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The Impacts of Transport Infrastructure on International Trade in Laos PDR

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Abstract

Laos PDR is a landlocked country with a low GDP growth rate of 6% over the last few decades. GDP per capita increased to USD 2,550 in 2018 and then dropped to USD 1,880 in 2020, which has been affected by the pandemic of COVID-19 since late 2019. The services sector is the largest contributor to GDP, accounting for 47% of it in 2018, followed by agriculture, fisheries, and forestry (17.9%), and electricity (12.3%). The fiscal deficit has been raised by external debts (WTO, 2020). The country is not only integrated with the three major trading partners, such as Thailand, Vietnam, and China, but it is also expanding to international and global trade following the improvement of the quantity and efficiency of transport infrastructure for logistics services. Currently, poor logistics services such as limited coordination among countries on border procedures, inefficiency of customs clearance process at the border checked point, fragmented and poor quality of transportation-related infrastructure, costly and infrequent shipping, delays in tracking and tracing consignments, delays in clearance of goods, the absence of cool storage facilities, and the inability to certify product quality can cause significant obstructing to international trade. This research will show the real situation and analyse some findings about ways for Laos's government to chase the new trend in the world in smart transportation systems.

Keywords*:* transportation infrastructure, smart transportation infrastructure
JEL Classifications: F18, L91, R42

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1. Literature Reviews

Hummels (2001) first observed that air freight has increased relative to sea freight over the past decades and attributes this change partly to a sharp decline in the relative price of air freight and partly to traders' valuation of time. Based on data on US trade by commodity category, source of imports, mode of transport, freight rates, and time in transit, he estimates the time cost of one day in transit. He also argues that time in transit is closed. related to the quality of ports and port services, customs procedures, etc., Thus, time in transit also depends on the quality of infrastructure in general.

Evans & Harrigan (2003; 2004) studied multimodal transport services, including packaging, warehousing, and transport from the premises of the exporter to the premises of the importer, which have become increasingly important (UNCTAD, 2003). Such multimodal transport services often include containerization, which in turn requires a minimum quantity of the goods in question. The choice of mode of transport is also limited by geography. Obviously, island countries are prevented from using rail and road transport for their exports, while landlocked countries are prevented from using ocean freight for the first leg of transportation to the destination.

The quality of transportation infrastructure can also create or reinforce comparative advantages. A study by Yeaple & Golub (2002) finds that differences in the quality of public infrastructure between countries can explain differences in total factor productivity. Furthermore, since sectors differ in how intensively they use services related to infrastructure and how dependent they are on good infrastructure, the impact of the quality of infrastructure on total factor productivity differs between sectors. For example, Yeaple & Golub (2002) found that the quality of road infrastructure is particularly important for productivity growth in the transportation equipment sector and for specializing in the production of textiles and apparel.

Moreover, there have been some studies about the relationship between transportation infrastructure and the development of trade in Laos. Firstly, according to Warr (2010), better roads are proven to reduce poverty by using a multi-household General Equilibrium Modelling approach (Laos GEM model) to study road improvement and poverty reduction in Laos with data sets from the Laos Expenditure Consumption Survey (LECS) from 1998 to 2002. The results indicate that road improvement does reduce poverty, but that the quantitative impact depends heavily on the types of roads that are provided and the areas in which the road is located. When no vehicle access areas are provided with dry season access roads (dirt and gravel), the reduction in poverty incidence is about 17 times the reduction that occurs when dry season access only roads are upgraded to all weather access (paved and improved gravel) roads. Reducing transport costs for households without road access is highly pro-poor.

Oraboune (2008) indicated that the improvement of all-weather roads in Laos PDR has significantly contributed to an increase in trade activities and poverty reduction as consumption expenditure increased. There is a close link between village connecting roads and poverty reduction through an increase in income opportunities for rural people. The rural connecting road provides market access opportunities to rural farmers and people, through which they can develop market linkages with other stakeholders in the economy. When income improved, their farming production improved through the increased opportunity to improve technology and other factors relevant to their farming production, such as closer links to markets and increased trade activities in the country. The road-sea route of freight transport is the most competitive, connecting the country

with regional and international trade, but others are not. Improving of the road-railroad and decentralizing industry are also significant in long term.

