



The Mediating Role of International Trade on the Relationship between Transportation Infrastructure and Economic Growth in Lao PDR

Kaysone Xayyalath*^a & Phoumsaydavone Sombounsack^b

^a *Academic Affair Office, Savannakhet University, 1300 Laos*

^b *Faculty of Business Administration, Savannakhet University, 1300 Laos*

Article info

Article history:

Received: 25 June 2024

Revised: 14 July 2026

Accepted: 24 July 2026

Keywords:

Transportation infrastructure,
International trade, Economic
growth

Abstract

This study investigated the relationship between transportation infrastructure and economic growth mediating the role of international trade in Laos. The study used panel data obtained between 2013 and 2022 and is quantitative research. The following sources provided the data: Ministry of Planning and Investment, Laos Statistic Bureau, World Bank, Bank of Laos, and Ministry of Public Work and Transportation. The analysis employed simple and multiple regression with fixed-effects and random-effects models, selected via the Hausman test. In addition, for testing the link between economic growth and transportation infrastructure as mediated by international trade a Sobel test was conducted. The result showed that transportation infrastructure and international trade are not statistically significant. It represented that transportation infrastructure is not influenced by economic growth. However, the research found a positive relationship between transportation infrastructure and economic growth. It explains that when transportation infrastructure increases then economic growth will increase. Furthermore, the result showed a negative relationship between international trade and economic growth. The results found that when international trade increases by one unit then economic growth decreases by one unit and in the opposite way when international trade decreases by one unit then economic growth would increase one unit. Moreover, the result represented that the association among transportation infrastructure and economic growth was not mediated by international trade. Therefore, the Lao government should prioritize international trade by reducing imports of non-essential goods and increasing export value to address the country's trade deficit. Additionally, the government should invest more in transportation infrastructure by improving and expanding roads connecting urban and rural regions.

Introduction

It is hardly disputed that transportation infrastructure has been one of the main factors facilitating steady

economic growth in recent years (Kadyraliev et al., 2022; Magazzino & Maltese, 2021; Zhang et al., 2021; Zhang & Cheng, 2023). Indeed, the significance and benefits

* Corresponding Author
email: kaysone2014@gmail.com

of transportation infrastructure for economic growth have long been recognized. By enhancing resource mobilization and productivity, a country's transportation infrastructure increases its productive capacity. This relationship can be understood in several ways, on which there is broad agreement. First, transportation infrastructure is commonly used in the industrial process as both a key component of production and a direct input. Second, transportation infrastructure may improve the productivity of other inputs; for instance, a well-designed road network promotes faster delivery of goods to market, lowering transportation costs in the production process. Third, transportation infrastructure may act as a magnet for economic growth by "accumulating" resources from neighboring areas.

The landlocked Lao People's Democratic Republic (Lao PDR) has a poor transportation system (World Bank, 2021), which has contributed to the slow growth of its economy over the last five years. With a population of only 7.2 million as of 2022 and a real GDP growth rate of 4.4%, the country has stepped up its efforts to integrate globally amid ongoing discussions to join the World Trade Organization (WTO). However, poor infrastructure and a lack of direct access to the sea have hindered the growth of this small domestic market (Bank of the Lao PDR, 2022). Because Laos has no coastline, road transport is the most common form of transportation, and it is anticipated to remain the primary mode for both passengers and freight for the foreseeable future. Given the population distribution and the important East-West connections to neighboring countries such as Vietnam, Thailand, and Myanmar, the major transportation routes run north-south. Roads carry 96% of passenger traffic (person/kilometer) and 36% of freight traffic (ton/kilometer). However, the country's total road length is approximately 59,000 km, of which only 1% is concrete, 2% is asphalt, 20% is paved, and 35% is earth road. In addition to transportation infrastructure, international trade has contributed significantly to economic growth, with the value of exports and imports increasing steadily from 2013 to 2022. In 2022, exports accounted for 52.58% of GDP, while imports accounted for 46.34% (Ministry of Planning and Investment, 2021). Therefore, both exports and imports have been significant drivers of economic growth.

In the case of Laos, research gaps exist regarding the specific contributions of international trade as a channel that transmits the benefits of enhanced transportation infrastructure to economic outcomes. Most

existing studies examine either infrastructure's effects on growth or international trade's effects separately, without considering their interconnected roles. Furthermore, prior research on infrastructure in Laos has concentrated primarily on road expansion or sector-specific development, often overlooking the broader economic interactions facilitated by improved transport systems. Therefore, this study addresses these gaps by examining the mediating role of international trade, providing a more holistic understanding of the infrastructure-growth relationship.

Research Objectives

This study looks at how international trade functions as a mediator in the link between economic growth and transportation infrastructure.

Literature review

Economic growth theory

According to classical economists, social, economic, and political structures are just as important to economic growth as essential components including land, labour, capital, and technology. Swan (1956) created the neoclassical model of economic growth. Swan relaxes the hypothesis of constant relative between capital and labour and runs the model under neoclassical situations. Neoclassical growth models are followed by endogenous growth models, offer a theoretical framework for examining output growth that is enduring and determined by the system that controls production. One important assumption of the (Romer, 1986) growth model is growing scale-related returns. Endogenous growth theory, developed by economists like Paul Romer and Robert Lucas in the late 20th century, emphasizes the concept that internal, not external, causes are what drive economic growth. Endogenous growth theory contends that investments in human capital, creativity, and knowledge can result in sustained economic growth without diminishing returns, in contrast to typical neoclassical models that highlight diminishing returns to capital. This theory highlights the role of technological advancements and policies that promote education, innovation, and infrastructure to enhance productivity. Knowledge spillovers, where knowledge generated in one firm or sector benefits others, are central to this model, making technological progress a non-rival good. Consequently, government policies play a significant role in fostering long-term growth by investing in education, research, and infrastructure. Endogenous

growth models often emphasize that returns to capital can remain constant or even increase due to knowledge accumulation, which promotes a cycle of continuous growth. This theory argues that factors like education, R&D investments, and technology policy are crucial for achieving long-term sustainable growth, highlighting those endogenous factors, rather than exogenous shocks, primarily determine economic growth.

