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The Effect of Foreign Direct Investment and Infrastructure on Economic Growth in Laos

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Abstract

The main of this study examines the long-run relationship between foreign direct investment and infrastructure on economic growth in Lao PDR using time series data from 1995-2020. The empirical evidence of cointegration among the variables in the long run by Autoregressive Distributed Lag (ARDL) bounds test estimates. The empirical results indicate that the FDI variable has a positive and significant impact on the level of Laos' economic growth in the long run. Similarly, infrastructure variables such as telecommunication, electricity, and air transport play important roles in supporting economic growth in the long run and there are positive and statistically significant impacts at the level. As a result, to achieve the target of sustainable economic growth the government of Laos should attract and sustain more foreign direct investment and improve the infrastructure such as telecommunication, electricity, and air transport to boost economic growth shortly.

Keywords: FDI, Infrastructure, Economic growth, ARDL, Laos.

1. INTRODUCTION

Foreign direct investment plays a very important role in the country's economic growth, especially the developing and least-developed countries like the Lao PDR. Foreign direct investment can also encourage the creation of new jobs, increase the capital for domestic investment, and promote overall economic growth in the host country. Accessibility includes ease of infrastructure-independent approach, entry and/or use of services and facilities such as electricity, transport, information, and communication technologies. So, the infrastructure sectors are very important in the country's economic growth and improve human development. The relationship between foreign direct investment inflows and economic growth in the host country has a positive and significant impact including Darrat and Sarkar (2009); and Mah (2010). Furthermore, the telecommunication infrastructure is an important element of an effective functioning economy in the communication, promotion of technology, and innovation. All over the world, telecommunication infrastructure affects how we can connect, communicate, and conduct business. Many previous empirical studies the both together the role telecommunication infrastructure and foreign direct investment have in supporting the economic growth by Lydon and Williams (2005) has been showed that the long-run relationship between foreign direct investment flows into developing countries and telecommunication infrastructure in the host country. Moreover, Williams (2015) and Masron (2017) concluded that the inflow of foreign direct investment into any country, especially ASEAN countries on telecommunication infrastructure, foreign direct investment often measured in terms of the fixed telephone and improvement in the institutional quality.

More specifically, Amos and Jidda (2018) focused on the export performance to the infrastructure development (transport, ICT, and electricity) and economic growth in Nigeria. Samir and Mefteh (2020) study causal the relationship between information and ICT, transport, and FDI in 63 countries the empirical results confirm the positive impact of transport and ICT infrastructures in advancing economic growth by increasing international trade and supporting countries' economic openness. Baita (2021) explained the role of infrastructure in supporting regional economic growth which all infrastructure variables have a positive impact on exports in ECOWAS countries. Roller and Waverman (2001); Zhang (2017); Zhang (2020) and Carbo (2020) show the role of infrastructure in supporting economic growth. Pereira's (2020) study estimates that infrastructure investments (such as transportation, social infrastructure, and telecommunications) have affected

the industry level. The empirical results confirmed that infrastructure development can boost both traded and non-traded industries in Portugal has a significant positive. Ekeocha (2022) has focused on the impacts of both aggregate and disaggregated infrastructural development indices on economic growth in Africa. Yilmaz, et al (2001) showed that the role of telecommunication infrastructure investment at the sectoral level, accumulation of telecommunication infrastructure supports the overall productive capacity at the regional level in the United States by investigating the impact of telecommunication infrastructure on economic growth both at the aggregate and sectoral levels. Greenstein and Spiller (1995) studied on impact of telecommunication infrastructure on economic activity in the sectors. The empirical result confirms that the impact of telecommunication infrastructure on economic activity has a positive and significant effect on employment growth.

This paper is organized into five sections including the introduction, section two presents theoretical and empirical literature on the relationship between infrastructure variables, foreign direct investment, and economic growth, section three is the research methodology with data collection, model specification, and explanation of the econometric techniques applied by the present research, section four presents the empirical results and the conclusion and recommendation are discussed in section five.

