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Development of Telecommunications Sector in Cambodia, Laos, Myanmar and Vietnam and Impacts on Economic Growth: An Analysis with Pooled Mean Group Estimator

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ABSTRACT

Telecommunications is regarded as an essential infrastructure for national economic development and competitiveness. In developing countries, telecommunications development can be a means to achieve economic growth. This study reviews the development of telecommunications sector and examines its impacts on economic growth in the CLMV countries (Cambodia, Laos, Myanmar, and Vietnam) over the period of 2000 to 2015 using the pooled mean group estimator (PMGE). The results show that fixed line telephony subscription, mobile phone subscription and internet users have positive correlations with economic growth in the CLMV countries. In addition, the telecommunications sector is different for each ASEAN country, and it must correspond to each social, political and economic needs. As a region, ASEAN trends towards different forms of deregulation, liberalization of markets and privatization of the telecommunications authorities. The result provides a guideline to implement reforms in the ICT sector and economic development of CLMV countries. This study concludes that telecommunications are a key driver of CLMV economic growth.

Keywords: Telecommunications; economic impact; economic growth; CLMV countries; pooled mean group estimator.

1. BACKGROUND OF DEVELOPMENT OF TELECOMMUNICATIONS SECTOR IN CLMV COUNTRIES

This paper begins with the review of the development in telecommunications sector in CLMV countries including Cambodia, Laos, Myanmar and Vietnam as follows:

1.1. Cambodia

A remainder of the least developed countries and poor countries in Southeast Asia, despite its status as one of its communications infrastructure expansion and upgrade Cambodia's efforts are bearing fruit. The tumultuous Khmer Rouge, there were only a few days remaining before the infrastructure. Jump-started with digital technology as a result of its telecommunications infrastructure, Cambodia crossed the rebuilding of the fixed-line market and the rapid replacement technology initiatives. Not surprisingly, mobile services have been completely covered market. In fact, at speeds strongly growing market segment in the individual competition with another eighty between the mobile operators. At the same time, reducing a market operator began to go through the process of rational numbers.

But Communications Cambodia dominates the fixed-line services in Cambodia, three fixed-line telephone service providers, namely telecommunications Cambodia, Camintel Camshin. The company also operates international connection to the call. Internet in Canada and Telecom Cambodia's International Development Research Center (IDRC), with support from MPTC was introduced to Cambodia in 1997 is now run under the name of CamNet Internet. In May 2016, Viettel Global Cambodia units Metfone considering to sell part of its stake in the statement. Viettel Metfone holds a 90% stake. In August 2016 Smart Axiata is to continue to expand its 4G LTE network, as well as during the rest of 2016 announced plans to invest an additional USD75 million.

Cambodia earlier that about the limited fixed-line growth mainly focused on the capital, Phnom Penh, through an investment under foreign assistance programs. A decade later, geographical coverage or more. Which did not increase significantly. To expand the mobile segment continues in Cambodia as the number of telephone lines gradually declining from a very small base is fixed. Overall penetration of up to 1.6% in 2015 and 2016 dropped to 1.4% from 2.3% in 2014.Cambodia on the massive expansion of Internet services for mobile services has been overshadowed by a strong focus. Up Internet rates the country one of the lowest Internet penetration in the region, claiming remained low for several years. The limited fixed-line infrastructure, dial-up and DSL Internet services to both inhibit the roll out of the main factors. Fixed broadband penetration from a very small base is growing moderately. Penetration of up to 0.4% in 2014 increased from 0.2 in 2012 and 0.6% 2016 fixed broadband penetration by 2021 to reach between 2.2% and 2.7% and 1.2% in 2016 is forecast to grow from.

The Ministry Posts & Communication Center (MPTC), the official transfer of the efficient spectrum allocation in the key areas of the responsible authority of the new TRC MPTC over the role of regulation in 2012 Cambodia's Telecommunications Regulator (TRC), among others, with an opening price of rules. By 2016, the TRC has been already in the local telecommunications industry has a major role; Market rules are still to be resolved, and the problem remained a significant distance. In January 2016 Cambodian telecom company Kingtel, Key Bridge International (Hong Kong), a subsidiary of investment capital, Phnom Penh commercial fibre -based Internet access to begin offering a service, and during the early 2016 plans to open a voice telephone.

Starting May 2016, Huawei Technologies, a digital TV MUDS Cambodia with communications and media consulting firm, signed a Memorandum of Understanding (MoU). Huawei 4G network to support the implementation of the digital telecommunications star agreed to provide equipment and services. In June 2016, Thailand's National Broadcasting and Telecommunications Commission (channel), Thailand,

Cambodia, Laos, Myanmar, for pre-paid mobile SIM cards through the standard has been reported to be planning to set up a registration platform.

Expanding its telecommunications infrastructure and to upgrade Cambodia's efforts have been bearing fruit. This is the remainder of the least developed countries and poor countries in Southeast Asia, despite its status as one. Cambodia jump-started with digital technology in its telecommunications infrastructure, the fixed-line market with a post-reconstruction rapid replacement technology Release severe. As the market continues to expand the mobile segment Cambodia number of fixed telephone lines fell steadily from a very small base year 2016 reached 21.2 million subscribers in 2015 and 2016, mobile subscriber growth rate was 2% lower. Overall penetration dropped from 2.3% in 2014 to 1.6% in 2015 and 1.4% in 2016. The number of mobile phone subscriptions in Cambodia numbered 20 million at the end of 2015. The chart below illustrates the Figures 2.