The link between economic growth and transportation infrastructure

Wang et al. (2021) examined the relationship between the growth of Korea's logistics infrastructure and its economic growth. Given Korea's industrial and economic structure, it is likely that the country's logistics infrastructure has a favorable impact on the nation's economic development. Considering the long-run equilibrium between the two factors, by utilizing vector autoregressive (VAR) and vector error correction model (VECM) approaches, the causal link between logistical infrastructure and economic development is evaluated. To do this, a 1990–2017 dataset made up of 5 economic growth indicators and 7 proxies for logistics infrastructure is used. It was found that the expansion of the logistical infrastructure is typically followed by economic growth. The results specifically demonstrate a beneficial relationship between maritime transportation and Korea's economic growth as measured by GDP and international trade. Additionally, Korea's GDP and international trade benefit from many modes of transportation.

Acheampong et al. (2022) examined the effects of transportation infrastructure and technological innovation on GDP, energy consumption, and carbon emissions in the European Union (EU), using data from 1995 to 2019 and the dynamic system-GMM (generalized method of moments) technique. The results indicate that while GDP and energy consumption (EC) exert opposing effects on carbon emissions (CO₂e), EC has a unidirectional positive effect on GDP. Furthermore, improvements in freight transportation infrastructure increase GDP and CO₂e while decreasing EC, whereas technological innovation directly increases both GDP and EC.

Raimbekov & Syzdykbayeva (2021) evaluated the effect of logistics and transportation on economic growth in the Republic of Kazakhstan's emerging economies. Examining the relationship between logistics metrics and Kazakhstan's economic growth between 1995 and 2019 was the goal. Models of total production, demand, and vector error correction were used to

examine factors and the causal relationship between the indicators of transportation development and economic growth. The study made clear the complexities of the relationship between economic growth and a number of transport indicator variables, as well as the nature and direction of that relationship. A two-way cause-and-effect relationship between the expansion of railway transportation infrastructure and economic growth was demonstrated via the Granger test. Long-term advancements in land and marine transportation were found to accelerate economic growth in tiny economies. In a one-way link, economic growth promotes pipeline transportation, which in turn promotes the growth of all other modes of transportation. It was discovered that economic expansion in Kazakhstan has less impact on the demand for transportation and logistics services as well as the infrastructure supporting such services than it does in a country with sizable economies. Based on the highlighted long-term link between the factors researched, a customized approach to transport policy was advised to increase the economy's effectiveness.

Nguyen (2022) examined Vietnam's transportation infrastructure's spatial spillover effects. The study employed the spatial Durbin model to determine the geographic influence of transportation infrastructure on Vietnam's economic growth between 2000 and 2019. The data showed that there was strong evidence for each time because of the interconnectedness of the national transportation infrastructure. Among Vietnam's four macro-regions, the regional spillover effects of transportation infrastructure varied greatly over time: the southern region consistently experiences positive spillover effects; from 2000 to 2009, there were negative spillover effects in the northern region; from 2010 to 2019, there were positive spillover effects; from both times, there were negative spillover effects in the central region; and starting in 2010, there were negative spillover effects in the Mekong Delta's economic sector.

Saidi et al. (2018) examined the impact of energy consumption and transportation infrastructure on economic growth using panel data for MENA (the Middle East and North Africa) nations from 2000 to 2016. Three groupings of nations comprise the MENA area panel: the North African nations, generally referred to as MATE (Morocco, Algeria, Tunisia, and Egypt); and the N-GCC panel, which consists of those not affiliated with the Gulf Cooperation Council. By using the Generalized Method of Moments (GMM), the findings showed that the energy consumption of transportation in the MENA,

N-GCC, and MATE regions significantly contributed to economic growth. The transportation infrastructure contributed to healthy economic growth in every region. The link between economic growth and the feedback effects of energy consumption and transportation infrastructure is shown by the Dumitrescu-Hurlin panel causality analysis. A new aspect of the benefits of investing in modern infrastructure that encourages the employment of alternative technologies and more energy-efficient forms of transportation while lowering negative externalities was brought to light by the empirical data.

The relationship between international trade and economic growth

Maitra & Chakraborty (2023) reexamined India's trade-growth dynamics while highlighting the significance of human capital within a trade liberalization framework. The autoregressive distributed lag-bound testing approach can be used to determine the cointegrating relationship between income and various combinations of the human capital dimensions of import, export, exchange rate, trade openness, education, and health. The theories of export-led and import-led growth are supported by the long-term and short-term dynamics of these connections, which both imply that imports and exports contribute to income growth. Trade openness harms growth, whereas human capital fosters it. However, the growth benefits from human capital differ across various human capital measurements. These conclusions are substantially corroborated by a battery of diagnostic testing. The implementation of trade promotion policies may help India's economy grow more quickly.

Bajo-Rubio (2022) investigated the relationship between global commerce and economic expansion from the perspective of the export-led growth hypothesis, one of the most well-known theories in this field, for the case of Spain during a 170-year period. Because of the increased productivity associated with the export sector, exports seem to have had a positive, if modest, impact on the growth of the Spanish economy for the whole period. However, the contribution of exports to growth seems to have been higher in the last years of the 19th century, in contrast to the rest of the period when it proved to be negligible.

Sarania (2021) used the Toda-Yamamoto (TY) causality test and the auto-regressive distributed lag (ARDL) bounds testing approach to cointegration to

examine the dynamic relationships between infrastructure, trade openness, foreign direct investments (FDI), economic growth, fixed capital formation, labor, and inflation rate in the context of India for the years 1970 to 2018. This was carried out in order to offer policy recommendations concerning the effectiveness of these significant macroeconomic factors. This study created two composite indices, the infrastructure development index (INFI) and the trade openness index (TOI), to examine the impact of trade openness and infrastructure indicators on economic growth as well as other relevant variables. The results indicated a strong causal relationship between infrastructure, trade openness, foreign direct investment, and economic progress from 1970 to 2018. India should expedite the development of adequate and expanded infrastructure facilities in the economy and, among other things, liberalize its policies in a number of areas, including infrastructure, in order to attract more foreign direct investment inflows and increase trade and globalization in an environment that facilitates business dealings, given the long-term, reciprocal relationship between INFI and GDP. Long-term, this will support continued economic growth.