2. LITERATURE REVIEW

2.1 Theoretical Literature

Theoretical foundation, economic growth, and understanding the determinant of growth play a very important role in the country's economic growth such as exogenous growth theory and endogenous growth theory to determine the promotion of foreign direct investment inflows to economic growth in the host countries. The exogenous growth theory (neoclassical growth model) was pioneered by Solow (1956) explained that economic growth in the host country was created through two factors of production functions (human capital and labor). Specifically, endogenous growth theories as applied by Brems (1970) and De Mello (1997) show that foreign direct investment plays an important role in promoting long-run economic growth and foreign direct investment is considered more effective than domestic investment in the recipient country by De Mello (1999) and Herzer et al (2008). However, Romer (1986, 1990); Amos and Jidda (2018); Baita (2021); and Irshad et al (2022) showed the role of infrastructure and foreign direct investment on economic growth.

2.2 Empirical Literature

Wani and Mir (2021) investigate the relationship among FDI, exports, imports, remittances, and economic growth in India with annual secondary data from 1988 to 2018 by employing the Autoregressive Distributed Lag (ARDL) approach. The empirical result showed that both FDI and imports have a positive impact on economic growth in India. However, foreign remittances and exports have a negative impact and are significant at the level of economic performance of India.

Srithilat, *et al*., (2018) focused on the long run relationship between FDI and trade openness on economic development in Laos with time series data during 1990-2015 by using the Autoregressive Distributed Lag (ARDL) bounds testing approach and this paper has used the Augment Dickey-Fuller (ADF) test to test unit root for stationary all variables. The result of ARDL found that FDI and trade are major catalysts on Laos' economic development in the long run which have a positive impact and are significant at the level. Therefore, this study recommends that the government of Laos should attract and sustain more foreign capital and increase international trade to achieve the target of sustainable economic growth in the long run.

Lin and Wang (2020) employed a Bootstrap ARDL bounds test to investigate the impact of life expectancy (a longer life after giving birth) and alcohol consumption on economic growth in both China and India with time series data from 1992-2015 which empirical result showed that relationship between economic development, longevity, and alcohol on both China and India. The result of ARDL shows that, a unidirectional causality link between longevity and alcohol consumption in China. On the other hand, a bidirectional causality relationship between longevity and alcohol use in India.

Oyeniran and Alliyu (2016) examine the long-run and short-run effects of investment in telecommunication infrastructure on economic growth in Nigeria by using time series data from 1980 and 2012. In analyzing the data employ the Autoregressive Distributed Lag (ARDL) bounds testing approach. The empirical result showed the long- run relationship between dependent and all independent variables. The study from the cointegration test confirmed that foreign direct investment (FDI) in information and communication technology determines and improves economic growth in Nigeria.

Uaman and Mazadu (2021) focused on the nexus between telecommunication infrastructure investment and economic growth in Nigeria by employing Autoregressive Distributed Lag (ARDL) and Granger Causality Test approach with time series data from 1981-2019. The findings from the cointegration test confirmed that telecommunication investment and telecommunication revenue exert a positive impact and significant on economic growth in both the long run and short run. As a result, the government of Nigeria should attract and sustain more licenses to GSM operators, support concessionary fiscal incentives, and encourage active investment in fixed telecommunication assets.

Ouedraogo (2010) has focused on the causality relationship between electricity consumption and economic growth in Burkina Faso by ARDL bounds testing approach evidence of cointegration to analyze the long-term relationship among variables such as between electricity consumption, GDP, and capital formation with the period 1968– 2003. The empirical results of the Granger causality test indicate that there is no significant causal relationship between electricity consumption and investment. However, these results also suggest that in the both short and long run, there is a bidirectional causal relationship between economic growth (real GDP) and electricity consumption. There is also evidence of a positive feedback causal relationship between capital formation and GDP in Burkina Faso. These results suggest that electricity is an important factor in socio-economic development in Burkina Faso where electricity consumption is growing with the income level so must implement policies ensure that electricity generates fewer potential negative effects but should not be an obstacle to development such as solar energy and bio-energy.

Karanfil (2015) analyzed the long and short-run dynamics causal relationship between electricity consumption and economic activities on the per capita GDP of 160 countries with panel data for the period of 1980–2010. The results show that long-run cointegration links and inferences arise among electricity consumption and economic growth which is very different in the full sample and the majority of the subsamples. According to the research results conclude that the connection of electricity growth is highly sensitive to regional differences, urbanization rates, electricity dependency, low-income countries, lower-middle-income countries, and high-income countries.