Kim et al. (2013) studied "Impact of the Road to Household Production and Income-Expenditure in Vientiane Province" to analyse the impact of the road on the production and generating income for rural consumption by using the fourth expenditure consumption survey data (LECS 4, 2007-2008) in Vientiane province. The development of transportation infrastructure contributes to raising consumption and commerce activities in the province. The results show that village access roads have a positive effect on household production, opportunities to reach markets, and household expenditure. Better road conditions will allow farmers to enter the urban market and expand their agricultural production by improving productivity. Phadouangdeth, (2013) also proved the influence of road accessibility on poverty reduction in Laos PDR through increasing trading activities by comparing the terms of Laos PDR with the international cross-section analysis using the multiple regression analysis method. The results show that road throughout the year has a significant positive impact on real expenditure per capita. That road access would allow farmers all-season access to urban markets, expand agricultural production by improving productivity, and help reduce poverty, especially in rural areas.

All the studies provide theories and evidence to show that there is a positively strong linkage between international trade and transport infrastructure variables on the aspect of distance among proxy of international trade; there is, however, no study on moderated factors to either increase nor decrease the relationship between transport infrastructures and international trade. This study aims to fill the gap in the literature.

2. The real situation of international Trade of Laos PDR

This research used time series data as retrieved from the World Bank Database, World Integrated Trade Solution (WITS), and Laos government authorities from the years 2010 to 2019, which is in the period that Lao PDR accessed international trade and many regional and international trade agreements have been signed following national legislation improvements. Target alliance countries were selected by prioritizing crossing borders with Laos PDR, the top 10 trade shares for 2010- 2019, the Signatory of Regional Trade Agreement (RTA) with Laos PDR and Preferential Trade Agreement.

The data is based on a 6-digit HS to be suitable with neighbour classification for re-export via ocean mean.

Table 1: International Trade of Laos PDR from 2010 to 2019

No.	Country Name	Code	Total trade volume to Laos from 2010 to 2019 (US$ Thousand)
1	Thailand	TH	36,782,665
2	China	CN	16,321,908
3	Vietnam	VN	8,875,526
4	Australia	AU	2,207,964
5	Japan	JP	1,482,557
6	Germany	DE	754,477
7	India	IN	685,891
8	Korea, Rep.	KR	674,422
9	United States	US	506,221
10	United Kingdom	GB	444,034

Source: Lao Statistic Bureau (2021)

3. Real Situation of Transportation Infrastructure of Laos

Laos PDR's transport infrastructure is in its initial stages, as evidenced by the country's road density of 8.1 km per 1,000 people and poor road quality. Furthermore, the overall demand for transportation infrastructure is low. However, demand has been increasing at an annual rate of 5% to 8% for goods and 8% to 10% for passengers over the years. Road transportation accounts for more than 90% of total freight transport in 2020 and 63% of total passenger transport in 2019, with water freight transport accounting for 9%, air passenger transport accounting for 31%, and other modes accounting for extraordinarily little. In connectivity with ASEAN and GMS countries as illustrated in Map 1, there are eight ASEAN highways with 2,913 kilo meters of road length and six GMS highways as shown in Table 5, with five Mekong Friendship bridges crossing the Mekong River between Laos and Thailand (one under-construction), one Friendship Bridge with Myanmar, and five Mekong bridges for domestic transportation, together with eighteen international cross border checkpoints as shown in Table 6, but among interstate, bilateral transport agreement have been agreed for twenty-six cross borders such ten borders between Laos-Thai, thirteen borders between Laos-Vietnam, two borders between Laos-China, and one border between Laos-Cambodia (ASEAN, 2017).