Saeed et al. (2021) investigated the complex relationships between bilateral trade, domestic production as indicated by GDP per capita, and marine connectivity. Path Analysis (PA) and non-recursive models were used to achieve this. For the analysis, the top ten maritimately connected countries' 155 commercial partners were chosen. To investigate the reciprocal link between the export/import of 10 countries and the GDP per capita of their 155 trading partners, the elements of maritime connectivity, maritime distance, and gravity factors were chosen as instrumental variables. The findings showed that GDP per capita, import values, and export values from trading partners do not have a reciprocal connection.

Adnan Hye et al. (2016) evaluated the relationship between trade openness and China's economic growth between 1975 and 2009 using the autoregressive distributed lag (ARDL) cointegration technique and the rolling regression approach. The empirical findings showed a long-term and short-term favorable correlation between trade openness and economic growth. This outcome further demonstrated the significance of trade openness for economic growth and related to (Abdullahi et al., 2016) evaluated the effect of international trade on the economic growth of 16 of the 17 West African countries between 1991 and 2011 using the STATA 10.0 version of the economic program.

Researchers looked at the exchange rate, imports, and exports in relation to GDP. The model population was statistically significant, according to the regression result, however the factors' effects on economic growth varied. The economic growth of West African countries was positively and significantly impacted by exports. GDP growth would rise by 5.11% for every 1% increase in exports. The GDP was positively impacted by imports as well; a 1% rise in imports would result in a 0.41% boost in GDP growth. Nonetheless, there was no statistically significant effect of imports on the economic growth of West African nations. Economic growth was negatively but statistically significantly impacted by the exchange rate. Based on these findings, researchers confirmed the importance of export promotion on economic growth.

Nantharath & Kang (2019) examined the effects of foreign direct investment (FDI), human capital, trade openness, and institutional quality on the economic growth of the Lao People's Democratic Republic (Lao PRD) between 1993 and 2015. The research findings demonstrated that while trade openness and foreign direct investment (FDI) had a beneficial influence on Lao PRD's economic growth, institutional quality and human capital had a negative effect. Based on the study's findings, the authors advised the Lao PRD government to keep encouraging foreign direct investment (FDI) and draw in higher caliber, more sustainable FDI in order to achieve a long-term, sustainable growth rate. Additionally, enhancing regional and international economic competitiveness should be a top priority for the Lao PRD government. In addition, Erum et al. (2016) used the Fixed Effects Model to assess how labor, government spending, foreign direct investment (FDI), and domestic investment affected the economic growth of the South Asian Association of Regional Cooperation nations between 1990 and 2014. The authors demonstrated the beneficial effects of both foreign direct investment and domestic investment on economic growth. Labor had a significant and positive association with GDP, whereas government spending had minimal effect on economic growth. China's economy is growing steadily.

Babatunde et al. (2017) evaluated the effect of international trade on Nigeria's economic growth between 1981 and 2014. Using the ordinary least-squares (OLS) method, the researchers modeled GDP as the dependent variable against six independent variables: imports, exports, government spending, interest rates, foreign direct investment, and exchange rates. The results

showed that foreign direct investment and the exchange rate had negligible negative effects on the Nigerian economy, whereas government spending, interest rates, imports, and exports had clear, favorable effects on economic growth.

Barzelaghi et al. (2012) examine the connection between trade openness and economic growth in the context of India, with the primary objective of developing a novel trade openness index. The study employed a rolling window regression technique, an autoregressive distributed lag (ARDL) model, and a novel endogenous growth model to examine both the immediate and long-term relationships between economic growth and trade openness. More specifically, the Granger causality test was used to ascertain the short-run and long-run directions of causality. The results indicate that both human and physical capital exert long-term positive effects on economic growth, whereas the trade openness index negatively affects economic growth over the long run. The rolling window regression results provide new evidence that the influence of the trade openness index on economic development varies across the sample period. In the short run, the trade openness index is positively correlated with economic growth. Finally, the Granger causality test results support the trade openness-led growth hypothesis in the short run and the human capital-led growth hypothesis in the long run.

Jamilah et al. (2017) examined the connection between economic growth and trade openness in 87 chosen countries between 1977 and 2011; these countries included both developing and Organization for Economic Co-operation and Development (OECD) countries. The study used two measures of trade openness: trade openness in nominal (TO), which is typically expressed as exports plus imports in nominal value divided by real GDP, and trade openness in real (RO), which is the total of imports and exports in US dollars divided by GDP in purchasing power parity US dollars (real GDP). An empirical investigation was conducted on the causal relationship between trade openness and growth from a panel approach. The research used a dynamic panel data estimation method called the general method of moments (GMM). The empirical results demonstrated a causal relationship between OECD and emerging nations that is reciprocal. The findings were consistent with the endogenous approach, which holds that greater openness leads to faster growth, which in turn encourages more openness.

Lawal & Ezeuchenne (2017) studied the links

between economic growth and trade openness, often suggesting that nations with a more global perspective have more robust long-term economic growth. On the other hand, different trading methods can be hidden by an equivalent level of economic transparency. In order to better quantify trade openness, this study took into consideration two different facets of nations' involvement in international trade: export diversity and export quality. The findings confirmed that countries that export innovative and superior goods have faster economic growth. The findings indicated that countries that export innovative and superior goods have faster economic growth. This is based on the estimation of an endogenous growth model on a panel of 169 countries between 1988 and 2014 using a generalized method of moments estimator. More importantly, the findings showed a non-linear relationship between the export ratio and the export basket's quality, indicating that trade openness may be bad for growth in nations that produce low-quality items. Additionally, a non-linear relationship between export variety, export ratio, and growth was found, suggesting that if a country reaches a certain level of extensive margin of exports, it will grow faster.

Kong et al. (2021) examined how China's opening affected the standard of economic expansion despite fluctuations in currency rates between 1994 and 2018. Economic growth and opening up have a stable, long-term relationship of co-integration. Trade openness has the potential to significantly enhance both the short- and long-term quality of economic growth. When the short-term volatility deviates from the long-term equilibrium, automatic adjustment can preserve the quality of economic growth. The positive impacts of trade openness on the caliber of economic growth were mostly due to regional variability and non-linear threshold characteristics.