1.2. Laos

Laos is still in communication, there are numerous issues to resolve. The rate of regulatory reform being a developing economy, allowing the country is still well behind the more vast industrial development. Delayed reform process to be speeded up if not likely to go away already made good progress.

The Laos, the Lao World Group, entered its post-WTO accession as a result was required to implement the program was completed in early 2013. The setting up of an independent telecommunications regulator called for, among other things national communications for the World Trade Organization Reference Paper on the communication of vital importance. In fact, after two years (February 2015) to mean that I need to be in place. This did not achieve February 2016. It was understood that it did not proceed on the matter, but took no formal steps. The country's mobile sector was going through a difficult period. Back in 2011/2012 Beeline Saga was felt to still further after 2016.

The country's mobile sector was going through a difficult period. Back in 2011/2012 Beeline Saga still further after 2016, a cloud of uncertainty in the market as a whole has suffered seems to be hung. After the market has gone backwards weak subscriber growth. The price cellcos regulator to keep a tight hold on the impact and open competition in despair in an environment where the operating concessions. Mobile operator emerging again a problem for the network performance is bad across the board. This, in turn, highlights the two key issues - the network operators for the maintenance and upgrading of areas, there is an insufficient investment, and secondly, the regulatory authorities in the environment have a significant deficiency criteria for application and network performance management.

Laos Internet services continue to lag. This is regarding the country's overall social and economic development are still major concerns. Good news on this part of the market (although it was difficult to obtain reliable statistics) since 2011/2012 mobile broadband Bend Internet services, because there was a boom. Expanding the Internet and especially in the provinces and rural broadband development is a high priority list of government.

On a positive note, the Lao economy continued to perform well, and the IMF has been at least a short-term forecast further strong growth. For the last five or six years, surely Laos in the economic and social prospects, there was a significant shift. A poorly performing economy and reform were in desperate need for a commercial environment after decades of having to struggle with a population of nearly seven

million to be reported on the face of this many people have no positive news now. Most importantly, the number of hydroelectric power projects and mining significantly more pipelines. Possible projects have become a reality. Lao finally, a trust may be described after a fashion, so moving forward. The following figure shows the Lao mobile subscription.

1.3. Myanmar

The change in the country's telecom sector, a large former monopoly operator, Myanmar and Telecommunications (MPT) in the two local mobile markets was the entry of the foreign operator. Qatar's Ooredoo and by the success of the arrival of Norway's Telenor Buoyed. Licensee a fourth mobile license, while the foreign partner will hold the remaining 49% The joint venture will be 51% owned by the SPV is scheduled to be awarded during 2016. Much work in Asia with the latest being impoverished telecoms market is still to be done, however. Mobile services sector with explosive growth and focus on fresh, but only slightly in 2016, a person had access to a fixed telephone line.

The first Internet connection established in 2000, but still in the Internet services in Myanmar is still slow and unstable. The fixed broadband market is mainly dominated by mobile platforms and fixed operators to invest in broadband infrastructure is an unwillingness is still very poor penetration stood at just 0.5% in 2016 over the five years since 2021 is forecast to increase at a slower rate of Fixed-line telephone penetration is still low at just under 1% of the mobile market influence gradually been declining since 2014 and to mature. Penetration of up to 0.96% in 2016 decreased from 1.00% in 2013.

The market in the country's mobile market penetration to reach the 46 million subscribers, up from 85% in 2016 has risen from 7% in 2013, from 2013 to 2016 was a very strong economic growth experienced. Further strong growth is expected to reach more than 90% market share in mobile penetration by 2018 to 2021. Over the next five years is estimated. Mobile broadband Bend mobile sector higher, driven by the rapid growth experienced very strong economic growth. Penetration up to 26% in 2015, a 15% increase from 2014 and has a strong 35% growth in 2016, but at a slower rate over the next five years is estimated. Figure 4 shows total mobile subscriptions in Myanmar 1993 to 2015.

1.4. Vietnam

Vietnam's telecommunications networks and services in the country so far, he has made great efforts in developing. According to the telecommunications development strategy, advanced communications infrastructure to facilitate social and economic development were built. The government, since its reform demands of industrialisation and modernization of the country, to fulfil the sector has been paying special attention. Priority policies in the region and the world to catch up with the standards provided. Communication is currently one of the fastest growing industries in Vietnam.

With a population of more than 80 million people, the prospects for Vietnam's telecommunications market. The communication gives way to compete with the monopoly of the State Corporation. Vietnam's telecommunications market competition, a competition in domestic markets that enable the rapid transition of the government's strategy was introduced in 1995, private investors and some foreign businesses can now take part to ensure the delivery of telecommunications services. The non-state sector in 2010 by 25-30% by 2005, its services and to increase the market share in telecom 40-50% is estimated.

In 1995, Vietnam became a full member of ASEAN, with some shortcomings when the communication begins an ambitious target setting. However, as the level of competition in its business climate in sustainable development for many years, Vietnam has its limits he saw the development of the telecommunications industry. When Vietnam became an official member of the World Trade Organization, as well as in the country, up to this date from a more competitive telecommunications market for reducing the control of the sector towards freedom and more opportunities opened.

Vietnam Posts & Telecommunications (VNPT), Viettel, Mobi Fone and Vina Phone are this country's leader in the telecommunications industry. The Vietnam's mobile market has experienced strong growth in the past of 3G and fibre broadband uptake both the inclination of the rise in the use of mobile and fixed data, 2015 was a robust demonstration. The following figure shows Vietnam's mobile subscription.