3.1 Road transportation infrastructures

The road network in Laos PDR is approximately 59,101 km long and classified into six categories, as shown in Table 1. There is also a 109 km expressway from Vientiane Capital to Vang Vieng, Vientiane province, which has been operating since the end of 2020. In general, more than 77% are classified as not in good condition. While thirty-two national road classes account for approximately 13% of the total length of roads in Laos PDR, they play a key role as bloodlines for freight and passenger transportation at domestic and international levels. However, the total national road length of 7,846 km has been paved for only 85%, which means 1,171 km needs to be paved. The local road length of 51,029 km (provincial roads, district roads, municipality roads, rural roads, and specific roads) accounts for almost 87% of the total length of the country, but they are paved for only 13.42%, and approximately 44,181 km needs to be paved. Therefore, most of the local roads are difficult to access during the rainy season. As illustrated in figure 1, Length of the roads in Laos PDR (1976-2021), since the revolution year of 1975, the road development in the first two decades (1976-1995) was developed very slowly because the country needed to recover after the war and grew by 3% per year, from 11,500 km in 1976 to 18,363 km in 1995. However, the road's length had been sharply increased for the next two decades in the period of 1996 to 2015, reaching 56,331 km in 2015, or more than 10% annually, to support the high increase in freight transport by land, which was 21% annually during these years. As shown in figure 1 , road development has gradually increased between 2015 and 2021, only 0.75% a year, constrained by the country's fiscal budget limitation, but freight traffic volume by land has consistently increased by approximately 7% a year from 2011 to 2021 (556.66 million tons.km), and share modes of road freight traffic increased to 90% in 2020 and increased to 99% in 2021 with road traffic volume of 556.66 million tons per km during the COVID-19 pandemic (Share Modes of Freight Traffic (tons per kilo meters) in Laos PDR) because other freight modes had been obstructed by government policy.

Table 2: Road Surfaces and Classification in Laos PDR (2021)

Classes /Surfaces	National roads	Provincial roads	District roads	Municipality roads	Rural roads	Specific roads	Total length (km)
Concrete roads	130.36	132.35	79.80	300.30	75.13	55.61	773.55
Asphalt concrete roads	1,034.26	61.60	-	148.41	4.00	36.53	1,284.80
Tarred roads	5,510.56	2,256.57	961.67	1,403.62	928.63	403.62	11,464.67
Gravelled roads	892.67	5,051.61	4,532.32	1,454.66	11,207.40	1,312.63	24,451.29
Earth roads	278.69	1,082.75	1,839.70	805.10	13,055.78	3,839.26	20,901.28
Total length (km)	7,846.54	8,584.88	7,413.49	4,112.09	25,270.94	5,647.65	58,875.59

Sources: Laos Statistic Bureau (2021)

However, the share mode of passenger traffic has gradually declined from 95% of persons per km in 2010 to 84% in 2020, then was affected by the pandemic, decreasing to zero percent of persons per km in 2021.

Transportation infrastructure is extremely poor, just for small trucks and vehicles. The signal system is not smart enough for all vehicles to rely on. So, they need to be replaced by smart systems.

3.2 Waterway transportation infrastructures

The Mekong River has served as a crucial transportation route for people and goods, connecting the several towns located along its banks for thousands of years. Small boats are still used for traditional kinds of trade between communities, but the Mekong River is also growing in importance as it links the six Mekong countries. Navigation continues to be difficult in the upstream portions of the Mekong River due to narrower and more turbulent sections of water as well as significant yearly water level variations. As a result, seasonal changes in water levels have a direct impact on trade along this river stretch. The limited draughts available during the low water season are principally to blame for the more than 50% fall in trade volume being shipped. There are 21 river port facilities in Laos that are small and typically utilized for domestic trade. These ports have seen an increase in cross-border trade in recent years with countries like China, Myanmar, and Thailand. There are three major routes along the Mekong River, such as Houayxay-Luangpabang, Luangpabang-Vientiane, Vientiane-Thakek-Savannaket, and Savannaket-Champasak, that can be used for domestic trade. But because of waterfalls, rapids, and low water levels during the dry season, the length of the navigable river is less than 1,000 km. Ships are used for regional trade in Laos to transport three main commodities: lumber, agricultural goods, and building supplies. Most of the traffic volume is freight traffic. The freight traffic volume of the river fluctuated between 60 and 90 million tons-kilometres for two decades (2000–2020), then sharply declined to approximately 2.3 million tons-kilometres in 2021 during the COVID-19 pandemic, but passenger traffic by water traffic was gradually increased during the temporary migration of Laos labour from Thailand to Laos during the pandemic policy of the two countries. All infrastructure is fabricated without rules, so it is not easy to rely on. Moreover, the system is not synchronized and full.