Fetahi-Vehapi et al. (2015) analyzed the effects of trade openness on the economic growth of Southeast European (SEE) nations. Despite being in different stages of development and EU membership, there were not any clear differences in trade openness between these nations. Both regional trade cooperation and integration into the global economy were the main goals of their trade policy. The empirical analysis of this study was predicted on 16 years of panel data from 10 SEE nations between 1996 and 2012. The system GMM is the most effective estimating method for handling endogeneity problems and other econometric challenges. A number of trade openness interaction variables, human capital,

gross fixed capital creation, FDI, labor force, and baseline per-capita income were among the control factors that were used to estimate the growth rate of the sample nations. According to the estimation results, the positive benefits of trade openness on economic growth need initial per capita income and other explanatory factors; otherwise, there is no significant link between the two variables. Furthermore, nations with greater levels of gross fixed capital formation, foreign direct investment, and initial income per capita gain more from trade openness than do other nations.

Mamasoliev (2024) examined the relationship between international trade and economic growth. This study provides important new information about how trade agreements affect American companies' ability to compete. Agreements like the now-defunct Trans-Pacific Partnership (TPP) and the United States-Mexico-Canada Agreement (USMCA), for example, have been crucial in expanding U.S. market access while applying laws that can strengthen environmental and labor standards. Such agreements have economic repercussions that extend to labor markets, where they can both challenge traditional employment in industries with increasing international competition and promote job growth in export-oriented sectors. Empirical evidence also shows that international trade promotes innovation and productivity by creating a dynamic economic environment. Therefore, in order to better support industries impacted by globalization and maintain equitable and sustainable U.S. economic growth, authorities should think about increasing investment in infrastructure and workforce development.

Wang & Garduño-Rivera (2023) employed a difference-in-differences regression approach to evaluate the effect of trade openness on Mexico's indigenous peoples. The authors demonstrate that, as a result of the North American Free Trade Agreement (NAFTA), indigenous peoples in Mexico have experienced significant disadvantages in employment opportunities and economic output (as measured by gross value added) relative to their non-indigenous counterparts. The study concludes with a discussion of relevant policy implications aimed at addressing this disparity.

Adebayo et al. (2023) examined the importance of the United Nations' Sustainable Development Goals 7 (SDG-7) and 8 (SDG-8), which seek to guarantee that everyone has access to reasonably priced, reliable, and sustainable energy. This study, which empirically examined the long-term and causative relationship

between energy consumption, urbanization, trade openness, and economic development for annual frequency data for Mexico from 1965 to 2021, was inspired by the SDGs described in this article. Researchers accomplished this by using canonical regression estimation methods, dynamic ordinary least squares, and fully modified ordinary least squares. The causal direction is ascertained using wavelet coherence and gradual shift approaches. Under the Autoregressive Distributed Lag (ARDL), the limits test demonstrates a long-term relationship between the variables indicated during the sampled period. There is empirical evidence to support the idea of energy-induced growth. The causality analysis indicated that Mexico's energy consumption propels economic expansion in a single way. This makes the case that Mexico should not implement energy-saving measures since they will obstruct its economic development. Furthermore, there is proof that trade openness, urbanization, and economic growth are causally related in a one-way fashion.

Aggarwal & Karwasra (2023) provided a thorough examination of the economic relationship between trade openness and economic growth to pinpoint present trends, promising areas for further study, and the way forward. The focus was on identifying the annual growth in publications, the distribution of publications by country, the cluster analysis of scientific output in this field, the publication pattern, and the intellectual structure. The study employed evaluation approaches, a text-mining strategy, and performance analysis to search for possible patterns and correlations in order to quantify the impact of authors, citations, and scientific output. Additionally, bibliometric mapping was used in this study to reflect the structural features of scientific production. Based on the prevalence of indexed keywords, active researchers, and publications, this study aimed to determine which research topics were most active between 2000 and 2022. Since it has been established that trade openness influences economic growth, an examination of the relationship between the two is essential. Trade openness tends to liberalize over time and encourage economic expansion. Empirical studies have shown a high correlation between trade openness and economic growth. Furthermore, a keyword timeline analysis revealed that the connection between trade openness and economic growth is a topic of contemporary study interest. The bibliometric analysis indicated that the three most prolific nations in terms of the quantity of publications on this topic are China, Pakistan, and Malaysia. Based

on citation and h-index, Turkey is the nation that publishes the most important papers on the connection between trade openness and economic growth. According to the cluster analysis of this study, future research could concentrate on elements like technology and sustainable development, while current research focuses on the relationship between trade openness and economic growth in relation to other factors like FDI, financial development, labor force, environmental degradation, and carbon emissions.

Raghutla (2020) investigated the impact of trade openness on economic development in a panel of five developing market economies using data spanning 1993 to 2016. The results of long-run elasticities show that trade openness significantly boosts economic growth, while the empirical findings, which are based on panel estimation methods, support the long-term relationships between trade openness, economic growth, financial development, inflation, labor force, and technology. Additionally, the heterogeneous panel non-causality tests indicate that there is a bidirectional relationship between economic growth and inflation and a short-term unidirectional causal association between economic growth and trade openness. Lastly, the findings showed that in these five emerging market economies, trade openness plays a major role in economic growth and development.

The relationship between transportation infrastructure and international trade

Han & Li (2022) propose a Ricardian model variant that may structurally understand the estimate of a variable that is country-specific transportation infrastructure. This article demonstrates that the improvement of transportation infrastructure for international trade outweighs that for domestic trade under this new theoretical paradigm. Additionally, the quantitative research indicated that a 10% improvement in transportation infrastructure results in a 3.9% rise in real income, with more than 95% of the gains going to the nation with better infrastructure. This study also implied that a reduction in internal trade costs leads to an increase in real income when transportation infrastructure is improved. All of the aforementioned findings imply that stronger infrastructure generates large gains, adding more evidence in favor of policies aimed at enhancing transportation infrastructure.

Rehman et al. (2020) utilized cointegration techniques including the Pedroni and Kao test and the

Pooled Mean Group (PMG) estimator to examine the short- and long-term effects of infrastructure on export and trade imbalance in a few South Asian countries between 1990 and 2017. The PMG empirical results showed that the overall and sub-indices of infrastructure—such as the energy, finance, transportation, and telecommunication sectors—have a significant long-term influence on the imbalance between trade and exports. The findings showed that infrastructure boosts exports but hurts the trade imbalance. South Asian economies should focus on how infrastructure and exports are related in order to boost export volume and catch up to wealthy nations.