2. METHODOLOGY

This research intends to study the relationship between telecommunication and economic growth of CLMV countries over the period from 2000 to 2015 with secondary data. There are six variables used in this paper, GDP per capita (GDPPC), fixed line telephony subscription per hundred people (FTS), number of mobile phone subscription per hundred people (MS), internet user per hundred people (IU), labor force participation rate (LFPR) and degree of trade openness (OPN).

2.1. Conceptual Framework

In this study, the author examines the impact of telecommunication on economic growth for CLMV countries. The conceptual framework of the study can be shown as follows:

In this research, the GDPPC (GDPPC) is set as a proxy of economic growth in CLMV countries. Telecommunication development measured in number of fixed line telephone subscription per hundred people (FTS) and number of mobile phone subscription per hundred people (MS) will be used. Another indicator of telecommunications is internet user per hundred people (IU). The labor force participation rate (LFPR) is the number of employed and unemployed persons who are looking for jobs as a percentage of the population. Trade openness (OPN) supports higher economic growth.

2.2. Variables Used in the Model and Sources of Data

This research study focuses on panel data from CLMV countries, namely Cambodia, Lao, Myanmar and Vietnam by using the period of 2000-2015. The data used in this research are secondary data from the World Bank Database. The dependent variable is economic growth, measured by the GDP per capita, denoted by GDPPC. The independent variables include fixed telephone line subscription (FTS), mobile phone subscription (MS), internet user (INT), trade openness (OPN) and labor force participation rate (LFPR).

2.3. The Empirical Model

Based on the literature reviews, the economic growth equation is as follow:

$$(GDPPC)_{it} = f(FTS_{it}, MS_{it}, IU_{it}, OPN_{it}, LFPR_{it}) \quad (1)$$

$$(lnGDPPC)_{it} = \beta_0 + \beta_1(lnFTS_{it}) + \beta_2(lnMS_{it}) + \beta_3(lnIU_{it}) + \beta_4(lnOPN_{it}) + \beta_5(lnLFPR_{it}) + \mu_{it} \quad (2)$$

Table 1
Variables Definitions, Proxies and Data Sources

Variables Notation	*Proxy/Determinants*	*Definitions*	*Units*	*Data Sources*
GDPPC	Economic growth	GDP per capita in current USD	USD	World Bank
FTS	Infrastructure	Fixed line telephony subscription per hundred people	Number	World Bank
MS	Infrastructure	Mobile phone subscription per hundred people	Number	World Bank
IU	Infrastructure	Internet user (per 100 inhabitant)	Number	World Bank
OPN	Trade openness	Total trade as a % of GDP	%	World Bank & CSO Myanmar
LFPR	Abundance of labors	Labor force participation rate	%	World Bank

Source: Author's Design.

β_0 = constant terms, β_1, …, β_5 = coefficients

lnGDPPC = natural log GDP per capita in current USD

lnFTS = natural log fixed telephone line subscription (per 100 inhabitant)

lnMS = natural log of mobile phone subscription (per 100 inhabitant)

lnIU = natural log of internet user (per 100 inhabitant)

lnOPN = natural log of trade openness (Total trade as a % of GDP)

lnLFPR = natural log of labor force participation rate

i = cross-section data (country)

t = time-series data

2.4. Research Methodology

This study employs the methodology of Panel ARDL (Autoregressive Distributed Lag Model) from Mahyideen, Ismail and Hook (2012). It begins by Panel Unit Root Test. Then it performs Pooled Mean Group (PMG) estimator. It compares the result with Mean Group (MG) estimator. It adjusts the short-run effect by the Error Correction Term (ECT) to make the model follow the long-run effect. Finally, it selects a better model by Hausman Test.

2.4.1. Pool Mean Group Estimator

The pooled average group (PMG) is an estimation method based on both the pool and the average and estimates the correlation between long runs and short runs using one equation. The escalator allows error dispersion, intercept, and short term coefficients to freely differ between countries, and the long run coefficient remains constant across groups. The PMG estimator is used to apply the homogeneity constraint of long-run coefficients, to take the average between countries and obtain means of estimating error correction coefficients and other short-term parameters. The problem with this estimator is that it is possible to estimate the parameters of the dynamic model from panel data including time series observations and to estimate individual equations for each country.

The main feature is that the reactivity of co-integration variables can have a deviation from long-term ram equilibrium. Therefore, this deviation from equilibrium influenced on short-run dynamics of variables and thus error correction model needs to apply. Panel analysis on the unrestricted specification for the autoregressive distributed lag (ARDL) model for time periods $t = 1, 2, \ldots, T$ and groups $i = 1, 2, \ldots, N$; and the dependent variable y is:

$$\Delta y_{it} = \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q} \gamma'_{ij} x_{i,t-j} + \mu_i + \varepsilon_{it} \tag{3}$$

where, y_{it} is a scalar dependent variable, x_{it} is the $k \times 1$ vector of explanatory variables for group i, μ_i in denotes the fixed effects, λ_{ij}'s are scalar coefficients of the lagged dependent variables, γ'_{ij}'s are $k \times 1$ coefficient vectors. The re-parameterised form of Equation (3) can be formulated as follows:

$$y_{it} = \phi_i y_{i,t-1} + \beta'_i x_{i,t-1} + \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \gamma'_{ij} \Delta x_{i,t-j} + \mu_i + \varepsilon_{it} \tag{4}$$