3.3 Air transportation infrastructures

There are eleven airports in Lao PDR (domestic and international services) which provide major services for tourist traffic. Wattay International Airport, located in Vientiane Capital, is the main airport, serving international flights to Thailand (BKK),

Vietnam (Hanoi), China (Kunming), Cambodia, Singapore, and the Republic of Korea. Other important but minor ones are in Luanprabang, Pakse, Savannakhet, Oudomxay, and Luang Namtha. However, Xayyabouly only does a small number of surgeries. The main entry point to international airports is Vientiane, while Louangphrabang and Pakxe receive regional traffic and provide services for customs, immigration, and quarantine. Savannakhet is another important provincial airport. International traffic and associated services are handled by the two regional airports in Luangprabang and Pakxe, as well as the Wattay Airport in Vientiane. International services are provided by several international airlines, including Air Asia, Bangkok Airways, China Eastern Airlines, Laos Airlines, Thai Airways, and Vietnam Airlines. Direct flights from Louangphrabang to Bangkok, Chiang Mai, and Hanoi are also available, as are direct flights from Pakxe to Bangkok and Siem Reap. Laos Airlines operates scheduled domestic services on major routes daily. Air traffic in Laos PDR is all passenger traffic, with extraordinarily little freight traffic. Laos has recorded steady growth in air passenger traffic from 2009 to 2019, with a 20% annual increase that is encouraged by increasing tourist traffic. Laos Airlines recorded approximately 80,000 persons per km in 2010, then sharply increased between 2015-2019, reaching 1,97 million persons per km in 2019, and then declining to 56,000 persons.km in 2020. This system is good but not smart because there is no more funding to update the system from equipment to signals.

