Volume: 32, Issue: 1
Page: 1-15
2024

International Journal of Science and Business

Journal homepage: ijsab.com/ijsb

IJSAB International

Assessing the Key Drivers of Sustainable Economic Growth in Laos: Emphasis on Infrastructure Investment

Keoudone KEOTHEPHAR & Vilayvanh SRITHILAT

Abstract

This study delves into the factors driving sustainable economic growth in Laos, with a particular emphasis on infrastructure investments. Employing advanced analytical techniques, including GMM regressions and ARDL models, we analyze data spanning from 1995 to 2020, offering valuable insights and policy recommendations. Our consistent findings underscore the pivotal role of electricity infrastructure investments in spurring economic expansion. Highlights the positive impact of telecommunication infrastructure and a skilled workforce, emphasizing the importance of technological advancements and human capital development. An investigation from various angles reveals that variables like agriculture, air transport, industry, and services emerge as significant contributors to growth, emphasizing its multifaceted nature, and we introduce exchange rates as a variable, unveiling their potential for both positive and negative impacts on economic growth. In the long run, our study identifies a positive relationship between air transport, human capital, labor force, industry, services, exchange rates, and economic growth, highlighting their central role in policy efforts. In the short term, we observe that investments in the industry positively influence growth, while exchange rate fluctuations can have adverse effects. Our research underscores the critical importance of infrastructure investments, especially in electricity and air transport, for driving economic growth in Laos. Factors such as mobile telecommunication technology, human capital, agriculture, industry, and services also make substantial contributions to sustained growth. Notably, exchange rates can have both positive and negative effects, underscoring the need for meticulous management by policymakers to support Laos in its pursuit of rapid economic development.

IJSB
Accepted 18 January 2024
Published 22 January 2024
DOI: 10.58970/IJSB.2291

ISSN: 2520-4750 (Online) 2521-3040 (Print)

Keywords: *Infrastructure, Economic growth, GMM Model, ARDL Model, Laos PDR.*

About Author (s)

Keoudone KEOTHEPHAR (Corresponding author), School of Economics and Trade, Hunan University, Changsha, China.
Vilayvanh SRITHILAT, School of Economics and Trade, Hunan University, Changsha, China.

1. Introduction

Laos, a landlocked country in Southeast Asia with a population of 7.2 million, faces challenges due to its lack of direct access to the sea. The strategic location of Laos in the Indochina peninsula, however, provides significant development potential. The country has demonstrated its commitment to regional and international integration by becoming a member of key organizations such as the Greater Mekong Sub-region (GMS), the Association of Southeast Asian Nations (ASEAN), and seeking membership in the World Trade Organization (WTO) (World Bank, 2020).

One of the notable challenges for Laos is its inadequate infrastructure, particularly in transportation, which poses hurdles to economic development. The inefficiencies in the infrastructure result in increased transportation costs (Asian Development Bank, 2019). In response to these challenges, Laos has adopted a "land-linked" strategy, prioritized the development of domestic road networks and established connections with neighboring countries (World Bank, 2020). Additionally, the country is exploring collaboration with China's Belt and Road Initiative to further enhance its connectivity and infrastructure (Ministry of Foreign Affairs, Lao PDR, 2021). Despite the infrastructure challenges, Laos has achieved political stability and economic growth, along with low inflation and improvements in well-being. The country actively participates in sub-regional initiatives related to health, tourism, and trade, showcasing its commitment to regional cooperation and development (Ministry of Foreign Affairs, Lao PDR, 2021). Overall, while Laos faces certain obstacles, its strategic initiatives and collaborations indicate a positive trajectory for its future development.

The motivation and significance of this study emphasizing the unique contributions it brings to the understanding of sustainable economic growth in Laos. The utilization of advanced analytical techniques, such as GMM regressions and ARDL models, adds a layer of sophistication to the research, ensuring robust and reliable findings. This methodological rigor enhances the credibility of the study's conclusions and sets it apart from previous research efforts.

Statement of the Problem

The research focuses on infrastructure investment as a critical driver of sustainable economic growth in Laos. It emphasizes the potential to provide insights for nurturing economic growth while leveraging infrastructure development. While the primary focus is Laos, the research recognizes that its findings may have broader relevance for other developing nations facing similar challenges and opportunities related to infrastructure and economic growth.

Research Objectives

The introduction sets the stage for an in-depth analysis of the key drivers of sustainable economic growth in Laos, with a specific emphasis on the role of infrastructure investment such as electricity, air transportation and telecommunications. It promises to explore methodology, empirical results, and discussions to provide a comprehensive understanding of the topic.

2. Literature review

Our review of the literature reveals that it provides valuable insights into the relationship between access to electricity and air transport infrastructure and infrastructure investment on economic growth, primarily in the context of China and the Belt and Road Initiative (BRI). Here are the key findings:

Estimating Electricity and Economic Growth Studies by Zhang and colleagues (2017) and Xu (2022) discovered a significant interaction between electricity prices and economic growth in China. The analysis extends to 2019 and highlights the strengthening of the causal relationship between electricity use and economic growth, influenced by ecological awareness and the promotion of clean energy sources. Air Transport Infrastructure and Economic Growth, finds a positive impact of comprehensive air transport infrastructure on economic performance, particularly in more developed economies. However, this effect is less pronounced in less developed economies by Zhang (2020). Tolcha (2020) explores air transport demand in sub-Saharan African countries, showing variations in causal directions between economic development and air transport demand. Ali (2023) identifies a one-way long-run causality from air transportation factors to economic growth in BRICS countries.

Infrastructure Investment and Economic Growth

Several studies assess the impact of infrastructure investment, especially within the Belt and Road Initiative (BRI). Chen and Li (2021) find varying impacts on GDP, employment, and economic welfare across BRI countries due to transportation infrastructure investment. Yang et al. (2020) use the GTAP model to show positive impacts on economic growth from Asian nations' BRI infrastructure investments, although some regions experience negative effects. De Soyres, Mulabdic, and Ruta (2020) explore common transport infrastructure's effects within the BRI, highlighting potential GDP growth but acknowledging the possibility of negative welfare effects due to high infrastructure costs. Mukwaya and Mold (2018) reveal potential increases in exports and welfare in East Africa due to the BRI. Chen et al. (2016) investigates high-speed rail investment in China, finding it stimulates the economy while posing environmental challenges.

In summary, the literature reviews highlight those complex factors shaping economic growth, including ecological awareness and policy reforms. The significance of eco-friendly, cost-effective infrastructure investments. A gap in research focusing on diverse global regions and sectors. A need for nuanced studies to better understand links between electricity consumption, air transport, and economic growth, especially in a global context.