Qazi *et al*., (2021) investigated the causal relationship between electricity consumption and FDI on the economic growth of Pakistan with time series data during 1971-2017 by using the ARDL model approach. Analyzing the time series data has been verified as robust by the FMOLS and CCR. The results of the ARDL model found that all variables have a positive impact and significant long-run relationship between among variables on economic growth (GDP) in Pakistan.

Tolcha (2020) investigated the causal relationship between economic development and air transport demand in six sub- Saharan African countries under panel data from 1981 to 2018 by analyzing long- and short-run causalities between dependent and explanatory variables employing vector error correction and vector autoregression models. The results reveal that in South Africa, Nigeria, and Kenya there is directional causality from economic development to air transport demand in the long run, but causality runs in the opposite direction from air transport promoting economic development can be seen in low-income countries as Ethiopia, and for Senegal and Angola, there is too weak to determine causal directions from causality from economic development to air transport demand.

Irshad *et al*., (2022) investigated the causal relationship between infrastructure and economic growth in lower- middle- income countries with the panel data from 1995-2017 by using FMOLS and DOLS. The results confirm that the infrastructure (electricity, transport, and telecommunication) has a positive and significant impact at the level, including the control variable as FDI has a strongly positive impact and is statistically significant on economic growth in the long run. However, both labor and gross fixed capital formation have a strong positive and compelling impact in supporting economic growth. Thus, the government of lower middle-income countries should attract foreign direct investment and developments of these infrastructures such as telecommunication, electricity, and transport to boost economic growth.

3. RESEARCH METHODOLOGY

3.1 Data Collection and Stationarity Techniques

This paper has used various sources of secondary data to analyze the long-run relationship among the variables, to confirm the empirical result more accurately and can be used in the real economic situation of the Lao PDR with covered the period 1995-2020. All the variables are used from the World Development Indicator (WDI2022).

Table 1: The variables in the paper

Variables	Description	Source
GDP	gross domestic production (current US$)	WDI
MO	Mobile cellular subscriptions	WDI
ELE	Access to electricity (% of population)	WDI
AIR	Air transport, passengers carried	WDI
AG	Agriculture, forestry, and fishing, value added (current US$)	WDI
SER	Services, value added (current US$)	WDI
IND	Industry (including construction), value added (current US$)	WDI
EXCH	Official exchange rate (LCU per US$, period average)	WDI
FDI	Foreign direct investment, net inflows (BoP, current US$)	WDI

The stationary properties of the time series variables to a unit root test using the Augment Dickey-Fuller (Dickey & Fuller, 1979). The Augment Dickey-Fuller unit root test has a combination of variables with I(0) and I(1) order of integration on intercept and trend respectively. The stationary properties of those variables at the level, the calculated Augment Dickey-Fuller statistic value must be larger than the critical value with a significant level of no less than 90% or reject the null hypothesis of non-stationary, and otherwise, the time series variables are non-stationary at the level. In the case, of non-stationary time series data, we will have to tests similar to the procedure of unit root testing once again with the different order at the first difference I(1). To be specific the critical value with asterisks demonstrates the rejection of the null hypothesis, specifically, three asterisks, two asterisks, and one asterisk for 1%, 5%, and 10% significant level, respectively. The specific unit root testing equation can be written as follows:

$$\Delta y_t = \alpha + \gamma y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-1} + e_t \quad \text{(Intercept)}$$

$$\Delta y_t = \alpha + \lambda_t + \gamma y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-1} + e_t \quad \text{(Intercept and trend)}$$

Where y_t and y_{t-1} time variables of period t and $t-1$; α, λ and β : Coefficient; λ_t : Time trend; e_t : Error term

3.2 Model Specification

The specific model of the study is used to examines causal the relationship between infrastructure variables (telecommunication, electricity and air transport), foreign direct investment on economic growth in Lao PDR. Therefore, the model of long run relationship among variables can be written as bellows:

$$GDP = F(MO, ELE, AIR) \quad (1)$$

Transform into multiple regressions can be written as below:

$$\log GDP_t = \beta_1 + \beta_2 \log MO_t + \beta_3 \log ELE_t + \beta_4 \log AIR_t + \varepsilon_t \quad (2)$$

Where GDP: gross domestic production; MO: telecommunication; ELE: electricity; AIR: air transport; t : Time period; ε : Error term; β_1 : intercept; $\beta_2, \beta_3, \beta_4$: coefficients