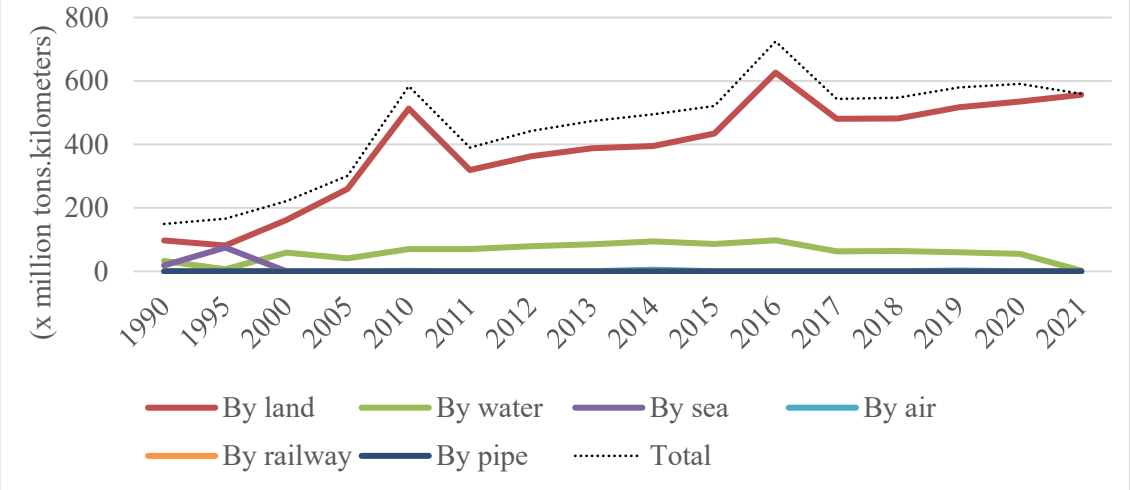
3.4 Rail transportation infrastructures

Before 2020, Laos had only a short railway section of 9 km from Thanaleng (Vientiane Capital) to Nongkhai (Thailand) through the Laos-Thailand Friendship Bridge, which crosses the Mekong River and can be connected at Nongkhai to Bangkok and the rest of Thailand's railroad system. Thanaleng Railway has been fully served for passenger travel; from 2014 to 2019, the number of passengers was stable at around 35,000 per year, but because of the COVID-19 pandemic, it dropped significantly to 2,300 and 700 from 2020 to 2021. However, the construction of the Laos-China railway began in 2016 and has been operating since December 2021, a rail link from Vientiane capital to Kunming, China. The Laos-China Railway is a part of six international economic corridors, called the China-Indochina Peninsula Economic Corridor (CICPEC), under China's Belt and Road Initiative (BRI), Laos-China Railway in Laos PDR, and the Belt and Road Initiative of China. It runs from Laos PDR's capital of Vientiane to the town of Boten on the border with China. The railway is 414 km long, with approximately 200 km passing through 75 tunnels and 61 km crossing 67 bridges. Passenger trains have a design speed of 160 km/h (maximum of 200 km/h), while freight trains run at 120 km/h and are powered by electricity. It is expected that it would expand the trade network from Kunming in China to Singapore via Laos PDR, Thailand, and Malaysia. The railway terminal also connects the export processing zones (EPZs) and the logistics park in Vientiane and connects to China-Thailand Corridor (NR3, China-Bokeo-Luangnamtha-Thailand), Thailand-Laos-Vietnam Corridor (NR2, Thailand-Oudomxay-Vietnam), and tourism areas such as Luangprabang, the world heritage, and Vang Vieng, which are attracted by tourists. The railway will reduce the cost of land-based transportation, allowing trade along the corridor to compete with the nation's current maritime routes. Laos PDR would be able to gain from freight transit between China and ASEAN as a result. Given that China is a significant market for Laos exports and imports, the country would also benefit from faster and less expensive goods transit between Laos PDR and China. Since the start of the Laos-China Railway, there has been a surge in tourism-related passenger traffic.

3.5 Pipeline transportation infrastructures

Laos PDR has no pipeline transportation infrastructure for transporting products such as natural gas, crude oil, or petroleum products; however, in 2017, the Hon La Oil Stockpile and an oil pipeline from Hon La Harbour in Vietnam's Quang Binh province to Laos' Khammuan province were the subject of an agreement between the governments of Laos and Vietnam, but the project has been temporarily put on hold due to Laos PDR's financial restrictions. (Global Energy Monitor, 2022; Laotian Times, 2017).

Figure 1: Freight Transport Volumes in Laos PDR



Sources: Laos' Statistic Department (2021)

4. Research model and findings

The qualitative research is to determine factors of transport infrastructure affecting international trade in Laos PDR; the individual in-depth interview is to gather the transport infrastructure with experts, government officers, enterprises, and literature reviews.

The quantitative research is conducted to collect data through a survey questionnaire on a large scale, which is constructed by the impact factors of transport infrastructure. At the in-depth stage, approximately 200 related companies in Laos will be gathered.

To reflect the past and current situation, the data was collected from both primary and secondary sources. The primary data was collected through face-to-face, in-depth interviews with relevant actors and stakeholders involved, including firms and enterprises related to trade and transportation.

An in-depth interview was conducted to expand the understating of all related factors in the transport infrastructure in the context of Laos PDR, which is a landlocked country at the early stage of international trade. The key stakeholders who have deep knowledge and experience on transportation issues and international trade developments were identified by the purposive and snowball sampling methods. The interview targeted at the high management positions of relevant ministries in Laos, such as the Ministry of Public Works and Transport, and the Department of Planning, including a few experts who were advisory to the ministers. At the enterprise's target, the interviewees were some management positions of the Laos Freight and Forwards Association, Dry Port, and outstanding trade and transportation companies in Laos PDR. 15 interviewees were interviewed in Laos language.