3. Materials and Methods

3.1. The Model specification of the study

3.1.1. GMM Model Specification:

To study the relationship between infrastructure investment, Human development and economic growth in Lao PDR, we built a series of models. Each model has different variables. These models and their logarithmic versions are defined as follows:

Model 01:

$$GDP = f(AIRT, ELEC, MOB, HUM, LABF) \quad (1)$$

A logarithmic approach for analyzing elasticities:

$$Log\ GDP_t = \beta_1 + \beta_2\ LogAIRT_t + \beta_3\ LogELEC_t + \beta_4\ LogMOB_t + \beta_5\ LogHUM_t + \beta_6\ LogLABF_t + \varepsilon_t$$

Model 02:

$$GDP = f(AIRT, ELEC, MOB, HUM, LABF, ARG) \quad (2)$$

A logarithmic approach for analyzing elasticities:

$$Log\ GDP_t = \beta_1 + \beta_2\ LogAIRT_t + \beta_3\ LogELEC_t + \beta_4\ LogMOB_t + \beta_5\ LogHUM_t + \beta_6\ LogLABF_t + \beta_7\ LogARG_t + \varepsilon_t$$

Model 03:

$$GDP = f(AIRT, ELEC, MOB, HUM, LABF, INDT) \quad (3)$$

A logarithmic approach for analyzing elasticities:

$$Log\ GDP_t = \beta_1 + \beta_2\ LogAIRT_t + \beta_3\ LogELEC_t + \beta_4\ LogMOB_t + \beta_5\ LogHUM_t + \beta_6\ LogLABF_t$$

$$+ \beta_7 \, LogINDT_t + \varepsilon_t$$

Model 04:

$$GDP = f(AIR, ELEC, MOB, HUM, LABF, SERV) \quad (4)$$

A logarithmic approach for analyzing elasticities:

$$Log\ GDP_t = \beta_1 + \beta_2 \, LogAIRT_t + \beta_3 \, LogELEC_t + \beta_4 \, LogMOB_t + \beta_5 \, LogHUM_t + \beta_6 \, LogLABF_t + \beta_7 \, LogSERV_t + \varepsilon_t$$

Model 05:

$$GDP = f(AIRT, ELEC, MOB, HUM, LABF, ARG, INDT) \quad (5)$$

A logarithmic approach for analyzing elasticities:

$$Log\ GDP_t = \beta_1 + \beta_2 \, LogAIRT_t + \beta_3 \, LogELEC_t + \beta_4 \, LogMOB_t + \beta_5 \, LogHUM_t + \beta_6 \, LogLABF_t + \beta_7 \, LogARG_t + \beta_8 \, LogINDT_t + \varepsilon_t$$

Model 06:

$$GDP = f(AIRT, ELEC, MOB, HUM, LABF, ARG, SERV) \quad (6)$$

A logarithmic approach for analyzing elasticities:

$$Log\ GDP_t = \beta_1 + \beta_2 \, LogAIRT_t + \beta_3 \, LogELEC_t + \beta_4 \, LogMOB_t + \beta_5 \, LogHUM_t + \beta_6 \, LogLABF_t + \beta_7 \, LogARG_t + \beta_8 \, LogSERV_t + \varepsilon_t$$

Model 07:

$$GDP = f(AIRT, ELEC, MOB, HUM, LABF, EXR) \quad (7)$$

A logarithmic approach for analyzing elasticities:

$$Log\ GDP_t = \beta_1 + \beta_2 \, LogAIRT_t + \beta_3 \, LogELEC_t + \beta_4 \, LogMOB_t + \beta_5 \, LogHUM_t + \beta_6 \, LogLABF_t + \beta_7 \, LogEXR_t + \varepsilon_t$$

Model 08:

$$GDP = f(AIRT, ELEC, MOB, HUM, LABF, ARG, INDT, SERV) \quad (8)$$

A logarithmic approach for analyzing elasticities:

$$Log\ GDP_t = \beta_1 + \beta_2 \, LogAIRT_t + \beta_3 \, LogELEC_t + \beta_4 \, LogMOB_t + \beta_5 \, LogHUM_t + \beta_6 \, LogLABF_t + \beta_7 \, LogARG_t + \beta_8 \, LogINDT_t + \beta_9 \, LogSERV_t + \varepsilon_t$$

Model 09:

$$GDP = f(AIRT, ELEC, MOB, HUM, LABF, ARG, SERV, INDT, EXR) \quad (9)$$

A logarithmic approach for analyzing elasticities:

$$Log\ GDP_t = \beta_1 + \beta_2 \, LogAIRT_t + \beta_3 \, LogELEC_t + \beta_4 \, LogMOB_t + \beta_5 \, LogHUM_t + \beta_6 \, LogLABF_t + \beta_7 \, LogARG_t + \beta_8 \, LogINDT_t + \beta_9 \, LogSERV_t + \beta_{10} \, LogEXR_t + \varepsilon_t$$

In these models, GDP is an indicator for gross domestic product, and the variables AIRT, ELEC, MOB, HUM, and LABF are indicators of electricity, air transportation, telecommunications, human capital, and labor force participation, respectively. In addition, there are various control variables, including ARG (agriculture), INDT (industry), SERV (services), and EXR (exchange rate). These models are structured to investigate the relationship between these variables and economic growth in Laos. The logarithmic version was used to examine the elasticity of these variables.

3.2. ARDL Model Specification:

The study will employ the Cobb-Douglas production equation to analyze the impact of various factors on economic growth.

$$\mathrm{GDP} = \mathrm{AK}^{\alpha}\mathrm{L}^{\beta} \quad (10)$$

From the above production equation, we put the log on both parts of the equation to obtain the following new results:

$$logGDP = logA + \alpha logK + \beta logL \quad (11)$$

Model (11) above is log and extended by including other important variables as shown in Equation below By gathering all factors influencing economic growth from the previous discussion, the Lao economic growth function can be written as:

$$GDP = f(AIRT, ELEC, MOB, HUM, LABF, ARG, SERV, INDT, EXR) \quad (12)$$

A logarithmic approach for analyzing elasticities:

$$log(GDP_t) = \beta_1 + \beta_2\, log(AIRT_t) + \beta_3\, log(ELEC_t) + \beta 4\, log(MOB_t) + \beta 5\, log(HUM_t) + \beta_6\, log(LABF_t) + \beta_7\, log(ARG_t) + \beta_8\, log(INDT_t) + \beta_9\, log(SERV_t) + \beta_{10}\, log(EXR_t) + \varepsilon_t$$