Felbermayr & Tarasov (2022) find that the optimal level of infrastructure investment at a given location is determined not by local conditions alone, but by the production and demand conditions of other locations connected through that transit point. Furthermore, a country's territorial expansion—such as German reunification—causes investment to shift away from previously important locations toward the former border regions. While a higher elasticity of substitution between goods produced at different locations decreases investment, a higher degree of substitutability between investments at different locations has an ambiguous effect on investment.

Netirith & Ji (2022) examine the effectiveness of transportation infrastructure connectivity and trade within the Regional Comprehensive Economic Partnership (RCEP), a topic of critical importance for regional integration and global trade. The study evaluates the effectiveness of infrastructure connectivity in the RCEP with the aim of improving connectivity performance and offering policy recommendations. To this end, the authors incorporate a set of infrastructure connectivity input and output variables. The input variables include the number of ports, rail lines, and road systems, as well as the number of land borders, maritime borders, and cross-border points, along with railroad connections to foreign countries and the number of ports connected to rail and road networks, based on the "intermodal and multimodal" concept. The output variables most closely associated with trade and economic performance include GDP, transportation volume, and import and export volume. The study employs the Data Envelopment Analysis (DEA) model, with data analyzed using DEAP software. The results show that 10 countries achieved efficient infrastructure connectivity and international trade performance, while the remaining 5 countries were

inefficient in these areas. Based on these findings, the study proposes development strategies for enhancing connectivity, including investment in basic infrastructure, expansion of logistical connection points, and advancement of global trade within the RCEP.

Bensassi et al. (2015) calculated an augmented gravity model of trade comprising indices of transportation infrastructure and logistics in particular as explanatory variables. The model is estimated with data from 2003 to 2007 with bilateral exports to 64 destinations (45 countries and 19 regions of Spain). The findings highlight the importance of local logistics projects and show how important logistics is to comprehending the flow of goods in global trade. The number, size, and quality of logistical infrastructure in particular positively affect export flows.

Karymshakov & Sulaimanova (2021) using the data from Kazakhstan, Kyrgyzstan, and Tajikistan, examine how infrastructure affects trade in Central Asia. Implementing the panel data for the years 2010 to 2018, empirical estimations were developed. Quality and quantity metrics were used to evaluate infrastructure. The amounts of exports and imports from each of these countries' primary trading partners were used to calculate trade flows. According to the findings, Central Asia's infrastructure, both in terms of quality and quantity, positively affects trade flows. However, there is a declining trend in infrastructure's advantages over trade. The results of this study suggested that, given the Central Asian countries' generally remote geographic location, a regional approach to infrastructure development is important and that government policy toward infrastructure development should be linked to government policy that facilitates international trade.

Conceptual framework

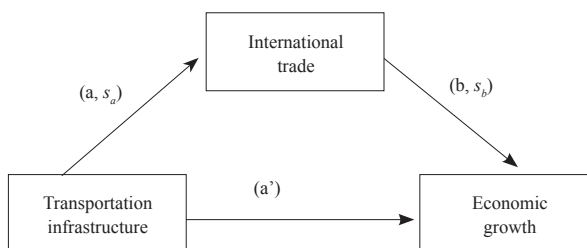


Figure 1 Conceptual Framework

Methodology

This study is quantitative research that uses secondary data which covers the period from 2013-2022

and was obtained from the following sources: World Bank, Bank of Laos, Ministry of Planning and Investment, Ministry of Public Work and Transportation and Laos Statistic Bureau. Collection of the data was obtained through online databases, government publications, and media sources. This research used a panel dataset from 18 provinces in Laos which allows for tracking changes over time and across regions, enabling researchers to analyze both temporal and spatial variations. This enhances the ability to identify trends, causal relationships, and province-specific factors influencing the study variables. For the dependent variable the GDP per capita is used to represent economic growth (Y), which is divided by the provincial population (GDP per capita) and the independent variable is transportation infrastructure measured by using the length of the road in kilometers as a proxy, and mediators were international trade by using the value of exports and imports divided by GDP. This study seeks to determine how international trade functions as a mediator in the relationship between transportation infrastructure and economic growth by using the Sobel test (1982).

The Sobel test is easy to use. Three steps are needed:

$$\text{Model1: } \ln INT = \beta_0 + a \ln TRA + \varepsilon_1 \quad (1)$$

$$\text{Model2: } \ln GDP = \beta_1 + a' \ln TRA + b \ln INT + \varepsilon_2 \quad (2)$$

$$\text{Model3: } Z = \frac{a \cdot b}{\sqrt{b^2 \cdot s_a^2 + a^2 \cdot s_b^2}} \quad (3)$$

Where:

$\ln GDP$ = Economic growth

$\ln INT$ = International trade

$\ln TRA$ = Transportation infrastructure

$\beta_0, a, \varepsilon_1$ were intercept, coefficient, and error terms of the model1 respectively

$\beta_1, a', b, \varepsilon_2$ were intercept, coefficient, and error terms of the model2 respectively

s_a = standard error of coefficient (a) in Model1

s_b = standard error of coefficient (b) in model2

Model 3 is used to compute the Sobel test statistic, employing a Z-score table to determine whether the calculated Z value falls outside the critical values (Abu-Bader & Jones, 2021). Specifically, the result is considered statistically significant if the calculated Z score exceeds ± 1.96 at a two-tailed alpha of .05, or exceeds ± 2.58 at a two-tailed alpha of .01. However, several scholars have challenged the validity of the Sobel test, noting that its reliance on the standard normal distribution (Z scores) requires a large sample size to

conduct mediation analysis (Baron & Kenny, 1986; MacKinnon et al., 2002; Sobel, 1982).

Results

The stationarity test (unit root test) was performed on all variables using the Levin–Lin–Chu (LLC) unit root test. Variables were used to calculate GDP growth per capita, international trade, and transportation infrastructure. The unit root test results are utilized to confirm that the variables in this study are stationary at level (0) and at statistical significance levels of 0.10 and 0.05, respectively, as shown in Table 1.

Table 1 Stationary test result

Variable	Method	Statistic	p-value	Remark
lnGDP	Levin, Lin & Chu	-3.6607	0.0833*	Stationary
lnTRA	Levin, Lin & Chu	-2.7334	0.0772*	Stationary
lnINT	Levin, Lin & Chu	-14.540	0.000***	Stationary

Source: Author's calculation

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$ — statistically significant at the 1%, 5%, and 10% levels, respectively.