It is assumed that the disturbance terms ε_{it}'s are independently distributed across i and t, with zero means and $\sigma_i^2 > 0$ variances. It is assumed further that $\phi_i < 0$ for all i's. Thus, there exists a long-run relationship between y_{it} and x_{it} which is defined by:

$$y_{it} = \theta' x_{it} + \eta_{it} \; i = 1, 2, \ldots, T \tag{5}$$

where, β'_i / θ_i, is the $k \times 1$ vector of the long-run coefficients and η_{it}'s are stationary with possibly non-zero means (including the fixed effects). Hence, Equation (4) can be written as:

$$y_{it} = \phi_i \eta_{i,t-1} + \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \gamma'_{ij} \Delta x_{i,t-j} + \mu_i + \varepsilon_{it} \tag{6}$$

where, $\phi_i = -\left(1 - \sum_{j=1}^{p} \lambda_{ij}\right)$

ϕ_i = error correction speed of adjustment term

If ϕ_i is zero, there is no long-run co-integration.

If $\phi_i > 0$, there has no long-run co-integration.

If $\phi_i < 0$, there has long-run co-integration.

$T = 1, 2, \ldots, T$ (time series)

i = cross-section groups

y_{it} = dependent variables in countries i at time

y'_{ij} = coefficient $kx1$ vector of independent variables

λ_{it} = scalars

μ_i = fixed effect

θ_i is the important vector which has long-run relationship between variables. PMG estimations allows for heterogeneous short-run dynamics and common long-run and for examining long-run homogeneity without imposing parameter homogeneity in the short-run.

2.4.2. Mean Group Estimator

There are two general methods of estimating separate equations in each country and applying panel data to examine distribution of estimation coefficients of each country. Estimates are called average estimates, MG estimates. The estimate gives the average estimate of the parameters, but we do not believe that the particular parameters are in the same group. MG estimate allows its interception, error variance, coefficient slope to vary from country to country. It has a restrictive process, allows heterogeneity of all parameters without cross - country restriction process, and enables heterogeneity of all parameters without cross - country restrictions.

MG estimator was derived from the equation for ARDL:

$$Y_{it} = \alpha_i + \gamma'_{1} y_{i,-1} + \beta_i X_{it} + \mu_i \tag{7}$$

where, $i = 1, 2, \ldots, N$ and $t = 1, 2, \ldots, T$, estimation of long run parameter's coefficient θ_i for country i can be written as:

$$\theta_i = \beta_i / 1 - \gamma_i \tag{8}$$

Mean Group (MG) estimator for the whole panel can be written as below:

$$\hat{\theta} = N - 1 \Sigma \hat{\beta}_i N_i = 1 \tag{9}$$

MG's variance is: $$(\hat{b}MG) = 1N(N - 1)\ \Sigma(\hat{b}_i N_i = 1 - \hat{b}MG)(\hat{b}_i - \hat{b}MG) \tag{10}$$

2.4.3. Error Correction Term

In the dynamic model, the error correction term (ECT) can be described as the speed of adjustment to reach equilibrium. The coefficients confirmed how the variables converged, diverged to equilibrium, and their signs were negative or positive. A statistically significant ECT indicates that it has a stable long-term operation relationship.

2.4.4. Hausman Test

The Hausman test is used to determine the best estimate for choosing between PMG and MG or PMG. Hypotheses of long-term parameter homogeneity cannot be presumed a priori. The Hausman test determines the effect of heterogeneity on the mean of the coefficients, and if the parameters are homogeneous, the PMG result is consistently more efficient than the MG. If the null hypothesis is accepted, it can be said that PMG has priority in choosing an efficient estimate and MG has priority if it is rejected. The test statistic is λ^2.

$$H = (\hat{\beta}b - \hat{\beta}B)D - 1(\hat{\beta}b - \hat{\beta}B) \tag{11}$$

$$D - 1 = (B\hat{\beta}b - V\hat{\beta}B), \text{ which is generalized inverse} \tag{12}$$

$V\hat{\beta}$ is the variance of coefficient

The hypothesis is set as follows:

H_0: Accept PMG if *p* value of $\lambda^2 > 0.05$

H_A: Reject MG or DFE if *p* value of $\lambda^2 < 0$

3. RESULTS AND DISCUSSION

3.1. Descriptive Results

This section will describe and discuss the descriptive analysis of the data nature, the data are collected for CLMV countries for the period of 2000 to 2015, and total observations in this study are 64.

Table 2
Descriptive Statistics (2000-2015)

Variable	*Mean*	*Std. Dev.*	*Minimum*	*Maximum*
GDPPC	848.1346	527.757	145.532	2111.138
MS	41.13312	49.57808	0.0276495	147.1109
FTS	3.939871	4.925494	0.1892136	19.75892
IU	8.490668	12.99927	0.0001517	52.72
OPN	86.40576	57.06319	0.2281228	178.7674
LFPR	82.13281	1.342593	79.9	85

Table 2 showed the summary statistics of the variables used in the study for the period of 2000 to 2015. As for GDPPC, its mean value is 848.1345, and the minimum and maximum values are 145.532 and 2111.138. The difference of GDP per capita between CLMV countries is quite high. The mean value of mobile phone subscription (per 100 inhabitants) is 41.13312 while the minimum value is 0.0276495 and the maximum value is 147.1109. The average value of fixed telephone line subscription (per 100 inhabitants) is 3.939871 with a minimum value of 0.1892136, and the maximum is 19.75892. Internet user (per 100 inhabitants) varied from 0.0001517 to 52.72 with the mean value of 8.490668. As for trade openness, OPN variable, the mean value is 86.40576, and the lowest and highest values are 0.2281228 and 178.7674. The total trade measures openness as a % of GDP. The average value of labour force participation rate is 82.13281 while the minimum value and maximum value are 79.9 and 85 respectively.