3.2.1. ARDL model for the Economic growth generation

Pesaran et al. (2001) introduced the Autoregressive Distributed Lag (ARDL) bound test method. When all the chosen variables exhibit stationarity at different orders, namely I(0) and I(1), the ARDL approach can be employed. In contrast, the cointegration test proposed by Johansen (1990) and Johansen and Juselius (1990) is widely recognized for assessing the presence of a long-term relationship, but it necessitates that all selected variables be stationary at I(1). The ARDL bound test, however, overcomes this requirement. We are suggesting the following ARDL model to analyze economic growth in Laos:

$$\Delta log(GDP_t) = \beta_1 + \beta_{2i} \sum_{i=0}^{n} \Delta log(AIRTt - i) + \beta_{3i} \sum_{i=0}^{n} \Delta log(ELECTt - i) + \beta_{4i} \sum_{i=0}^{n} \Delta log(MOBt - i) + \beta_{5i} \sum_{i=0}^{n} \Delta log(HUMt - i) + \beta_{6i} \sum_{i=0}^{n} \Delta log(LABFt - i) + \beta_{7i} \sum_{i=0}^{n} \Delta log(ARGt - i) + \beta_{8i} \sum_{i=0}^{n} \Delta log(INDTt - i) + \beta_{9i} \sum_{i=0}^{n} \Delta log(SERVt - i) + \beta_{10i} \sum_{i=0}^{n} \Delta log(EXRt - i) + \beta_{11} log(AIRT_{t-1}) + \beta_{12} log(ELECT_{t-1}) + \beta_{13} log(MOB_{t-1}) + \beta_{14} log(HUM_{t-1}) + \beta_{15} log(LABF_{t-1}) + \beta_{16} log(ARG_{t-1}) + \beta_{17} log(INDT_{t-1}) + \beta_{18} log(SERV_{t-1}) + \beta_{19} log(EXR_{t-1}) + \varepsilon_t \quad (13)$$

In these models, GDP represents gross domestic production, and in model (13), Δ indicates the first difference operator, n represents the optimal number of delays, β_2 to β_{10} correspond to the short-term coefficients, and β_{11} to β_{19} represent the long-term coefficients, the error term ε_t is characterized as a sign disturbing white. To check for the existence of a long-term relationship, we used the F statistic in the bound test. The null hypothesis posits that there is no cohesion between the variables. We will reject this null hypothesis if the F statistic exceeds the upper bound. This indicates that there is long-term cointegration between the variables.

3.2.2. The following is the Error Correction Model:

$$\Delta log(GDP_t) = \beta_1 + \beta_{2i} \sum_{i=0}^{n} \Delta log(AIRTt - i) + \beta_{3i} \sum_{i=0}^{n} \Delta log(ELECTt - i) + \beta_{4i} \sum_{i=0}^{n} \Delta log(MOBt - i) + \beta_{5i} \sum_{i=0}^{n} \Delta log(HUMt - i) + \beta_{6i} \sum_{i=0}^{n} \Delta log(LABFt - i) + \beta_{7i} \sum_{i=0}^{n} \Delta log(ARGt - i) + \beta_{8i} \sum_{i=0}^{n} \Delta log(INDTt - i) + \beta_{9i} \sum_{i=0}^{n} \Delta log(SERVt - i) + \beta_{10i} \sum_{i=0}^{n} \Delta log(EXRt - i) + \lambda ECT_{t-1} + \varepsilon_t \quad (14)$$

Within equation (14), λ acts as a proxy for the adjustment rate. It represents the speed with which long-term deviations from the previous year are corrected in the current year in response to short-term changes. It is expected that the error correction specification (ECT) will show a negative sign and a p-value lower than 5%, confirming statistical significance.

3. Methodology:

3.1. Data and Empirical Methodology

Data Sources and Timeframe

This research relies on secondary data collected from various sources to investigate the long-run associations among the variables under consideration. The dataset encompasses the years from 1995 to 2020 and has been sourced from the World Development Indicator (WDI 2022).

Variables

Table 1 outlines the variables utilized in this study, each of which plays a crucial role in comprehending and quantifying the economic dynamics within the Lao People's Democratic Republic (Lao PDR). The employment of the World Development Indicator dataset contributes to the precision and practical relevance of the empirical findings obtained in this analysis.

Table 1 presents the variables used in this study

Variables	Description	Source
GDP	Gross domestic production (current US$)	WDI
MOB	Mobile cellular subscriptions	WDI
ELEC	Access to electricity (% of population)	WDI
AIRT	Air transport, passengers carried	WDI
ARG	Agriculture, forestry, and fishing, value added (current US$)	WDI
INDT	Industry (including construction), value added (current US$)	WDI
SERV	Services, value added (current US$)	WDI
LABF	Labor force participation rate, total (% of total population ages 15+) (modeled ILO estimate)	WDI
HUM	Human capital (School enrollment, secondary (% gross))	WDI
EXR	Official exchange rate (LCU per US$, period average)	WDI

Description Variables

The table 2 indicates information in detail for each variable including the average value or Mean; Median, the amount of Maximum, Minimum, standard deviations, Skewness, Kurtosis and the number of data observations between the periods 1995 and 2020. The descriptive statistic among the dependent and independent variables are normal distribution and shown in the table 2 applies in the next step of the investigation. The data have been summarized and converted into the different units of estimation in the form of Logarithms or percentages of GDP, HUM, LABF, INDT, MOB, SERV, ELEC, AIRT, ARG and EXR.

Table 2: Description of Variables

	Log(GDP)	Log(HUM)	Log(INDT)	Log(LABF)	Log(MOB)	Log(SERV)	Log(ELEC)	Log(EXR)	Log(AIRT)	Log(ARG)
Mean	22.35	4.41	20.97	0.02	13.13	21.50	4.12	8.87	0.05	20.95
Median	22.42	4.40	21.11	0.02	14.52	21.60	4.19	9.02	0.00	21.00
Maximum	23.67	4.43	22.54	0.02	15.52	22.78	4.61	9.27	0.52	21.86
Minimum	20.97	4.40	19.47	0.01	8.24	20.14	3.44	6.83	-0.93	19.89
Std. Dev.	0.97	0.01	1.16	0.00	2.62	0.96	0.36	0.61	0.28	0.65
Skewness	0.03	0.83	-0.02	-1.25	-0.75	0.02	-0.26	-2.57	-1.23	-0.04
Kurtosis	1.42	2.12	1.38	6.42	1.94	1.42	1.90	8.35	7.55	1.54
Obs	25	25	25	25	25	25	25	25	25	25

Source: Author estimation

Stationarity Testing:

To ensure that the time series variables exhibit stationarity, we will execute the Augmented Dickey-Fuller test, as proposed by Dickey and Fuller in 1979, to conduct unit root analysis.

3.2. Analysis of Infrastructure Investment and Economic Growth:

3.2.1 Generalized Method of Moments (GMM) Model:

The Generalized Method of Moments (GMM), introduced by Hansen in 1982, is the widely adopted approach for assessing the connection between infrastructure investment and economic growth. To ensure the reliability of GMM estimations, diagnostic tests on residuals and coefficients will be conducted. This includes using Jarque-Bera statistics to assess the normality of residuals and employing confidence ellipses to scrutinize coefficient stability, ultimately providing a robust framework for evaluating the relationship between infrastructure investment and economic growth.