The link between international trade and transportation infrastructure was examined using panel regression. The findings shown in Table 2 below indicate that neither the fixed effect nor the random effect model were significant because the p-value was greater than 0.05. The Hasman test was also recommended as a means of choosing the optimal strategy between fixed and random effects. Thus, we can conclude that there is no relationship between international trade and transportation infrastructure.

Table 2 The relationship between transportation infrastructure and international trade

lnINT	Fixed effect			Random effect			Hasman test
	Coef.	t-value	p-value	Coef.	Z-value	p-value	
lnROAD	0.504	0.48	0.631	0.543	0.53	0.595	0.867
Constant	-0.028	-0.01	0.989	-0.107	-0.05	0.959	
R2							
0.003							
R ²		0.003		R ²		0.003	
F-test		0.23		F-test		0.28	

Source: Author's calculation

As shown in Table 3, the Hausman test yielded a p-value of 0.978 ($p > 0.05$), indicating that the random effects model was appropriate for this regression. The results reveal a positive and statistically significant relationship between transportation infrastructure and economic growth ($p = 0.002$), suggesting that increases in transportation infrastructure are associated with corresponding increases in economic growth. Conversely,

the results indicate a negative and statistically significant relationship between international trade and economic growth ($p = 0.032$), suggesting that increases in international trade are associated with decreases in economic growth, and vice versa.

Table 3 The link between international trade, economic growth, and transportation infrastructure

Lngdp	Fixed effect			Random effect			Hasman test
	Coef.	t-value	p-value	Coef.	Z-value	p-value	
lnROAD	0.995	3.09	0.003**	0.943	3.11	0.002**	0.978
lnINT	-0.64	-2.07	0.042**	-0.65	-2.15	0.032**	
Constant	5.678	9.06	0.000***	5.70	9.07	0.00***	

Source: Author's calculation
Note: *** $p < .01$, ** $p < .05$.

We used the following procedures to apply the Sobel test: Calculate the standard errors (S_a and S_b , respectively) of the unstandardized regression coefficients "a" and "b." Tables 2 and 3, respectively, include these numbers, which are summed together in Figure 2.

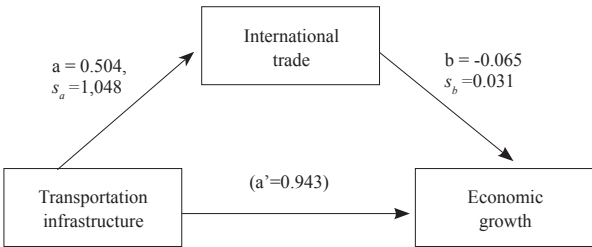


Figure 2 Standard Errors and Unstandardized Regression Coefficients

According to the result from the figure, we used the Sobel test to compute the Z score (MacKinnon et al., 2002), using equation 3 as follows:

$$Z = \frac{0.504 \times (-0.064)}{\sqrt{(-0.064)^2 \times (1.048)^2 + (0.504)^2 \times (0.031)^2}} = -0.46$$

For the reason that the calculated z score = -0.46, $p\text{-value} = 0.63$ (Soper, 2024), it shows that the numbers are not important. First, international trade was not statistically significantly predicted by transportation infrastructure, according to the results of simple linear regression in Table 2 ($a = 0.504$, $S_a = -0.064$, $t = 0.543$, $p < 0.595$). Following the inclusion of international trade as a mediator in the regression analysis, the results showed that there was a positive correlation between transportation infrastructure and economic growth ($\beta = 0.955$, $SE = 0.309$, $t = 3.09$, $p > .003^{**}$). Furthermore,

there is a negative correlation between economic growth and foreign commerce ($b = -0.064$, $S_b = 0.031$, $t = -2.15$, $p < 0.032^{**}$). The Sobel test was applied to determine whether international trade significantly mediated the relationship between economic growth and transportation infrastructure in order to better understand the mediator. The findings, however, demonstrated that the relationship between transportation infrastructure and economic growth was not substantially mediated by international trade ($Z = -0.46$, $p < 0.63$). In summary, the association between economic growth and transportation infrastructure is not mediated by international trade.

Discussion

This study investigated the mediating effects of international trade on the relationship between transportation infrastructure and economic growth in the Lao People's Democratic Republic (Lao PDR), adopting the approach of Sobel (1982) and Soper (2024). Panel data from 2013 through 2022 were used in this study, and both the direct and indirect effects of transportation infrastructure on economic growth were examined.

The results of the analysis show no significant relationship between transportation infrastructure and international trade, a finding consistent with Şahan & Tuna (2021), who reported only weak short-run causality between highway infrastructure and exports, with no evidence of a long-term association between road stock and trade gains. This finding challenges the conventional wisdom that improved transportation infrastructure directly correlates with increased trade, suggesting that other factors may play a more significant role in determining trade outcomes. Similarly, Yeo et al. (2020) explored the mediating role of international trade in the relationship between infrastructure and economic performance; their findings suggest that although infrastructure development can indirectly affect economic growth through trade, the direct impact of infrastructure on trade may be limited. This implies that improvements in infrastructure alone may not suffice to enhance trade performance without concurrent developments in trade policy and market access.

Nonetheless, international trade may mediate economic growth by expanding international markets and production capacities. This expansion, in turn, leads to increased foreign direct investment (FDI), job creation, and ultimately higher GDP per capita. Consistent with this view, the findings of the present study indicate a positive relationship between transportation

infrastructure and economic growth (Wang et al., 2021); specifically, a one-unit increase in transportation infrastructure is associated with a corresponding increase in economic growth. Conversely, an inverse relationship was found between international trade and economic growth (Shahzad et al., 2023), indicating that as trade increases, economic growth decreases, and vice versa. This inverse relationship may be attributable to the fact that, over the past five years, Laos's imports have consistently outpaced its exports, resulting in a persistent trade deficit. Thus, in the case of Laos, international trade appears to exert a negative impact on economic growth.

Despite a low R-squared value, this research remains valuable, as it highlights statistically significant relationships between key variables (e.g., lnTINF and lnINT) and GDP. Economic phenomena are inherently complex and are often influenced by numerous factors beyond the scope of any single model. While a low R-squared suggests unexplained variability, the significant coefficients nonetheless provide actionable insights for policymakers. This study lays the groundwork for future research to refine existing models, incorporate additional variables, and deepen understanding of these relationships. Moreover, it addresses gaps in the literature and provides empirical evidence specific to the context of the 18 provinces of Laos.

