0.107**	0.042*
		(3.82)	(3.82)	(2.96)	(3.29)	(2.36)
Trade		0.02	0.022*	0.057**	0.049**	0.025*
		(1.63)	(2.06)	(2.69)	(2.88)	(2.4)
CPI		0.356***	0.383***	0.393***	0.350***	0.433***
		(7.37)	(8.33)	(10.99)	(11.58)	(5.39)
Internet server	*0.107****	*0.051****	*0.093****			*0.102****
connections	*(18.07)*	*(6.56)*	*(9.37)*			*(5.26)*
Internet x Lao			-0.06***			-0.131***
			(-4.82)			(-5.47)
Internet x Myanmar			-0.05***			-0.064**
			(-4.35)			(-3.38)
Internet x Vietnam			-0.055***			
			(-5.63)			

Table 5. (Continued)

Economic output	**Baseline regression equation, FGLS**					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Computer				*-0.0799*	*-0.706****	*-0.056*
				(-1.97)	(-5.74)	(-1.15)
Computer x Cambodia						0.174
						(1.05)
Computer x Lao					0.618***	-0.094
					-4.98	(-1.51)
Computer x Myanmar					0.808***	
					-5.47	
Constant term	6.760***	5.037***	4.938***	4.895***	5.674***	4.819***
	(391.13)	(24.15)	(23.75)	(20.11)	(23.36)	(11.69)
Time dummy	Yes	Yes	Yes	Yes	Yes	Yes
Cross – sectional dummy	Yes	Yes	Yes	Yes	Yes	Yes
Adjust r square	0.7534	0.6673	0.7242	0.3254	0.388	0.039
Observations	73	72	72	62	57	51

Note: t-statistics in parentheses and *** p<0.01, ** p<0.05 and * p<0.1.
Source: Author's estimates.

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Appendix

Table 1a: Data description and source from WDI, the World Bank (1990 – 2016)

Variable		Obs.	Mean	SD	Min	Max
Explained variable						
GDPPC	GDP per capita is gross domestic product divided by midyear population. GDP per capita (constant 2010 US$)	88	6.645	0.487	5.506	7.479
Explanatory variables						
Technological progress variables						
Internet	Individuals using the Internet (% of population)	73	-0.408	3.144	-8.912	3.965
Computer	Share of ICT goods imports (% total goods imports) and Communications, computer, etc. (% of service imports, BoP)	62	3.471	0.675	1.534	4.596
Control variables						
FDI	Foreign direct investment, net inflows (% of GDP)	79	1.415	0.666	-1.374	2.333
Trade	Trade (% of GDP). Trade is the sum of exports and imports of goods and services	83	3.732	2.065	-1.787	5.219
CPI	Inflation, consumer prices (annual %)	88	4.084	0.792	1.713	5.008
Dummy based variables, 1 for determined period and 0 otherwise						
Internet x Cambodia Dummy		73	-0.217	1.176	-5.142	2.944
Internet x Lao Dummy		73	0.040	1.087	-4.640	2.901
Internet x Myanmar Dummy		73	-0.494	1.860	-8.794	3.082
Internet x Vietnam Dummy		73	0.263	1.914	-8.912	3.965
Computer x Cambodia Dummy		62	1.064	1.562	0.000	3.845
Computer x Lao Dummy		62	1.213	1.798	0.000	4.596
Computer x Myanmar Dummy		62	1.194	1.713	0.000	4.405
Computer x Vietnam Dummy		62	0.000	0.000	0.000	0.000

Source: Author’s calculation