This paper has applied the Autoregressive Distributed Lag (ARDL) model introduced by Pesaran *et al*., (2001) to identify the existence of any long-run relationship between foreign direct investment, telecommunication, electricity, air transport, and economic growth, regarding a variety of the number of variables following advantages: Firstly, all variables in the ARDL model are stationary at the level I(0), or stationary at the first difference I(1), and or all variables are integrated mixture of level I(0) and the first difference I(1). Secondly, all variables in the ARDL model can also apply to a small sample size and can be estimated by the error correction model (ECM) by the Simple Ordinary Least Square (OLS) approach. Finally, the ARDL technique contributes unbiased estimates of the long-run relationship among the variables. The specific equation (2) can be transformed into ARDL bounds test for economic growth in Laos as below:

$$\begin{aligned}\Delta \log GDP_t = \alpha_0 &+ \sum_{i=1}^{N_1} \alpha_1 \Delta \log GDP_{t-i} + \sum_{i=1}^{N_2} \alpha_2 \Delta \log MO_{t-i} + \sum_{i=1}^{N_3} \alpha_3 \Delta \log ELE_{t-i} \\ &+ \sum_{i=1}^{N_4} \alpha_4 \Delta \log AIR_{t-i} + \lambda_1 \log GDP_{t-1} + \lambda_2 \log MO_{t-1} + \lambda_3 \log ELE_{t-1} \quad (3) \\ &+ \lambda_4 \log AIR_{t-1} + \varepsilon_t\end{aligned}$$

Short run model (the error correction model)

$$\Delta \log GDP_t = \alpha_0 + \sum_{i=1}^{N_1} \theta_1 \Delta \log GDP_{t-i} + \sum_{i=1}^{N_2} \theta_2 \Delta \log MO_{t-i} + \sum_{i=1}^{N_3} \theta_3 \Delta \log ELE_{t-i} + \sum_{i=1}^{N_4} \theta_4 \Delta \log AIR_{t-i} + \omega ECT_{t-1} + \varepsilon_t \quad (4)$$

We add some independent variables such as agriculture (AG), service (SER) and industry (IND) on economic growth in Laos which the model 3 can be transformed into ARDL bounds test as below:

$$\begin{aligned}\Delta \log GDP_t = {} & \alpha_0 + \sum_{i=1}^{N_1} \alpha_1 \Delta \log GDP_{t-i} + \sum_{i=1}^{N_2} \alpha_2 \Delta \log MO_{t-i} + \sum_{i=1}^{N_3} \alpha_3 \Delta \log ELE_{t-i} \\ & + \sum_{i=1}^{N_4} \alpha_4 \Delta \log AIR_{t-i} + \sum_{i=1}^{N_5} \alpha_5 \Delta \log AG_{t-i} + \sum_{i=1}^{N_6} \alpha_6 \Delta \log SER_{t-i} \\ & + \sum_{i=1}^{N_7} \alpha_7 \Delta \log IND_{t-i} + \lambda_1 \log GDP_{t-1} + \lambda_2 \log MO_{t-1} + \lambda_3 \log ELE_{t-1} \\ & + \lambda_4 \log AIR_{t-1} + \lambda_5 \log AG_{t-1} + \lambda_6 \log SER_{t-1} + \lambda_7 \log IND_{t-1} + \varepsilon_t\end{aligned} \quad (5)$$

The error correction model is written as below:

$$\begin{aligned}\Delta \log GDP_t = {} & \alpha_0 + \sum_{i=1}^{N_1} \varphi_1 \Delta \log GDP_{t-i} + \sum_{i=1}^{N_2} \varphi_2 \Delta \log MO_{t-i} + \sum_{i=1}^{N_3} \varphi_3 \Delta \log ELE_{t-i} \\ & + \sum_{i=1}^{N_4} \varphi_4 \Delta \log AIR_{t-i} + \sum_{i=1}^{N_5} \varphi_5 \Delta \log AG_{t-i} + \sum_{i=1}^{N_6} \varphi_6 \Delta \log SER_{t-i} \\ & + \sum_{i=1}^{N_7} \varphi_7 \Delta \log IND_{t-i} + \omega ECT_{t-1} + \varepsilon_t\end{aligned} \quad (6)$$