Suggestions for Implementation

Based on the findings, Laos's government should emphasize the value of international trade by lowering the value of imports of unnecessary goods and raising the value of exports to protect the nation's trade balance. The government should also increase investment in transportation infrastructure by building new roads connecting urban and rural areas.

Suggestions for Future Research

Future research on transportation infrastructure is advised to focus specifically on how imports and exports affect Laos's economic growth, as well as to identify other potential mediators of that growth.

Acknowledgements

I would like to sincerely thank each of my advisors for their guidance, which enabled me to conduct this study. In particular, I would like to thank my family and friends for their support in funding the data collection and dissemination.

Declaration of Generative AI and AI-Assisted

Technologies in the Writing Process

During the writing of this manuscript, the author utilized AI and AI assisted technologies to assist with language editing and formatting. The authors thoroughly reviewed, and revised all content produced, taking full responsibility for the final accuracy, integrity, and intellectual substance of the published work.

Conflict of interests

The authors report no potential or actual conflicts of interest regarding the research, authorship, or publication of this article.

References

- Abdullahi, A. O., Safiyanu, S. S., & Soja, T. (2016). International trade and economic growth: An empirical analysis of West Africa. *IOSR Journal of Economics and Finance*, 7(2), 12–15.
- Abu-Bader, S., & Jones, T. V. (2021). Statistical mediation analysis using the Sobel test and Hayes SPSS process Macro. *International Journal of Quantitative and Qualitative Research Methods*, 9(1), 42–61.
- Acheampong, A. O., Dzator, J., Dzator, M., & Salim, R. (2022). Unveiling the effect of transport infrastructure and technological innovation on economic growth, energy consumption and CO2 emissions. *Technological Forecasting and Social Change*, 182(1), Article 121843. <https://doi.org/10.1016/j.techfore.2022.121843>
- Adebayo, T. S., Bekun, F. V., Ozturk, I., & Haseki, M. I. (2023). Another outlook into energy-growth nexus in Mexico for sustainable development: Accounting for the combined impact of urbanization and trade openness. *Natural Resources Forum*, 47(2), 334–352. <https://doi.org/10.1111/1477-8947.12283>
- Aggarwal, V., & Karwasra, N. (2023). A bibliometric analysis on trade openness and economic growth: current dynamics and future direction. *Competitiveness Review*, 34(2), 446 – 467. <https://doi.org/10.1108/CR-11-2022-0177>
- Afolabi, B., Danladi, J. D., & Azeez, M. I. (2017). International trade and economic growth in Nigeria. *Global Journal of Human-Social Science*, 17(E5), 29–39.
- Bajo-Rubio, O. (2022). Exports and long-run growth: The case of Spain, 1850-2020. *Journal of Applied Economics*, 25(1), 1314–1337. <https://doi.org/10.1080/15140326.2022.2152562>
- Bank of the Lao PDR. (2022). *Annual Economic Report*. Bank of the Lao PDR. https://www.bol.gov.la/en/fileupload/29-06-2023_1688003428.pdf
- Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, 51(6), 1173–1182. <https://doi.org/10.1037/0022-3514.51.6.1173>

- Barzelaghi, M. T., Dizaji, M., & Laleh, M. M. (2012). The effect of transportation infrastructure on foreign direct investment attraction in Iran. *International Journal of Economics and Finance Studies*, 4(2), 153–161.
- Bensassi, S., Márquez-Ramos, L., Martínez-Zarzoso, I., & Suárez-Burguet, C. (2015). Relationship between logistics infrastructure and trade: Evidence from Spanish regional exports. *Transportation Research Part A: Policy and Practice*, 72(1), 47–61. <https://doi.org/10.1016/j.tra.2014.11.007>
- Erum, N., Hussain, S., & Yousaf, A. M. (2016). Foreign direct investment and economic growth in SAARC countries. *The Journal of Asian Finance, Economics and Business*, 3(3), 57–66. <https://doi.org/10.13106/jafeb.2016.vol3.no3.57>
- Felbermayr, G. J., & Tarasov, A. (2022). Trade and the spatial distribution of transport infrastructure. *Journal of Urban Economics*, 130, 103473. <https://doi.org/10.1016/j.jue.2022.103473>
- Fetahi-Vehapi, M., Sadiku, L., & Petkovski, M. (2015). Empirical analysis of the effects of trade openness on economic growth: An evidence for South East European countries. *Procedia Economics and Finance*, 19, 17–26. [https://doi.org/10.1016/S2212-5671\(15\)00004-0](https://doi.org/10.1016/S2212-5671(15)00004-0)
- Han, Z., & Li, H. (2022). Transportation infrastructure and trade. *Japan and the World Economy*, 64, 101162. <https://doi.org/10.1016/j.japwor.2022.101162>
- Hye, Q. M. A., Wizarat, S., & Lau, W.-Y. (2016). The impact of trade openness on economic growth in China: An empirical analysis. *The Journal of Asian Finance, Economics and Business*, 3, 27–37. <https://doi.org/10.13106/jafeb.2016.vol3.no3.27>
- Idris, J., Yusop, Z., & Habibullah, M. S. (2017). Trade openness and economic growth: A causality test in panel perspective. *International Journal of Business and Society*, 17(2), 281–294. <https://doi.org/10.33736/ijbs.525.2016>
- Kadyraliev, A., Supaeva, G., Bakasa, B., Dzholdosheva, T., Dzholdoshev, N., Balovac, S., Tyurina, Y., & Krinichansky, K. (2022). Investments in transport infrastructure as a factor of stimulation of economic development. *Transportation Research Procedia*, 63, 1359–1369. <https://doi.org/10.1016/j.trpro.2022.06.146>
- Karymshakov, K., & Sulaimanova, B. (2021). The impact of infrastructure on trade in Central Asia. *Asia Europe Journal*, 19, 567–586. <https://doi.org/10.1007/s10308-021-00613-7>
- Kong, Q., Peng, D., Ni, Y., Jiang, X., & Wang, Z. (2021). Trade openness and economic growth quality of China: Empirical analysis using ARDL model. *Finance Research Letters*, 38, Article 101488. <https://doi.org/10.1016/j.frl.2020.101488>
- Lawal, E. O., & Ezeuchenne, K. (2017). International trade and economic growth in Nigeria. *IOSR Journal Of Humanities And Social Science*, 22(6), 35–43. <https://doi.org/10.9790/0837-2206083543>
- MacKinnon, D., Lockwood, C., Hoffman, J., West, S., & Sheets, V. (2002). A comparison of methods to test the mediation and other intervening variable effects. *Psychological Methods*, 7(1), 83–104. <https://doi.org/10.1037/1082-989X.7.1.83>
- Magazzino, C., & Maltese, I. (2021). Transport infrastructures: Investments, evaluation and regional economic growth. *Research in Transportation Economics*, 88, Article 101125. <https://doi.org/10.1016/j.retrec.2021.101125>
- Maitra, B., & Chakraborty, M. (2023). Foreign trade, human capital and economic growth in India under the liberalised trade regime. *Journal of Asian Economic Integration*, 5(1), 29–50. <https://doi.org/10.1177/26316846221147581>
- Mamasoliev, S. (2024). The role of international trade in U.S. economic growth. *Innovative Developments and Research in Education*, 3(32), 139–147.
- Ministry of Planning and Investment. (2021). *Statistical yearbook 2021*. Lao Statistics Bureau.
- Nantharath, P., & Kang, E. (2019). The effects of foreign direct investment and economic absorptive capabilities on the economic growth of the Lao People's Democratic Republic. *Journal of Asian Finance, Economics and Business* 6(3), 151–162. <https://doi.org/10.13106/jafeb.2019.vol6.no3.151>
- Netirith, N., & Ji, M. (2022). Analysis of the efficiency of transport infrastructure connectivity and trade. *Sustainability*, 14(15), 9613. <https://doi.org/10.3390/su14159613>
- Nguyen, H. M. (2022). Spatial spillover effects of transport infrastructure on economic growth of Vietnam regions: a spatial regression approach. *Real Estate Management and Valuation*, 30(2), 12–20. <https://doi.org/10.2478/remav-2022-0010>
- Raghutla, C. (2020). The effect of trade openness on economic growth: Some empirical evidence from emerging market economies. *Journal of Public Affairs*, 20(3), e2081. <https://doi.org/https://doi.org/10.1002/pa.2081>
- Raimbekov, Z., & Syzdykbayeva, B. (2021). Assessing the impact of transport and logistics on economic growth in emerging economies: A case study for the conditions of the republic of Kazakhstan. *Transport Problems*, 16(2), 200–211. <https://doi.org/10.21307/tp-2021-035>