The correlation matrix of the coefficients are presented in the following Table 3. The measurements showed how strong the linear relationships among variables and it helps to point out the problems of multicollinearity in estimation process. Because the presence of high correlation among independent variables showed that there has multicollinearity. The below table was given out the results that the correlations between GDPPC and MS, FTS, IU and OPN are positive and significant while GDPPC and LFPR is negative but insignificant. The results with significant levels are attached in the Appendix of this study. Most of the independent variables are seemed highly correlated so that the author tested the estimations with five different variables as discussed in Chapter (3) Empirical Model and Pool Mean Group Estimator of this study. In view of this fact, the author tested the six variables with method of PMG estimation in order to estimate for the panel level long run and short run coefficients and their effects.

Table 3
Correlation matric of the variables

Variables	*GDPPC*	*MS*	*FTS*	*IU*	*OPN*	*LFPR*
GDPPC	1.0000					
MS	0.7688	1.0000				
FTS	0.5708	0.4930	1.0000			
IU	0.79 59	0.8035	0.6434	1.0000		
OPN	0.3436	0.5588	0.4775	0.5312	1.0000	
LFPR	–0.0523	0.2400	–0.1968	–0.0510	0.4603	1.0000

4.2. Results of the ADF Panel Unit Root

This paper aims to determine the impact of telecommunications on economics growth in the CLMV countries for the period of 2000 to 2015. The panel unit root tests applied in this research is ADF panel unit root test. Table 4 shows the statistics from the panel unit root test.

Table 4
ADF panel unit root test

Variables	*Level*	*First Difference*
lnGDPPC	1.65797	29.1219***
	(0.9898)	(0.0003)
lnFTS	7.26054	23.0907***
	(0.5088)	(0.0032)
lnMS	20.8230***	6.78077
	(0.0076)	(0.5605)
lnIU	16.2244**	46.9597***
	(0.0393)	(0.0000)
lnOPN	24.7302***	29.8176***
	(0.0017)	(0.0002)
lnLFPR	25.1869***	2.13763
	(0.0014)	(0.9857)

Note: *** is statistically significant at 1% level, ** is statistically significant at 5%, * is statistically at 10%.

The above table 4 showed the test statistics, *p*-values and the results of Panel Unit Root Tests performed on the variables used in this research. After data collection, Panel Unit Root tests are the first tests to test the stationary status of the data to determine order of integration. In this study, the author took natural logarithm to all selected variables in order to have clear relationships between variables, to make data more interpretable and to help meeting the assumptions of inferential statistics. Moreover, log transformation can help lessen high skewed distributions. The panel unit root tests applied in this research is ADF panel unit root test by using Eviews software. As a result, this tests are applied to make sure variables are not stationary at I(2).

The null hypothesis and alternative hypothesis of panel unit root tests can be discussed generally as H0: panel data has unit root (non-stationary) & Ha: panel data has no unit root (stationary). Acceptance or rejection to null hypothesis can be determined by two ways: checking the test statistics with critical values

from 1%, 5% and 10% confidence levels and another way is checking with *p*-values. For the first method, the absolute value of test statistics must be higher than the absolute value of critical values in order to reject the null hypothesis. For the second method, *p*-value must be less than at least 10% significant level in order to reject the null hypothesis of having unit root. One of them is worked well to check for the stationary status of the panel data to determine order of integration. Panel ARDL approach is based on the assumptions of mixed levels I(0) and I(1). None of the variables for this approach are acceptable if the order of integration for stationary is I(2) and above. Therefore, it is necessary for the data to be stationary at I(0) or I(1) in order to fit with the criteria set for panel ARDL approach.

The null hypotheses of panel unit root tests for lnMS and lnLFPR can be rejected in level I(0) that means we reject the null hypotheses of having unit root for these two variables at 1% significance levels. It can also be said that these two variables are stationary at level I(0). However, the null hypotheses of panel unit root tests for the rest of the variables used in this research (lnGDPPC, lnOPN, lnLFPR and lnIU) cannot be rejected when the series are in level I(0). Therefore, we have to check them at the first difference level and found that these variables are stationary at I(1). Based on the ADF panel unit root tests results that two variables (lnMS and lnLFPR) were significant and stationary at level I(0) and the rest four variables were non-stationary at level I(0) and stationary at first difference I(1). Because of this, we can confirm that the data stationary status for the order of integration are in mixed levels I(0) and I(1), so panel ARDL approach is the most suitable method for the long run and short run estimations.

3.2. Results of PMG Estimations for Panel Level

The results of PMG estimation is reported in Table 5, 6 and 7, long run results and short run results separately. The specific of PMG estimation is allows the short run coefficients, involves the intercepts, the speed of adjustment to the long run values and error variances.