3.2.2 Autoregressive Distributed Lag (ARDL) Model:

The ARDL model will be utilized to establish the existence of a long-run relationship between infrastructure investment and economic growth. The F-statistic will be employed to assess the intensity of cointegration. Additionally, diagnostic tests will be conducted to validate the model's underlying assumptions, including the Jarque-Bera test for normality, the Breusch-Godfrey Serial Correlation LM test, and the Breusch-Pagan-Godfrey test.

3.2.3. Error Correction Model (ECM):

An Error Correction Model (ECM) will be utilized to investigate the short-term dynamics and the rate of adjustment toward long-term equilibrium between infrastructure investment and economic growth. The adjustment speed is encapsulated by the error correction term (ECT_{t-1}) in Model. The ECT_{t-1} value must be not only negative but also statistically significant at the 5% level, signifying the importance of the short-term to long-term equilibrium adjustment process.

3.2.4. Model Stability Assessment:

To ensure the stability of the models utilized, CUSUM and CUSUMQ tests will be conducted, which will assist in the identification of potential structural changes or instability in the relationship between infrastructure investment and economic growth. It is stressed that diagnostic tests hold significant importance for both the GMM and ARDL models and stability checks will be executed to validate the robustness of the findings.

4. Results and Discussion

4.1 Results from Unit Root Testing for All Variables

The results presented in Table 3 shows that 5 variables (GDP, MOB, ELEC, ARG, HUM, & EXR) display stationarity at either the Level (I(0)), whereas the remaining variables (GDP,MOB, ELEC,ARG, AIRT, INDT, SERV, and LABF) demonstrate stationarity at the First Difference (I(1). Importantly, 4 variables (GDP, MOB, ELEC, and ARG) exhibit stationarity at both the Level (I(0)) and the First Difference (I(1)). These unit root findings suggest the appropriateness of the ARDL bound test approach for our analysis.

Table 3. Unit root results.

Variables	Level		First Difference	
	Intercept	Intercept and Trend	Intercept	Intercept and Trend
$LOG(GDP)_t$	-3.2355**	-1.1427	-3.0434**	-3.0025
$LOG(MOB)_t$	-3.5987**	-0.0519	-1.3778	-4.1773**
$LOG(ELEC)_t$	-2.8277*	-4.6541***	-3.7931***	-5.0119***
$LOG(AIRT)_t$	-2.0425	-2.2380	-5.4926***	-5.7262***
$LOG (ARG)_t$	-2.7185*	-1.0637	-5.5448***	-5.6341***
$LOG(SERV)_t$	-2.5766	-0.3518	-3.9231***	-3.0073
$LOG(INDT)_t$	0.2726	-2.9104	-3.6203**	-1.6436
$LOG(LABF)_t$	0.6215	-0.4437	-2.8824*	-3.4264*
$LOG(HUM)_t$	-3.3780**	-2.5750	-0.9999	-2.4069
$LOG (EXR)_t$	-11.4443***	-4.2959**	-2.0645	-3.1358

Note: ***, **, and * represent significance levels of 5%, 1%, and less, respectively.

4.2 Results of GMM Estimations.

The empirical outcomes of GMM regressions offer insights into how infrastructure and various factors impact economic growth in Laos. Employing nine distinct models, each focusing on specific variables, this study consistently underscores the significant positive influence of particular independent variables, with a special emphasis on electricity infrastructure investment as a key driver of economic growth (illustrated in Table 4 across Model 01 to Model 09).

In Model 01, which serves as the foundational model, variables such as electricity, air transportation, telecommunication, human capital, and labor force participation are considered. The GMM results reveal that electricity investment, telecommunication, and human capital have positive and statistically significant effects on economic growth, whereas labor participation and air transport lack statistical significance. Notably, the coefficient for electricity infrastructure investment indicates that a one percent increase in such investment results in a 1.7943 percent increase in GDP. **Model 02** expands on the initial model by introducing agriculture investment, showing positive and substantial impacts on economic growth from electricity investment, air transport, and agriculture investment. **In Model 03**, industry investment is incorporated, with electricity investment and industry investment both contributing positively and significantly to economic growth. **Model 04** introduces service investment, indicating that air transport investment and service investment exert favorable and substantial effects on the acceleration of economic growth. **Model 05** combines agriculture and industry investments, resulting in beneficial and noteworthy impacts on economic growth from electricity investment, industry, and agriculture investments. **In Model 06**, agriculture investment and service are combined, displaying favorable and substantial impacts on the acceleration of economic growth due to electricity investment, service, and agriculture investment. **Model 07** expands to include foreign exchange rates as a variable, showing that economic growth is positively influenced by electricity investment, while labor force participation and exchange rates exert a negative impact. The coefficient for electricity infrastructure investment in Laos stands at 2.4928, indicating that a one percent increase results in a 2.4828 percent increase in GDP. **Model 08** introduces agriculture, industry, and service investments, with results indicating that both electricity investment and industry investment have positive and significant effects on economic growth. **Model 09** encompasses agriculture, industry, service investments, and foreign exchange rates, demonstrating that industry, agriculture, and the exchange rate positively and significantly influence the acceleration of economic growth. Across all models, the study consistently highlights the pivotal role of electricity infrastructure investment as a fundamental driver of economic growth in Laos. Additionally, it emphasizes the significance of other factors such as technology, human capital, agriculture, industry, and services. The study advises policymakers to recognize the dual role of the exchange rate, which can have both favorable and unfavorable impacts on growth, emphasizing the need for careful management. These findings offer valuable insights for policymakers and stakeholders working to promote and sustain economic growth in Laos.

Table 4. Results from the GMM estimation

Variables	Model 01	Model 02	Model 03	Model 04
$LOG(AIRT)_t$	0.1604	0.0982***	-0.0718	0.0486*
$LOG(ELEC)_t$	1.7943**	0.9748***	0.5362*	0.2740
$LOG(MOB)_t$	0.6821*	0.0716	-0.1448	0.0975
$LOG(LABF)_t$	-32.9513	-1.7828	2.8218	-4.1924
$LOG(HUM)_t$	122.4412*	15.3832	-19.9264	17.5268
$LOG(ARG)_t$		0.9779***		
$LOG(INDT)_t$			0.7769***	
$LOG(SERV)_t$				0.8672***
C	-533.0409*	-70.8639	93.5355	-75.8775
R^2	0.9499	0.9947	0.996123	0.9966
Adj.R^2	0.9368	0.9930	0.99483	0.9954
D-W	0.8296	2.5126	1.5293	2.1790

Continue...