Specially, we are used the control variables such as official exchange rate (EXCH) and foreign direct investment (FDI) into model 5 for the economic growth in Laos as below:

$$\begin{aligned}\Delta \log GDP_t = {} & \alpha_0 + \sum_{i=1}^{N_1} \alpha_1 \Delta \log GDP_{t-i} + \sum_{i=1}^{N_2} \alpha_2 \Delta \log MO_{t-i} + \sum_{i=1}^{N_3} \alpha_3 \Delta \log ELE_{t-i} \\ & + \sum_{i=1}^{N_4} \alpha_4 \Delta \log AIR_{t-i} + \sum_{i=1}^{N_5} \alpha_5 \Delta \log AG_{t-i} + \sum_{i=1}^{N_6} \alpha_6 \Delta \log SER_{t-i} \\ & + \sum_{i=1}^{N_7} \alpha_7 \Delta \log IND_{t-i} + \sum_{i=1}^{N_8} \alpha_8 \Delta \log EXCH_{t-i} + \sum_{i=1}^{N_9} \alpha_9 \Delta \log FDI_{t-i} \\ & + \lambda_1 \log GDP_{t-1} + \lambda_2 \log MO_{t-1} + \lambda_3 \log ELE_{t-1} + \lambda_4 \log AIR_{t-1} \\ & + \lambda_5 \log AG_{t-1} + \lambda_6 \log SER_{t-1} + \lambda_7 \log IND_{t-1} + \lambda_8 \log EXCH_{t-1} \\ & + \lambda_9 \log FDI_{t-1} + \varepsilon_t\end{aligned} \quad (7)$$

The error correction model is written as below:

$$\begin{aligned}\Delta \log GDP_t = {} & \alpha_0 + \sum_{i=1}^{N_1} \varphi_1 \Delta \log GDP_{t-i} + \sum_{i=1}^{N_2} \varphi_2 \Delta \log MO_{t-i} + \sum_{i=1}^{N_3} \varphi_3 \Delta \log ELE_{t-i} \\ & + \sum_{i=1}^{N_4} \varphi_4 \Delta \log AIR_{t-i} + \sum_{i=1}^{N_5} \varphi_5 \Delta \log AG_{t-i} + \sum_{i=1}^{N_6} \varphi_6 \Delta \log SER_{t-i} \\ & + \sum_{i=1}^{N_7} \varphi_7 \Delta \log IND_{t-i} + \sum_{i=1}^{N_8} \varphi_8 \Delta \log EXCH_{t-i} + \sum_{i=1}^{N_9} \varphi_9 \Delta \log FDI_{t-i} \\ & + \omega ECT_{t-1} + \varepsilon_t\end{aligned} \quad (8)$$

The error correction term (ECT_{t-1}) in the short run model indicates the speed adjustment of Laos' economic growth from short - term equilibrium to long - term equilibrium. Normally, the ECT_{t-1} value expected to be negative and statistically significant or the value of ECT_{t-1} is between minus one and zero (-1 to 0).

Given the above model, the estimation of the long-run relationship among variables is obtained from the F-statistic value for the bound test with the null hypothesis (H_0) and alternative hypothesis (H_1) as follows:

$$\begin{cases} H_0 : \lambda_i = \lambda_j = 0 \\ H_1 : \lambda_i \neq \lambda_j \neq 0 \end{cases} ; i \neq j, i \& j = 1,2,3,...$$

Where: H_0 is no long-run relationship or no cointegration; H_1 is long-run relationship or cointegration

As a rule of thumb, the null hypothesis (H_0) will be rejected, if the value of the bound test F-statistic is greater than the upper and lower bound values or alternative hypothesis (H_1) is accepted. On the other hand, the null hypothesis H_0 will be accepted, if the value of the bound test F-statistic is smaller than the upper and lower bound values.

3.3 Cointegration Test

The ARDL bounds test developed by Pesaran et al. (2001) were used to estimate the joined F-statistic whether the null hypothesis (H_0) of no cointegration will be rejected or not, the calculated joined F-statistic value is higher than 10%, 5%, 2.5%, and 1% of the upper bound critical in the order zero and one respectively, rejecting the null hypothesis (H_0) by suggesting the presence of cointegration amongst the variables have a long run relationship. Moreover, the Johansen cointegration test (Johansen and Juselius, 1990) is a one of the well-known techniques to verify the ARDL bounds test findings.