- Rehman, F. U., Noman, A. A., & Ding, Y. (2020). Does infrastructure increase exports and reduce trade deficit? Evidence from selected South Asian countries using a new Global Infrastructure Index. *Journal of Economic Structures*, 9, Article 10. <https://doi.org/10.1186/s40008-020-0183-x>
- Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of Political Economy*, 94(5), 1002–1037.
- Saeed, N., Cullinane, K., & Sodal, S. (2021). Exploring the relationships between maritime connectivity, international trade and domestic production. *Maritime Policy & Management*, 48(4), 497–511. <https://doi.org/10.1080/03088839.2020.1802783>
- Şahan, D., & Tuna, O. (2021). Policy implications on transport infrastructure–trade dynamics: Case of Turkey. *Logistics*, 5(3), 47.
- Saidi, S., Shahbaz, M., & Akhtar, P. (2018). The long-run relationships between transport energy consumption, transport infrastructure, and economic growth in MENA countries. *Transportation Research Part A: Policy and Practice*, 111, 78–95. <https://doi.org/10.1016/j.tra.2018.03.013>
- Sarania, R. (2021). Interactions among infrastructure, trade openness, foreign direct investments and economic growth in India. *Journal of Infrastructure Development*, 13(1), 21–43. <https://doi.org/10.1177/09749306211023621>
- Shahzad, U., He, X., & Muhammad, S. (2023). How terms of trade impact economic growth: The case of the United States. *SAGE Open*, 13(2), 21582440231176452. <https://doi.org/10.1177/21582440231176452>
- Sobel, M. E. (1982). Asymptotic confidence intervals for indirect effects in structural equation models. *Sociological Methodology*, 13, 290–312. <https://doi.org/10.2307/270723>
- Swan, T. W. (1956). Economic growth and capital accumulation. *Economic Record*, 32(2), 334–361. <https://doi.org/10.1111/j.1475-4932.1956.tb00434.x>
- Soper, D. (2024, March 16). *Sobel test calculator for the significance of mediation*. <https://www.danielsoper.com/statcalc/calculator.aspx?id=31>
- Wang, C., Kim, Y.-S., & Kim, C. Y. (2021). Causality between logistics infrastructure and economic development in China. *Transport Policy* 100, 49–58. <https://doi.org/10.1016/j.tranpol.2020.10.005>
- Wang, C., Kim, Y.-S., Wang, C., & Kim, C. Y. (2021). A Study on the Causal Relationship between Logistics Infrastructure and Economic Growth: Empirical Evidence in Korea. *Journal of Korea Trade*, 25, 8–33. <https://doi.org/10.35611/jkt.2021.25.1.18>
- Wang, H., & Garduno-Rivera, R. (2023). The economic impact of trade openness on Mexico's indigenous peoples. *Regional Science Policy & Practice*, 15(7), 1612–1625. <https://doi.org/https://doi.org/10.1111/rsp.3.12700>
- World Bank. (2021). *Lao PDR Economic Monitor: A path to recovery* (Thematic section: Impacts of COVID-19 on Businesses and Households). World Bank.
- Yeo, A. D., Deng, A., & Nadiedjoa, T. Y. (2020). The effect of infrastructure and logistics performance on economic performance: The mediation role of international trade. *Foreign Trade Review*, 55(4), 450–465. <https://doi.org/10.1177/0015732520947676>
- Zhang, M., Li, Z., Wang, X., Li, J., Liu, H., & Zhang, Y. (2021). The mechanisms of the transportation land transfer impact on economic growth: Evidence from China. *Land*, 11(1), Article 30. <https://doi.org/10.3390/land11010030>
- Zhang, Y., & Cheng, L. (2023). The role of transport infrastructure in economic growth: Empirical evidence in the UK. *Transport policy*, 133(1), 223–233. <https://doi.org/10.1016/j.tranpol.2023.01.017>