Therefore, a structured interview was used, and the scheduling of questions was flexible during the interviewing; therefore, the authors adopted the question line accordingly as interacting. The semi-structured interview was used because the related factors of transport infrastructure and international trade are uncertain and dynamic, and the interview form is appropriate to investigate motive, attitude, and value based on the experiences and practices of participants implicating the exploring subject. Preparedness of the interview was made via an official letter of the author ministry for the perception, followed by a phone call and email for an appointment to identify the time and location of interviewing. Furthermore, a phone call was made to each participant a day prior to the interviewing date. Every interview is to take about 30-60 minutes with audio recording and note-taking, including the recording of body language. The audio recording was initially transcribed into a Lao language transcript, then translated to English language transcript. Finally, the transcript is to be sent to the interviewee for confirmation of the validity of the data.

The quantitative research was conducted to gather secondary data, such as international trade data among Laos PDR and alliance countries, collected from the World Bank, the World Integrated Trade Solution (WITS), and Laos government authorities.

The World Bank Database, the World Integrated Trade Solution (WITS), and Laos government authorities provided the time series data for this study. During this time, Laos PDR gained access to international trade, and numerous regional and global trade agreements were signed because of improvements to its domestic legal system. The target alliance countries were chosen and prioritized based on their impact on Laos PDR, including the countries that share borders with Laos PDR, their top-ten trade shares in a decade, which took 94% of the total international trade volume of Laos PDR, and their participation in preferential trade agreements (PTAs) with Laos PDR, shown in Table 3.

Table 3: Selected Trade Partners

No.	Country Name	Shared border	Shared Trade Ranked	Trade Agreement
1	Thailand	Yes	1	Yes
2	China	Yes	2	Yes
3	Vietnam	Yes	3	Yes
4	Cambodia	Yes	19	Yes
5	Myanmar	Yes	23	Yes
6	Australia	No	4	Yes
7	Japan	No	5	Yes
8	Germany	No	6	Yes
9	India	No	7	Yes
10	Korea, Rep.	No	8	Yes
11	United States	No	9	Yes
12	United Kingdom	No	10	Yes

Sources: Laos' Statistic Department (2021) and SPSS 20 analysis.

To identify international trade, trade volumes in USD such as imports, exports, and total trade volumes among Laos PDR and the targeted countries were gathered from the World International Trade Solution (World Bank, 2022). The author used the percentage of paved roads to measure the level of transport infrastructure because road transport accounts for all freight transportation in Laos PDR (Laos Statistic Bureau, 2022).

Furthermore, the data on transport infrastructure factors was collected from related government agencies, such as the distance among proxy of trade, the type and condition of transport infrastructure, and times.

The secondary data was targeted for quantitative analysis; international trade volume data (import and export) among Lao PDR and alliance countries was collected from the World Bank, the World Integrated Trade Solution (WITS), and Laos government authorities. Alliance countries are to be selected from the highest rank sharing international trade amongst Laos PDR and other countries. Furthermore, policies on international trade and transport infrastructure development in Laos PDR and a literature review were gathered. GIS technology was used to assess shortest distances from the capital city of Laos PDR to the centre of the capital city of alliance countries by collecting data from the Department of Statistics of Laos; the type, conditions, and time of transportation of the connecting infrastructure were collected from the Ministry of Public Works and Transport and other studies.