3.4 Robustness and Diagnostic Test

To verify the intensity of the cointegration valuation by Breusch-Godfrey Serial Correlation LM Test, Heteroskedasticity Test: Breusch-Pagan-Godfrey, Harvey and Jarque-Bera (Normality test) approach. The normality Heteroscedasticity tests verified that the model of study is normally distributed by examined p-value regarding $ARDL(N_1, N_2, .., N_n)$, where, N_1 represents the appropriate lag of the dependent variable and $N_2, N_3, .., N_n$ represent the appropriate lag of other exogenous variables in the model. Those diagnostic probability values must to be greater than 5% level of significance. Afterward, testing the stability of the model is tested using Cumulative Sum (CUSUM) and Cumulative Sum of Square (CUSUMSQ).

4. EMPIRICAL RESULTS

4.1 Results of Unit Root Test

The results of unit root for all variables utilizing the ADF test are presented in Table 2. The ADF test results show that GDP was stationary at both I (0) and I (1) in terms of intercept, but not stationary at intercept and trend; MO was stationary at I(0) in terms of intercept and at I(1) in term intercept and trend, but no stationary in term of intercept and trend at I (0) and intercept at I (1); ELE was stationary at the both I(0) and I(1); AIR and FDI were non stationary at the I (0) in terms of intercept, and intercept and trend but became stationary at the I(1) in term of intercept, and intercept and trend; AG was stationary at I (0) and I (1), but in term of intercept and trend no stationary; SER and IND were stationary at the I (1) in terms of intercept; EXCH is found to be integrated at I (0) in terms intercept and intercept and trend, no stationary at the I (1).

Table 2: The results of unit root tests.

Variables	Level		First Difference	
	Intercept	Intercept and Trend	Intercept	Intercept and Trend
log(GDP)	-3.2355**	-1.1427	-3.0434**	-3.0025
log(MO)	-3.5987**	-0.0519	-1.3778	-4.1773**
log(ELE)	-2.8277*	-4.6541***	-3.7931***	-5.0119***
log(AIR)	-2.0425	-2.2380	-5.4926***	-5.7262***
log(AG)	-2.7185*	-1.0637	-5.5448***	-5.6341***
log(SER)	-2.5766	-0.3518	-3.9231***	-3.0073
log(IND)	0.2726	-2.9104	-3.6203**	-1.6436
log(EXCH)	-11.4443***	-4.2958**	-2.0645	-3.1357
log(FDI)	-0.8939	-2.1355	-5.1858***	-5.1912***

At 10%, 5% and 1% statistically significance level represents by *, ** and *** respectively

4.2 RESULTS OF THE COINTEGRATION TESTS

4.2.1 The Result of the ARDL Bounds Test

The ARDL bounds test was operated to calculate the F-statistic value to the null hypothesis of no cointegration will be rejected or not. Table 3-5 reports the calculated joined F-statistic values in models A, B, and C are 32.5561, 58.2291, and 52.4949, respectively, which are higher than 10%, 5%, 2.5%, and 1% of the upper bound critical in the order zero and one, respectively. So, rejecting the null hypothesis by suggesting the presence of cointegration among the variables has a long-run relationship.

Table 3: The model (A) result of the ARDL bound test

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	32.5561	10%	2.37	3.2
k	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66

Table 4: The model (B) result of the ARDL bound test

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	58.2291	10%	1.99	2.94
k	6	5%	2.27	3.28
		2.5%	2.55	3.61
		1%	2.88	3.99

Table 5: The model (C) result of the ARDL bound test

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	52.4949	10%	1.85	2.85
k	8	5%	2.11	3.15
		2.5%	2.33	3.42
		1%	2.62	3.77