Variables	Model 05	Model 06	Model 07	Model 08	Model 09
$LOG(AIRT)_t$	-0.0060	-0.0149	0.0977	-0.0079	-0.0199
$LOG(ELEC)_t$	0.6666***	0.3391***	2.4928***	0.4779***	0.0981
$LOG(MOB)_t$	-0.0928	-0.0454	0.7821	-0.0618	-0.0573
$LOG(LABF)_t$	2.8012	0.4398	-19.5397*	1.3906	4.3420
$LOG(HUM)_t$	-11.8837	-5.1822	0.0768	-7.4655	-3.5255
$LOG(ARG)_t$	0.4583***	0.3804***		0.2086	0.2480*
$LOG(INDT)_t$	0.4591***			0.3956***	0.4384**
$LOG(SERV)_t$		0.4786***		0.2856	0.3613
$LOG(EXR)_t$			-0.4790***		0.0993**
C	53.9212	26.1185	12.2674	35.2666	15.1158
R^2	0.9982	0.9983	0.9894	0.9983	0.9986
Adj.R^2	0.9975	0.9976	0.9858	0.9975	0.9977
D-W	1.9378	1.6054	1.6195	1.7893	1.9750

Note: ***, **, and * represent significance levels of 5%, 1%, and less, respectively.

4.2.1 Residual diagnostics test for GMM estimations

In this empirical study, diagnostic tests of GMM estimation for normality were conducted using Jarque-Bera statistics. These results affirm that Models 1 to 9 exhibit a normal distribution, suggesting that the residual series for these models also follow a normal distribution, as detailed in Table 5.

Table 5 Residual Diagnostics of Models

Estimated Models	Normality test	
	Jarque-Bera	Prob.
Model 01	0.2311	0.8908
Model 02	4.4123	0.1101
Model 03	2.3703	0.3057
Model 04	6.8942	0.0315
Model 05	0.3397	0.8437
Model 06	0.5841	0.7467
Model 07	0.5894	0.7447
Model 08	0.9989	0.6068
Model 09	6.8620	0.0323

Source: Authors.

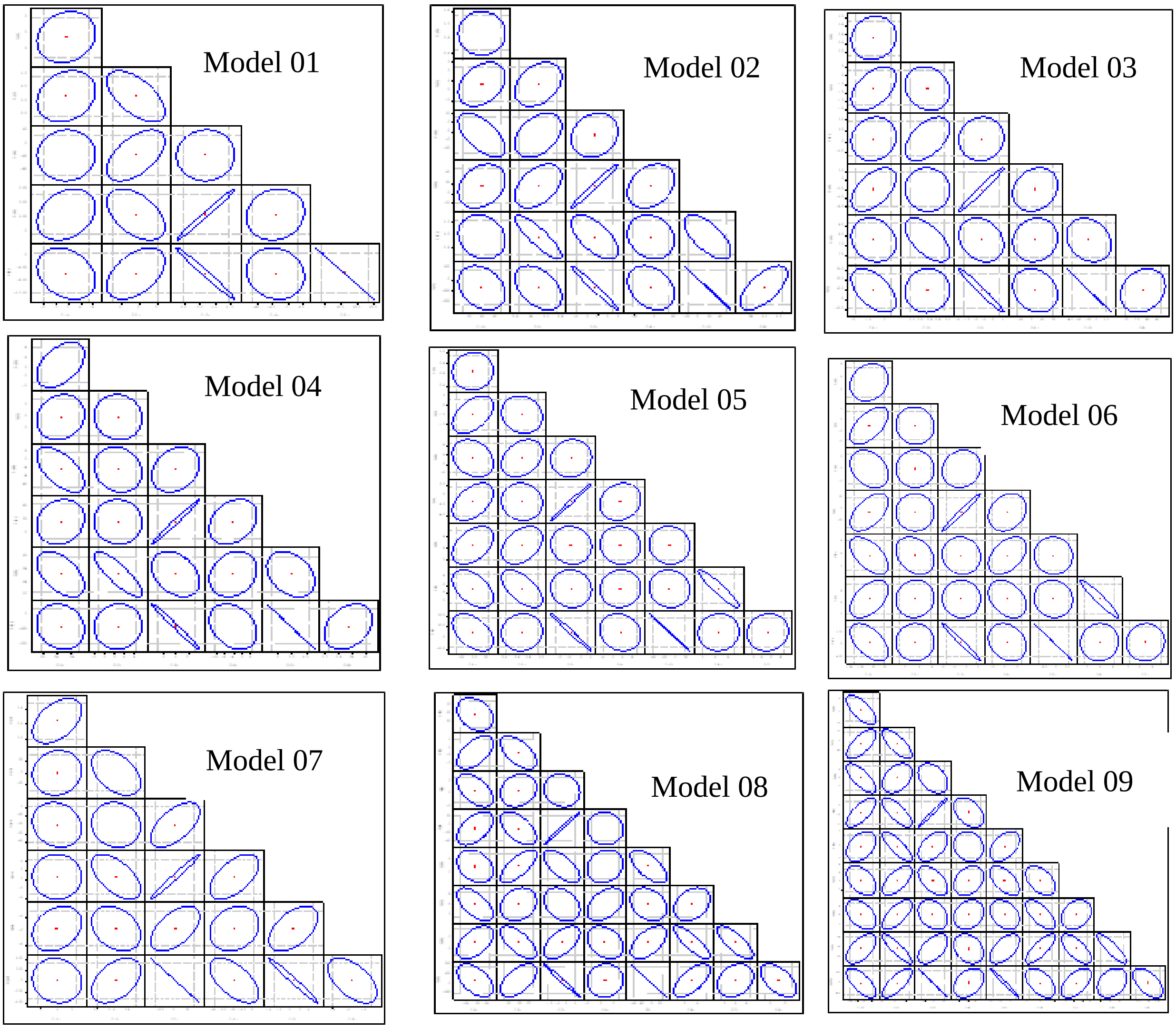


Figure 1. Evaluation of Coefficient Diagnostic Test for GMM Estimates: Confidence Ellipse Examination.

The GMM coefficient diagnostics test, as shown in Figure 1, employs the confidence ellipse criteria to verify the consistency of each model at a 95% confidence interval, with a 5% level of statistical significance. The estimated confidence ellipse criteria for all models (Model 01 to Model 09) presents the suitability of each coefficient.

4.3 The results of the ARDL model

4.3.1. Results of unit root tests.

To align with our study objectives, the unit root analysis in this study suggests the utilization of the ARDL method. Applying the ARDL method involves a series of crucial steps. The first step involves evaluating the stationarity of the data since non-stationary data could result in spurious outcomes. To assess data stationarity, the Augmented Dickey-Fuller test was performed. The results of the unit root analysis for our selected variables are presented in Table 2.

4.3.2. Bounds test for cointegration.

The cointegration bound test is utilized to ascertain the presence of a long-term cointegration relationship among the variables. When the F-statistic computed exceeds the upper bound values, the null hypothesis can be rejected, and the existence of a long-term association among the variables can be inferred. As shown in Table 6, the computed F-statistic is 37.1984, surpassing the upper bound values at the 1%, 5%, and 10% critical levels according to the criteria established by Pesaran et al. (2001).