The main feature of PMG is that it enables short-term coefficients including intercept, speed of adjustment to long-term equilibrium value, and that the error variance is heterogeneous from country to country, and the long term slope coefficient is homogeneous among countries. This is particularly useful when there is a reason to expect that the long-run equilibrium relationship between variables is similar between countries, or at least in their subset. Short-term adjustments can be adjusted for each country, as the impact of vulnerability on financial crisis, external shock, stabilization policy, monetary policy, etc. varies greatly. However, there are some requirements on the validity, consistency and efficiency of this methodology. First, the existence of a long-term relationship between the variables of interest requires that the coefficient of the error correction term be negative and not less than −2. Secondly, an important premise concerning the consistency of the ARDL model is that the residuals of the results of the error correction model are successively uncorrelated and explanatory variables are treated as exogenous. Such a condition can be realized by including the ARDL (*p*, *q*) lag of the dependent variable (*p*) and the independent variable (*q*) in the error correction form. Third, the relative size of T and N is important. Because, if both are big, you can use dynamic panel technique, avoid bias in average estimate and solve heterogeneity problem. Eberhardt and Teal (2010) argues that handling heterogeneity is central to understanding growth processes. Therefore, if these conditions can not be satisfied, an inconsistent estimate is generated in the PMG

In this research, the author imposed lag length selections by Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion, and got the result of optimal lag length at ARDL (1, 1, 1, 1, 1) for this model. Based on the panel unit root tests results, the data are stationary at level I(0) and I(1), therefore, panel ARDL approach is the most suitable method for the long run and short run estimations. In the below Table 5, 6 and 7, it shows the long run and short run coefficients between GDPPC and its telecommunications factors variables and the coefficients of error correction terms. The author used Stata software to analyse the estimations of this research.

3.3. Discussion of Long Run and Short Run Results for Panel Level

For the interpretation of the coefficients obtained from PMG model, it should be noted that the coefficients of the first difference model are as the same as those in the level model. Moreover, when all the variables are in the natural logarithm, the coefficients are interpreted as elasticity.

Table 5, 6 and 7 summa rise the long run and short run regression results by using Pool Mean Group Estimation. In the long run, the results show that mobile phone subscription, internet user, trade openness and labour force participation rate have positive long run relationship because they are statistically significance at 1% and then fixed telephone line subscription are significant at 10%. These findings suggested that increased trade openness as a major contributor to economic growth. The labour force participation rate coefficient was positive and significant at 1% level. An increased in labour force participation rate lead to an increase in demand for goods and services. The estimation find that the coefficient of the number of mobile subscriptions and internet user is significant at 1% level and contribute positively to the growth rate in the long run. This coefficient implies that for a 1% increase in the number of fixed line telephone subscriptions results to a 0.03% increase in GDP per capita. In addition, a 1% increase in the mobile phone subscriptions increases GDP per capita by 0.28%. Most importantly, a 1% increase in internet users results to an increase in GDP per capita by 0.05%.

In the short run, the results show that fixed telephone line subscription and mobile phone subscription are significant and have negative relationship with GDP per capita. These finding suggested that internet user is positively related with GDPPC and the result is statistically significant at 1%. One per cent increase in internet user can cause increased GDP per capita by 0.02%. Trade openness is insignificant in the short run. The findings indicated that labour force participation rate have positive short run relationship because they are statistically significance at 1%.

Table 5
Long Run ARDL Result (PMG Estimation)

Independence Variables	*Coefficient*	*Standard Error*	*P value*
lnFTS	0.0277444*	0.0156723	0.077
lnMS	0.277165***	0.0169679	0.000
lnIU	0.0521328***	0.0089781	0.000
lnOPN	0.4054741***	0.1107883	0.000
lnLFPR	22.78579***	1.733309	0.000

Note: *** is statistically significant at 1% level, ** is statistically significant at 5%,* is statistically at 10%.

Table 6
Short Run ARDL Result (PMG Estimation) with lagged dependent variable as an independent variable (Autoregressive term)

Independence Variables	*Coefficient*	*Standard Error*	*P value*
ECT	–0.4772556	0.3270778	0.145
$\ln GDPPC_{t-1}$	–0.0397406	0.1231111	0.747
lnFTS	–0.1089621	0.0859443	0.205
lnMS	–0.1525185	0.0970902	0.116
lnIU	0.0070423	0.0263245	0.789
lnOPN	0.0404115	0.0510103	0.428
lnLFPR	26.7614	13.7581	0.052
Constant	–46.62676	32.03958	0.146

Note: *** is statistically significant at 1% level, ** is statistically significant at 5%, * is statistically at 10%.

Table 7
Short Run ARDL Result (PMG Estimation) without lagged dependent variable as an independent variable (Autoregressive term) due to its insignificance

Independence Variables	*Coefficient*	*Standard Error*	*P value*
ECT	–0.4143594*	0.2531507	0.102
lnFTS	–0.1399991*	0.0831014	0.092
lnMS	–0.1770271*	0.0962552	0.066
lnIU	0.0803746*	0.0429837	0.061
lnOPN	0.0177521	0.1024436	0.862
lnLFPR	28.2678***	11.10623	0.011
Constant	–39.90684***	24.44912	0.103

Note: *** is statistically significant at 1% level, ** is statistically significant at 5%, * is statistically at 10%.