4.3 RESULTS OF THE LONG-RUN, SHORT-RUN AND DIAGNOSTIC

4.3.1 Results of the Long-Run

After confirming cointegration among the variables it has a long-run relationship. The long-run relationship between among variables in Table 10 the result of ARDL (3,2,2,1) in model A found that infrastructure as telecommunication and electricity have positive effects and are significant at the level, but air transport has positive, no significant at the level which cannot explain on the statistical conclusion. Implying that an increase of 1% in telecommunication and electricity will result increase in Laos' economic growth by 0.1226% and 1.8680% respectively. The result of ARDL (2,2,1,2,0,1,2) in model B found that electricity, air transport, agriculture, and industry have strongly positive and significant impacts on the level, but the value of service has positive with no significant at the level, of a 1% increase in electricity, air transport, agriculture, and industry will be increased 0.4399%, 0.0893%, 0.6166%, and 0.2859% respectively in economic growth, but the coefficient of telecommunication is negative and significant at the level of a 1% increase in telecommunication will result reduce in economic growth by 0.0469%. Finally, the outcome of ARDL (1,0,1,1,0,1,1,1,0) in model C shows that the coefficient of air transport, service, industry exchange rate, and FDI have a positive impact and significant at the level, an increasing 1% in the air transport, service, industry exchange rate, and FDI will rise about 0.0646%, 0.4657%, 0.3532%, 0.2048%, and 0.0170% respectively on economic growth in the long run, but telecommunication is negative (- 0.0377) and significant impact at the level which explain that a 1% increase in telecommunication will reduce about 0.0377% in Laos' economic growth, especially, both agriculture and electricity have no significant at the level which is positive and negative respectively.

Table 6: The long run results of ARDL for the economic growth (GDP) in Laos

Variables	Model A	Model B	Model C
log(MO)	0.1226***	-0.0469***	-0.0377***
log(ELE)	1.8680***	0.4939***	-0.1475
log(AIR)	0.1523	0.0893***	0.0646*
log(AG)		0.6166***	0.2854
log(SER)		0.1355	0.4657***
log(IND)		0.2859***	0.3532***
log(EXCH)			0.2048***
log(FDI)			0.0170**
C	13.3413***	-0.8752***	-2.0619

At 10%, 5% and 1% statistically significance level represents by *, ** and *** respectively

4.3.2 RESULTS OF THE SHORT RUN AND DIAGNOSTIC

The short-run impact of all variables on economic growth based on the error correction model (ECM) in the form ARDL model is presented in Table 12. The estimated coefficient of error correction term (ECT) in models (A-C) are negatives - 0.6914, -0.8260, and -0.9591, respectively, and significant at the level 1%, this means that a speed of adjustment of about 69.14, 82.60 and 95.91 percents per year which provides proof of the existence of a stable long-run relationship between dependent and independent variables in the models.

Table 7: The error correction model and diagnostic test results of ARDL

The error correction	Model A	Model B	Model C
ECT (-1)	-0.6914***	-0.8260***	-0.9591***
diagnostic test			
Jarque-Bera (Probability)	0.0648 (0.9680)	3.4590 (0.1773)	0.0676 (0.9667)

The error correction	Model A	Model B	Model C
Serial Correlation	A. F (2,4) = 0.5139 Pro = 0.9680 B. $\chi^2(2)$ =2.3574 Pro = 0.3077	A. F (2,4) = 0.3160 Pro= 0.7457 B. $\chi^2(2)$ =3.1387 Pro = 0.2082	A. F (1,8) = 0.0195 Pro= 0.8924 B. $\chi^2(1)$ =0.0583 Pro = 0.8091
Breusch-Pagan-Godfrey	A. F (11,11) =1.3285 Pro = 0.3228 B. $\chi^2(11)$ =13.1225 Pro = 0.2854	A. F (16.6) = 0.4537 Pro= 0.9032 B. $\chi^2(16)$ =12.5930 Pro = 0.7023	A. F (14,9) = 2.5227 Pro= 0.0831 B. $\chi^2(14)$ =19.1262 Pro = 0.1602
Harvey	A. F (11,11) = 0.8283 Pro = 0.6198 B. $\chi^2(11)$ =10.4204 Pro = 0.4930	A. F (16.6) = 0.4537 Pro= 0.9032 B. $\chi^2(16)$ =12.4927 Pro = 0.7094	A. F (14,9) = 2.3393 Pro= 0.1013 B. $\chi^2(14)$ =18.8265 Pro = 0.1717

At 10%, 5% and 1% statistically significance level represents by *, ** and *** respectively

The results can confirm that the estimated effects of FDI and infrastructure (telecommunication, electricity, and air transport) on Laos' economic growth in the long term are consistent and unbiased. To verify the intensity of the cointegration valuation by Jarque-Bera (Normality test), Serial Correlation, and Breusch-Pagan-Godfrey and Harvey approach. The diagnostic test results of models (A-C) given in Table 7 confirm that a 5% significance level in this study has been normally distributed. Afterward, we also tested the stability of the model by using the CUSUM and CUSUMQ test in Fig 1.