Table 6. The especially results of the ARDL bounds test

F-Bounds Test		Null Hypothesis: No levels of relationship		
Test Statistic	Value	Significance Level	I(0)	I(1)
F-statistic	37.1984	10%	1.8	2.8
k	9	5%	2.04	2.08
		2.5%	2.24	3.35
		1%	2.5	3.68

Note: ***, **, and * represent significance levels of 5%, 1%, and less, respectively.

4.3.2 The results of long-run relationship and error correction model

The F-statistics, when compared with upper and lower bounds, confidently reject the null hypothesis, confirming the presence of long-term cointegration among the chosen variables in our ARDL model. The optimal lag length for these variables was determined using the Akaike Information Criterion (AIC). Table 7 outlines the long-term relationships within our ARDL model. The critical variable "AIR" exhibits a significant positive impact on Laos' economic growth, with a coefficient of 0.0304. A 1% increase in air transport in Laos corresponds to a 0.03% increase in economic growth. Human capital also exerts a strong, positive, and statistically significant influence, with a coefficient of 11.3486. A 1% increase in human capital leads to an 11.35% increase in economic growth. The labor force similarly has a positive and significant effect, with a coefficient of 6.9068, indicating that a 1% increase in the labor force results in a 6.91% increase in economic growth. Furthermore, both the industry and services sectors contribute positively to economic growth in Laos, with significant coefficients of 0.4011 and 0.7167, respectively. A 1% increase in the industry sector corresponds to a 0.40% increase in economic growth, while a 1% increase in the services sector leads to a 0.72% increase in economic growth. The exchange rate also has a positive impact on economic growth, with a coefficient of 0.1592, signifying that a 1% increase in the exchange rate results in a 0.16% increase in economic growth. Conversely, there is a significant negative relationship between electricity usage and economic growth in Laos. A 1% increase in electricity usage reduces economic growth by 0.22%.

Table 7. The particular results of the long-run

Variable	Coefficient	Std. Error	t-Statistic	Prob.
$LOG(AIRT)_t$	0.0304**	0.0136	2.2363	0.0521
$LOG(ELEC)_t$	-0.2185**	0.0794	-2.7521	0.0224
$LOG(MOB)_t$	0.0021	0.0206	0.1038	0.9195

LOG(HUM)$_t$	11.3486**	4.9953	2.2718	0.0492
LOG(LABF)$_t$	6.9068**	3.1101	2.2207	0.0535
LOG(ARG)$_t$	-0.0513	0.1072	-0.4788	0.6435
LOG(INDT)$_t$	0.4011***	0.0333	12.022	0.000
LOG(SERV)$_t$	0.7167***	0.0953	7.5134	0.000
LOG(EXR)$_t$	0.1592***	0.0188	8.4637	0.000
C	-51.0650**	22.0193	-2.3191	0.0456

Note: ***, **, and * represent significance levels of 5%, 1%, and less, respectively.

The results of the short-run and error correction model estimation are presented in Table 8. The coefficient for ECT (Error Correction Term) is -1.3185, and its p-value is 0.000, indicating statistical significance at the 1% level. This implies that around 10% of the disequilibrium in Laos' economic growth from the previous year will move towards long-run equilibrium, and the adjustment speed is approximately 131.85%. In the short run, industry investment and Service have a positive impact on Laos' economic growth, significant at the 1% level. However, the short-run effect of the exchange rate contradicts the long-run result. A 1% increase in the exchange rate in the Laotian economy leads to a 0.10% decrease in economic growth. On the other hand, the short-run impact of the labor force on economic growth is not statistically significant.

Table 8. The specifically results of error correction model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LOG(LABF))$_t$	-0.2051	0.8966	-0.2288	0.8241
D(LOG(INDT))$_t$	0.3743***	0.0114	32.7745	0.000
D(LOG(SERV))$_t$	0.5672***	0.0127	44.6475	0.000
D(LOG(EXR))$_t$	-0.0960***	0.0076	-12.4972	0.000
CointEq(-1)*	-1.3185***	0.0448	-29.391	0.000

Note: ***, **, and * represent significance levels of 5%, 1%, and less, respectively.

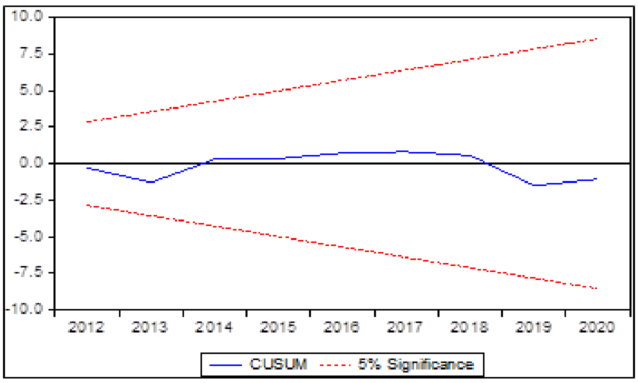
4.3.3. Diagnostic test results of the ARDL model

The ARDL bound test model was subjected to several diagnostic tests, the outcomes of which are displayed in Table 9. These tests affirm that there are no concerns regarding serial correlation or heteroskedasticity at the 5% significance level. The residuals derived from the model follow a normal distribution. To evaluate the stability of the model, CUSUM and CUSUMSQ tests were utilized. Figure 2 illustrates that the estimated coefficients of the model maintain their stability, as the blue line falls within the red lines at the 5% significance level, a pattern observed in both figures.

Table 9. Diagnostic test results of ARDL model.

Types of tests	**Statistical value**	**Prob**
Normality	1.4818	0.4767
Serial Correlation	F (2,7) = 1.2174	0.3518
	Chi-Square (2) = 6.1938	0.0452
Heteroskedasticity	F (14,9) = 0.6423	0.7792
	Chi-Square (14) =11.9947	0.6067

Source: Authors.



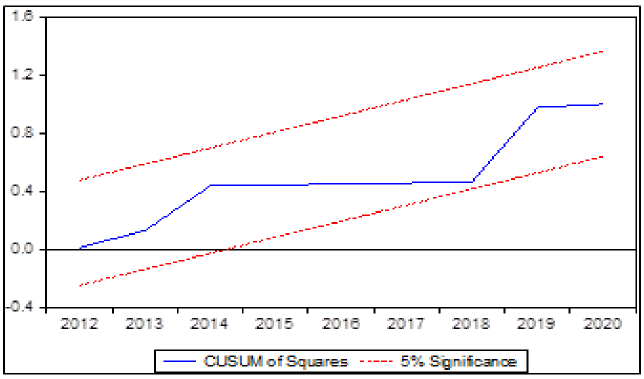


Figure 2 displays the outcomes of the CUSUM and CUSUMQ Square tests.