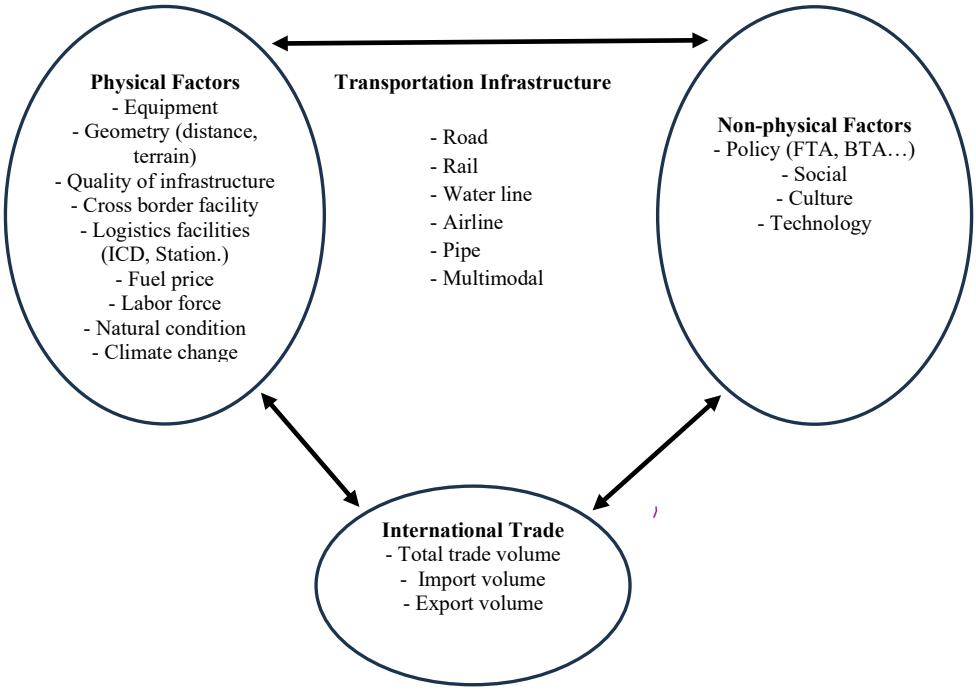
In this research, the physical infrastructure was measured by the number of trucks registered in Laos PDR, the amount of imported fuel in USD, the efficiency of customs services that respondents evaluated efficiency of customs clearance processes (i.e. speed, simplicity and predictability of formalities) on a rating ranging from 1 (very low) to 5 (very high), and the time used for export in hours since border compliance captures the time and cost associated with compliance with the economy's customs regulations and with regulations relating to other inspections that are mandatory in order for the shipment to cross the economy's border, as well as the time and cost for handling that takes place at its port or border, it includes time and cost for customs clearance and inspection procedures conducted by other government agencies, and the information and communication technology factor to measure the development of ICT system in the country, such as computers and peripheral equipment, communication equipment, consumer electronic equipment, electronic components, and other information and technology goods (World Bank, 2022),. These factors are important because they relate to the efficiency of transportation infrastructure in the country, which affects international trade.

To define the nonphysical infrastructure, the authors used the number of trade partners to Laos PDR (World Integrated Trade Solution, 2022), the frequency that shipments reach the consignee within the expected time, and how often the shipments to the assessed country reach the consignee within the scheduled or expected delivery time, on a rating ranging from 1 (hardly ever) to 5 (nearly always), the percentage of tariff rate that is the unweighted average of most favoured nation rates for all products subject to tariffs, calculated for all traded goods, the percentage of total employment that wage and salaried workers hold the type of jobs defined as "paid employment jobs" where the incumbents hold explicit (written or oral) or implicit employment contracts that give them a basic remuneration that is not directly dependent upon the revenue of the unit for which they work.

The collected data was analysed by the Gravity model (Joanna Bialynicka-Birula, 2014) to analyse the relationship between transportation infrastructure and international trade, determining the direction and value of the relationship between those factors and understanding the relationship at the country level.

The Gravity model has been harmonized by dividing the transportation infrastructure into physical and nonphysical components. And then, STATA Structural Equation Modelling (SEM) was used to regress the harmonized gravity model, solving dynamic relationships among transportation infrastructure. Both physical and nonphysical factors impact international trade between pairs of partner countries. Based on international trade data, researchers commended the gravity model, which seems to have the strongest impact on Laos because the boundaries are not water, so the distance variable is especially important. It causes the total international trade in Laos to be so low.