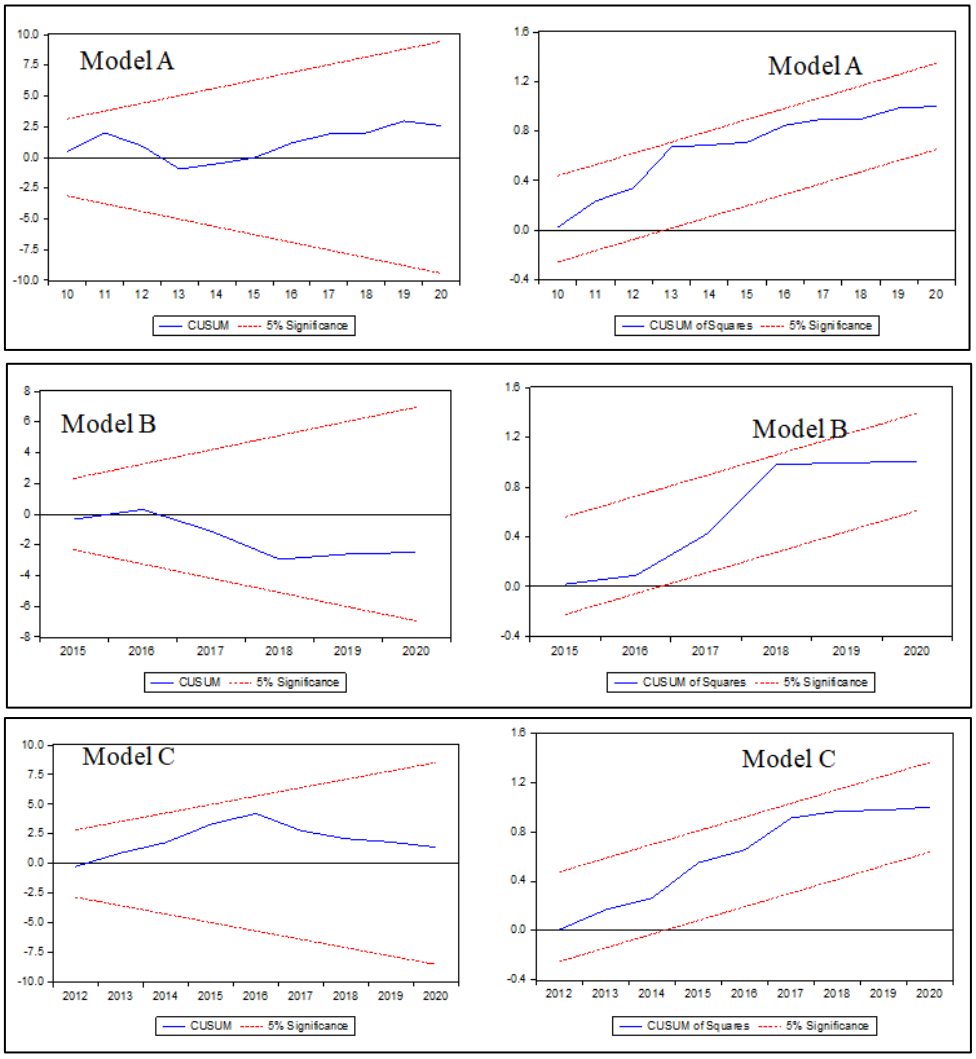

Fig. 1: The plots of Model A -C (CUSUM and CUSUMQ tests)

5. CONCLUSION AND RECOMMENDATION

This study is designed to investigate the long-run relationship between infrastructure (such as telecommunication, electricity, and air transport), and foreign direct investment on economic growth in Lao PDR during time series data from 1995-2020. Using the Autoregressive Distributive Lag (ARDL) model estimator to obtain of cointegration among the variables in the long run. The ARDL cointegration results of all models show strong statistical evidence that FDI and economic growth in Laos are cointegrated and can be confirmed that foreign direct investment has a significant impact on the host country's economic growth, especially in developing countries like the Lao PDR. The outcome of the present study shows that telecommunication, electricity, and air transport infrastructure play a very important role in promoting Laos' economic growth in the long run. The paper also found some variables in support Laos' economic growth in the long run as agriculture, service, industry, and exchange rate. Therefore, this study recommends that the government of Laos should attract and sustain more foreign capital and improve into account of economic development to achieve the target of sustainable economic growth in the long run.

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