4.4. Discussion

Our study delves into the critical factors shaping sustainable economic growth in Laos, with a particular emphasis on infrastructure investments. We offer significant insights and key contributions to the field, which are highlighted as follows:

Our research underscores the paramount importance of infrastructure investments, notably in electricity and air transport, as key drivers of economic growth in Laos. This finding is of utmost significance for regional policymakers and stakeholders, emphasizing the necessity of continued investment in these sectors to bolster economic development. We reveal that economic growth in Laos is influenced by a diverse array of factors, including agriculture, industry, services, and human capital. This underscores the complex and multifaceted nature of economic development, advocating for a comprehensive approach to policymaking. We acknowledge the intricate relationship between exchange rates and economic growth, with potential positive and negative consequences. This underscores the need for prudent management of currency exchange rates by policymakers to nurture economic development. We provide a comparative analysis with other relevant studies, such as Zhang et al. (2017), Xu (2022), Zhang (2020), Tolcha (2020), and Ali (2023). This enables readers to contextualize our findings within the global research landscape, which predominantly focuses on countries like China and BRICS nations. We acknowledge the growing influence of ecological and pollution awareness in shaping energy policies. This highlights the significance of sustainable and environmentally friendly infrastructure development, a critical consideration for future economic growth. Our research touches on the impacts of infrastructure investment within the Belt and Road Initiative (BRI), a significant global initiative. This not only broadens the perspective of our findings but also connects our study to a global context. We recognize the geographical and contextual limitations of existing research, primarily focusing on select regions like China, sub-Saharan Africa, and BRICS countries. This suggests potential directions for further research, exploring a wider range of countries and regions with diverse development levels and infrastructure characteristics. We suggest that a more detailed and refined perspective could be provided by exploring the linkages between infrastructure investments and economic growth within different economic sectors or industries, offering a promising avenue for future research.

5. Conclusion and recommendation

5.1 Conclusion and Recommendation

The empirical results of this study, employing GMM regressions and ARDL methods, provide essential insights into the determinants of economic growth in Laos. Across nine distinct models, the research uncovers several critical findings and policy recommendations: The study consistently shows that investments in electricity infrastructure have a significant and positive impact on Laos's economic growth. Policymakers should prioritize and encourage these investments to spur economic expansion. In Model 01, telecommunication infrastructure and human capital also positively influence economic growth. This emphasizes the importance of technology and skilled workforce development to drive economic progress. Subsequent models introduce variables related to agriculture, air transport, industry, and services, all of which positively contribute to economic growth. This highlights the multifaceted nature of development, emphasizing the need for a comprehensive approach across various sectors. Model 07 introduces the exchange rate as a variable, with the potential for both positive and negative impacts on economic growth. Policymakers must carefully manage currency exchange rates to support economic development. The study identifies significant long-run relationships between air transport, human capital, labor force, industry, services, exchange rate, and economic growth. These factors are pivotal for sustained economic expansion. Short-term analysis indicates that industry investment has a positive impact on economic growth, while the exchange rate has an inverse effect. Policymakers should consider these short-term dynamics when adapting policies.

5.2 Recommendation

The empirical results of our study offer essential insights into the determinants of economic growth in Laos, leading to the following detailed and targeted policy recommendations:

Prioritize Continued Investment in Electricity and Air Transport:

Policymakers should prioritize investments in electricity and air transport infrastructure to stimulate economic expansion because the study consistently shows these investments have a significant positive impact on economic growth.

Promote Technology and Skilled Workforce Development:

Policymakers should encourage the development of telecommunication infrastructure and human capital to drive economic progress because the study consistently indicates the positive influence of technology and skilled workforce development on economic growth.

Adopt a Comprehensive Approach Across Sectors:

Policymakers should adopt a comprehensive approach that considers agriculture, air transport, industry, and services for sustained economic growth because the study consistently the multifaceted nature of development, as highlighted in subsequent models, emphasizes the need for a holistic policy approach.

Prudent Management of Exchange Rates:

Policymakers should carefully manage currency exchange rates to support economic development, considering both short-term and long-term dynamics because the study consistently introduces the exchange rate as a variable, indicating potential positive and negative impacts on economic growth.

Embrace Long-Run Relationships for Sustained Expansion:

Policymakers should recognize and prioritize factors such as air transport, human capital, labor force, industry, services, and exchange rate for sustained economic expansion because the study consistently shows that the Long-run relationships identified in the study underscore the pivotal role of these factors in economic growth.

Consider Short-Term Dynamics for Policy Adaptation:

Policymakers should consider short-term dynamics, particularly the positive impact of industry investment and the inverse effect of exchange rate fluctuations because the study consistently shows that adapting policies to short-term dynamics ensures agility and responsiveness to immediate economic conditions.

In conclusion, our study provides detailed and targeted policy recommendations based on empirical evidence. Policymakers in Laos can leverage these recommendations to formulate strategic plans that prioritize infrastructure investments, address the multifaceted nature of economic development, and foster sustained growth.

References

Adhikary, B. K. (2012). Impact of Foreign Direct Investment, Trade Openness, Domestic Demand, and Exchang Rate on the Export Performance of Bangladesh: A VEC Approach. *Economics Research International, 1*, 1-10. doi:https://doi.org/10.1155/2012/463856

Akpan, E. S., & Eweke, G. O. (2017). Foreign Direct Investment and Industrial Sector Performance: Assessing the Long-Run Implication on Economic Growth in Nigeria. *Journal of Mathematical Finance, 7*, 391-411. doi:https://doi.org/10.4236/jmf.2017.72021

Ali, R., Bakhsh, K., & Yasin, M. A. (2023). Causal nexus between air transportation and economic growth in BRICS countries. *Journal of Air Transport Management, 107*. doi:https://doi.org/10.1016/j.jairtraman.2022.102335

Amos, A. K., & Jidda, D. C. (2018). Infrastructural development as a strategy for Nigeria's export promotion. *African Research Review, 12*(4), 40-49. doi: http://dx.doi.org/10.4314/afrrev.v12i4.4

Atchike, D. W., Zhao, Z. Y., & Bao. G. (2020). The Relationship between Electricity Consumption, Foreign Direct Investment and Economic Growth: Case of Benin. *International Journal of Energy Economics and Policy, 10*(4), 507-515. doi:https://www.researchgate.net/publication/341444923

Baita. (2021). Impact of infrastructure on trade: an empirical assessment by the Gravity model in ECOWAS. *Young Africa Leaders Journal of Development, 3*(20), 143-149. doi:https://digitalcommons.kennesaw.edu/yaljod/vol3/iss1/20

Belloumi, M. (2014). The relationship between trade, FDI and economic growth in Tunisia: An application of the autoregressive distributed lag model. *Economic Systems, 38*(2), 269-287. doi:https://doi.org/10.1016/j.ecosys.2013.09.002