In a previous study by Mahyideen, Ismail and Hook (2012), data on ICT infrastructure and economic growth of 1976-2010 in selected ASEAN-5 countries such as Indonesia, Malaysia, Thailand, Singapore and the Philippines was also investigated. In their study we used exactly the same way as Pool Average Group Estimation (PMGE). They found that long-term coefficient of fixed lines per 100 inhabitants and mobile phone numbers is significant at 1% and actively contributes to growth long term interest rate. The estimated coefficient means that if the number of fixed subscribers and number of mobile subscribers per 100 inhabitants increases by 1%, real GDP per capita will increase by 0.05%. Compared with this survey, the elasticity of fixed-line subscribers and mobile phone subscribers is 0.03% and 0.28% respectively.

The elasticity obtained from Mahyideen, Ismail and Hook (2012) is higher than those obtained from this study. This is because their study covers Indonesia, Malaysia, Thailand, Singapore and the Philippines whereas this study covers Cambodia, Lao PDR, Myanmar and Vietnam. The average income per capita of both group of countries may differ significantly as they launched the economic development following the more openness of the economy at the different time. Moreover, the time periods are also different. Their study ranges from 1976 – 2010 while this study ranges from 2000 – 2015. Therefore, this comparison must be considered both by the dimension of group of countries and time.

In conclusion, in this section, we can conclude that mobile, fixed line telephone and internet users have a positive impact on economic growth in the CLMV countries for the long run. We find that one percent increase in the number of fixed line telephone subscriptions and the mobile phone subscription results are 0.03 percent and 0.28 percent increase in GDP per capita respectively. Therefore, empirical evidence suggests that access to telecommunications sector is a major source of economic growth in ASEAN countries. Consequently, the governments of ASEAN nations should also consider about the ICT development to their countries. They should promote the modern telecommunication technology for the ASEAN Economic Community (AEC).

3.4. Results of MG Estimations for Panel Level

The results of MG estimation are reported in Table 8 and 9, long run results and short run results separately by using PMG and MG estimations and chooses the best estimators by using Hausman Test; Hausman Test results are discussed after MG estimations results. The use of these estimations allows us to take into considerations of country-specific heterogeneity cases. MG estimation does not make any restrictions and allows the coefficients to vary, be heterogeneous in the long-run and the short-run. However, MG estimation is valid if there has sufficient large T and N of the data. Even though the data used in the research are not large enough, the author would like to test the data set with different approaches to see which estimators is the best among PMG and MG. PMG estimator results gives better estimates as compared to MG estimator results with the assumption of homogeneity in the long run. Therefore, it seemed PMG estimator is more appropriate than MG, but we will confirm this by testing with Hausman test.

Table 8
Long Run ARDL Result (MG Estimation)

Independence Variables	*Coefficient*	*Standard Error*	*P value*
llnFTS	–0.4536006	0.4597614	0.324
llnMS	–0.0558987	0.1849278	0.762
llnIU	0.1149831	0.1158949	0.321
llnOPN	0.5272277	0.5032921	0.295
llnLFPR	29.82811	44.18289	0.500

Source: Calculation.
Note: *** is statistically significant at 1% level, ** is statistically significant at 5%, * is statistically at 10%.

Table 9
Short Run ARDL Result (MG Estimation)

Independence Variables	*Coefficient*	*Standard Error*	*P value*
ECT	–0.5621625*	0.3289126	0.087
lnFTS	0.2165345	0.2463824	0.379
lnMS	0.0752231	0.1171563	0.521
lnIU	–0.0371538	0.0466121	0.425
lnOPN	–0.2253068***	0.0223627	0.000
lnLFPR	9.858982	12.95665	0.447
Constant	–70.85719	153.8791	0.645

Source: Calculation.
Note: *** is statistically significant at 1% level, ** is statistically significant at 5%, * is statistically at 10%.

Regarding to both long run and short run results of MG estimations, most of the variables in each model are insignificant even though the ECT terms give out the negative coefficients and significant at 1% showing that the speed of adjustment is moving towards long run equilibrium. Moreover, the constant terms are also insignificant in this models. As for the short run results trade openness is significant but the rest variables are insignificant and gives out the opposite signs which are not consistent with the theories and situations. The detailed test results for this test is provided in the Appendix of this paper.

3.5. Hausman Test Results between PMG and MG

Hausman test is applied to test the two estimators that already discussed in the above sections whether there is any significant differences between them. According to the given results before testing with Hausman test, PMG can be considered a better estimator than the other two. The null hypothesis H_0 of Hausman test is that difference between Pooled Mean Group and Mean Group is insignificant. If the *p*-value is greater than 5% significance level and the null is not rejected, then the recommended efficient estimator is PMG. The alternative hypothesis H_a is that the difference between Pooled Mean Group and Mean Group is significant then the null hypothesis H_0 is rejected and H_a is accepted. If the P-value is not significant at 5%, it means PMG is the best estimator than MG. Otherwise, MG estimator is appropriate and becomes best estimator.

The results of Hausman Test are given out as expected and shown in table 10. The results of Hausman tests for choosing best estimators between PMG and MG that p-value is greater than 5% that means they are insignificant. Therefore, we can confirm based on the Hausman test results that, PMG is better and efficient than MG. As a result, we can conclude that PMG is the best estimator for this research. The detailed test results are attached in the Appendix.

Table 10
Results of the Hausman Test

	PMG	*MG*	*Differentiation Value*	*Standard Error*
lnFTS	0.0277444	–0.4536006	–0.481345	0.4594942
lnMS	0.277165	–0.0558987	–0.3330637	0.1841477
lnIU	0.1149831	0.1149831	0.0628503	0.1155466
lnOPN	0.5272277	0.5272277	0.1217536	0.4909469
lnLFPR	29.82811	29.82811	7.042323	44.14888

Chi^2 (5) = 8.92, Prob > chi^2 = 0.1124.
Source: Calculation.