Ekeocha, D. O., Ogbuabor, J. E., & Orji, A. (2022). Public infrastructural development and economic performance in Africa: a new evdence from panal deata analysis. *Economic Change and Restructuring, 55*, 931-950. doi:https://doi.org/10.1007/s10644-021-09334-8

Epaphra, M., & Mwakalasya, A. H. (2017). Analysis of Foreign Direct Investment, Agricultural Sector and Economic Growth in Tanzania. *Modern Economic, 8*, 111-140. doi: https://www.researchgate.net/publication/312599229

Kakar, Z. K., & Khilji, B. A. (2011). Impact of FDI and Trade Openness on Economic Growth: A Comparative Study of Pakistan and Malaysia. *Theoretical and Applied Economic, 18*, 53-58. doi:https://www.researchgate.net/publication/239804997

Long, P. D., Ngoc, B. H., & My, D. T. H. (2018). The Relationship between Foreign Direct Investment, Electricity Consumption and Economic Growth in Vietnam. *International Journal of Energy Economics and Policy, 8*(3), 267-274. doi:https://www.zbw.eu/econis-archiv/bitstream/11159/2122/1/1028135211.pdf

Lydon, R., & Williams, M. (2005). Communications networks and foreign direct investment in developing countries. *Communications and Strategies, 58*(2), 43-60. doi:https://mpra.ub.uni-muenchen.de/2492/

Majumder, S. C., Rahman, M. H., & Martial, A. A. A. (2022). The effect of foreign direct investment on export processing zones in Bangladesh using Generalized Method of Moments Approach. *Socail Sciences &Humanities Open, 6*(1), 1-10. doi:https://doi.org/10.1016/j.ssaho.2022.100277

Markusen, J. R., & Venables, A. J. (1999). Foreign direct investment as a catalyst for industrial development. *European Economic Review, 43*, 335-356. doi:https://www.researchgate.net/publication/223052299

Masron, T. A. (2017). Relative institutional quality and FDI inflows in ASEAN countries. *Jpurnal of Economic Studies, 44*(1), 115-137. doi:10.1108/JES-04-2015-0067

Mousavian, S. Z., Mirdamadi, S. M., Hosseini, S. J. F., & Najafabadi, M. O. (2021). Determinants of foreign direct investment inflow to the agricultural sector: a panel-data analysis. *Journal of Economic and Administrative Sciences, 1*, 1-22. doi:https://www.researchgate.net/publication/354763114

Nyiwul, L., & Koirala, N. P. (2022). Role of foreign direct investments in agriculture, forestry and fishing in developing countries. *Future Business Journal, 8*(50), 1-12. doi:https://doi.org/10.1186/s43093-022-00164-2

Oleyede, B. B. (2014). Impact of Foreign Direct Investment on Agricultural Development in Nigeria. *Kuwait Chapter of Arabian Journal of Business and Management Review, 3*, 14-24. doi:http://www.arabianjbmr.com/pdfs/KD_VOL_3_12/2.pdf

Pegkas, P. (2015). The impact of FDI on economic growth in Eurozone countries. *The Journal of Economic Asymmetries, 12*(2), 124-132. doi:http://dx.doi.org/10.1016/j.jeca.2015.05.001

Pereira, A. M., & Pereira, R. M. (2020). Infrastructure investment in Portugal and the traded/non-traded industry mix. *Journal of Infrastructure, Policy and Development, 4*(1), 1-26. doi:10.24294/jipd.v4i1.1124

Qazi, U., Alam, A., Ahad, S., & Ambreen. (2021). Impact of FDI and Electricity on the Economic Growth of Pakistan: A Long Run Cointegration and Causality Analysis. *Research in World Economy*, 273-288. doi:https://www.researchgate.net/publication/349729685

Sahoo, P., & Dash, R. K. (2012). Economic growth in South Asia: role of infrastructure. *Journal of International Trade and Economic Development, 21*(2), 217-252. doi:10.1080/09638191003596994

Tashfeen, R., Shah, S. M. A., Ali, M. S., & Anis, W. (2022). Impact of Foreign Direct Investment and Information Communication Technology on Economic Growth: An Emoirical Analysis from Selected Developing Countries. *Al-Qantana, 8*(2), 201-212. doi:https://www.researchgate.net/publication/366645679

Tiong, K. M., Cheng, M. Y., & Choong, C. K. (2022). The Roles of ICT Telecommunication Infrastructure on Foreign Direct Investment in Malaysia. *Asian Academy of Management Journal, 27*(2), 1-20. doi:https://doi.org/10.21315/aamj2022.27.2.1

Tolcha, T. D., Brathen, S., & Holmgren, J. (2020). Air transport demand and economic development in sub-Saharan Africa: Direction of causality. *Journal of Transport Geography, 86*, 1-14. doi:https://doi.org/10.1016/j.jtrangeo.2020.102771

Umer, F., & Alam, S. (2013). Effect of Openness to Trade and FDI on Industrial Sector Growth: A Case Study for Pakistan. *The Romanian Economic Journal, 48*, 179-197. doi:http://www.rejournal.eu/sites/rejournal.versatech.ro/files/articole/2013-06-01/1926/umer.pdf

Williams, K. (2015). Foreign investment in Latin America and the Caribbean: An empirical analysis. *Latin American Journal of Economics, 52*(1), 57-77. doi:10.7764/LAJE.52.1.57

Xu, G., Yang, H., & Schwarz, P. (2022). A strengthened relationship between electricity and economic growth in China: An empirical study with a structural equation model. *Energy, 241*, 1-11. doi:https://doi.org/10.1016/j.energy.2021.122905

Zhang, C., H. Zhou., Yang, S., & Shao, Z. (2017). On electricity consumption and economic growth in China. *Renewble and Sustainable Energy Reviews, 76*, 353-368. doi:https://doi.org/10.1016/j.rser.2017.03.071

Zhang, F., & Graham, D. (2020). Air transport and economic growth: a review of the impact mechanism and causal relationships. *Transport Reviews, 40*(4), 506528. doi:https://doi.org/10.1080/01441647.2020.1738587

Zhao, Z., & Zhang, K. H. (2010). FDI and Industrial Productivity in China: Evidence from Panel Data in 2001-06. *Review of Development Economics, 14*(3), 656-665. doi:10.1111/j.1467-9361.2010.00580.x

Cite this article:

Keoudone KEOTHEPHAR & Vilayvanh SRITHILAT (2024). Assessing the Key Drivers of Sustainable Economic Growth in Laos: Emphasis on Infrastructure Investment. *International Journal of Science and Business, 32*(1), 1-15. DOI: https://doi.org/10.58970/IJSB.2291

Retrieved from http://ijsab.com/wp-content/uploads/2291.pdf

Published by

IJSAB International