3.6. Results of PMG Estimation for Individual Country Level

The results of PMG estimation for individual country is shown in Table 11 with the discussion of the results beginning from Cambodia to Vietnam as follows:

3.6.1. Cambodia

The short run results of individual country, cross section PMG estimation indicates that mobile phone subscription (MS) and internet user (IU) have positive impact on GDP per capita. Many researchers have

Table 11
Short Run Panel ARDL Results (PMG Estimation) for CLMV countries

GDPPC	*Cambodia*	*Laos*	*Myanmar*	*Vietnam*
ECT	–0.0699955***	–0.5073907***	0.0123321	–1.092383***
	(0.000)	(0.000)	(0.885)	(0.000)
lnFTS	–0.0032277	–0.1703169***	–.3628994	–0.0235521**
	(0.781)	(0.000)	(0.155)	(0.034)
lnMS	0.0578296	–0.402243***	–0.1305914	–0.2331035
	(0.117)	(0.000)	(0.126)	(0.000)
lnIU	0.00741	0.2045569**	0.0471994	0.0623321***
	(0.719)	(0.028)	(0.121)	(0.000)
lnOPN	0.1344542**	0.2252532	–0.0529532	–0.2357456***
	(0.039)	(0.455)	(0.666)	(0.000)
lnLFPR	21.86185***	43.62797**	47.90626	–0.324873
	(0.000)	(0.011)	(0.116)	(0.871)
Constant	–6.808302***	–48.52119***	1.253561	–105.5514***
	(0.000)	(0.000)	(0.875)	(0.000)

Source: Calculation.

proved that in both developed and developing countries, telecommunications infrastructure has significant positive relationship with economic growth; Roller and Waverman (2001). ECT term is negative and significant at 1% which means that the model converges to the long run equilibrium with an expectation of 6%. Cambodia in the short run, trade openness (OPN) and labor force participation rate (LFPR) have significant positive relationship with GDP per capita. Increase in 1% trade openness in Cambodia can attract 3% increase of GDP per capita in the short run and 1% increase in labor force participation can cause 21.87% of GDP per capital.

Cambodia joined the ASEAN Free Trade Area in 1999 and joined the World Trade Organization (WTO) in 2003. Members of these organizations imposed further requirements on Cambodia to liberalize the trade of goods and services, the ownership of foreign capital. FDI has played an important role in creating production bases, especially to utilize trade opportunities in developed countries.

3.6.2. Laos

Table 11 reported for Laos that the short run coefficient of fixed telephone line subscription (FTS) and mobile phone subscription (MS) has negative impact on GDP per capita and significant at 10% level. This can be explained as 1% increase in FTS can decrease 17% of GDP per capita and 1% increase in MS can decrease 4% of GDP per capita. The PMG estimation indicates that trade openness (OPN) has insignificant and positive impact on GDP per capita (GDPPC). Several researcher have empirical studied that OPN has positive relationship with economic growth; (Phimphanthavong, 2013). ECT term is negative and significant at 1% level. The result shows the positive correlation between labor forces participation rate (LFPR) and GDP per capita. The high rate of labor force participation may affect the government policy to promote new jobs and encourage increase economic growth, these results still confirm that trade openness is good for economic growth of Laos.

3.6.3. Myanmar

According to the result of short run PMG estimation for Myanmar, the speed adjustment also known as adjustment of short run coefficient is 0.01 and statistically insignificant. Therefore, it can be said that there is no long run and short run relationship between telecommunication and economic growth and its selected determinants for the case of Myanmar due to speed of adjustment term is positive and insignificant. Telecommunication sectors are very low in Myanmar for a long time. The liberalization of the telecommunications market is started in 2013. ICT is being used increasingly worldwide to facilitate humanitarian and development work, supporting and improving coordination, mapping, information dissemination, access to knowledge and services, monitoring and evaluation, and more.

3.6.4. Vietnam

The findings for Vietnam pointed out that the speed of adjustment is negative and significant at 1% level and it converges to the equilibrium with a 1.09, but still within the acceptable range of −2 to 0. In the short run coefficient of fixed telephone line subscription (FTS) and mobile phone subscription (MS) has negative impact on GDP per capita and significant at 1% and 5% respectively. Openness (OPN) is significant negative relation with GDP per capita and this can be explained that Vietnam as a developing country cannot get full benefits from doing international trade as they have difficulties to access international market. The coefficient of labor force participation rate (LFPR) is negative and insignificant. Its mean that the higher labor force rate in developing countries has negative impact on economic growth.

4. CONCLUSION

This study analyses the impacts of telecommunications on economic growth in CLMV countries over the period of 15 years (2000- 2015) using the pooled mean group estimator. Telecommunication technologies are key in boosting economic growth and increasing economic productivity and efficiency. In the CLMV region, the technology development would support continuous improvement in terms of productivity, efficiency, competitiveness, and the quality of the lives of people by providing new services and products with positive effects on the overall economic development in CLMV countries. The results show that the fixed telephone main lines, mobile subscriptions and internet users have a positive correlation on economic growth in CLMV countries for the long run. The result will provide relevant guide line to implement reform in ICT sector and economics development of CLMV countries. This study believes that it is never too late for the ASEAN region to achieve the Sustainable Development Goals (SDGs).

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