Figure 2: Research Model



Source: Joanna Bialynicka-Birula (2014)

The model is harmonized to Joanna Bialynicka-Birula (2014). The basic system of equations of interest in this study can be written in a general functional form as follows:

$$T_{ij} = k(X_{ij}) \frac{E_i^{\propto i} \; M_j^{\propto j} \; q_{ij}^{\beta}}{d_{ij}^{\gamma}} \tag{1}$$

where,

T_{ij} = Trade volume between country i and j.

$E_i^{\propto_i}$ = Economic scale of the exporting country

$M_j^{\propto_j}$ = Economic scale of the importing country

q_{ij}^{β} = Quality of transport infrastructure between country i and j.

d_{ij}^{γ} = Distance between country i and j.

X_{ij} = A vector of other variables.

Most of the cited econometric studies employ a log-transformation of the gravity model in time series:

$$\log T_{ij} \; = \; k_0 + \propto_i \log E_i + \propto_j \log M_j \; + \; \beta \; log \; q_{ij} \; + \; \gamma \; log \; d_{ij} \; + \; \varepsilon_{ij} \tag{2}$$

The quality of transport infrastructure is presented by the transport infrastructure index among countries, determined by the following equation:

$$Q_j \; = \; P_j^{\propto_1} \; G_j^{\propto_2} \; C_j^{\propto_3} \tag{3}$$

where,

Q_j = Transport infrastructure index for country j

P_j = Percent of paved road for country j

G_j = GDP per capital in country j (an index of capacity to maintain roads)

C_j = Country Policy and Institutional Assessment (CPIA) for country j.

The CPIA of the World Bank rates countries against a set of 16 criteria grouped into four clusters: (i) economic management; (ii) structural policies; (iii) policies for social inclusion and equity; and (iv) public sector management and institutions.

Logistics Performance is scored by the six components, such as infrastructure, customs, international shipments, competence in logistics, timeless, tracking, and tracing to a better indicate countries' logistics performance (World Bank, year). The harmonized Gravity regression model is to analyse dependent, independent, and moderated variables as shown in Table 4.

Table 4: The Intended Variables to be Measured, their Characteristics, and Sources of Information.

VARIABLE ABR.	DETAILS	PROPERTIES	EXPECTED SIGN	SOURCE
DEPENDENT VARIABLES				
T_{ij}	Total trade volume between country I and j.	Varies		The World Bank
Q_j	Index of transport infrastructure quality for country j	Index number	(+)	equation 3
INDEPENDENT VARIABLES				
d_{ij}^{γ}	Average distance between Lao capital city and the city of country trading pair	Varies	(+/-)	GIS Statistic Department of Laos, Ministry of Public Works and Transport
q_{ij}^{β}	Quality of transport infrastructure	Varies	(+)	Index of transport infrastructure of countries
$E_i^{\propto i}$	Economic scale of the exporting country	Varies	(+)	The World Bank
$M_j^{\propto j}$	Economic scale of the importing country	Varies	(-)	The World Bank
P_j	Percent of paved road for country j, another mode of transportation is to be equivalented.	Varies	(+)	GIS Statistic Department of Laos,
G_j	GDP per capital in country j	Varies	(+)	Ministry of Planning and Investment, Lao
C_j	Country Policy and Institutional Assessment (CPIA) for country j	Varies	(-)	The World Bank
Rd	Road transport infrastructure	Dummy 1 = Yes	(+)	Ministry of Public Works

VARIABLE ABR.	DETAILS	PROPERTIES	EXPECTED SIGN	SOURCE
	between Laos and its alliance country	0 = No		and Transport of Laos.
Ra	Rail transport infrastructure between Laos and its alliance country	Dummy 1 = Yes 0 = No	(+)	Ministry of Public Works and Transport of Laos.
Wt	River transport infrastructure between Laos and its alliance country	Dummy 1 = Yes 0 = No	(+)	Ministry of Public Works and Transport of Laos.
Ar	Air transport infrastructure between Laos and its alliance country	Dummy 1 = Yes 0 = No	(+)	Ministry of Public Works and Transport of Laos.
Pl	Pipeline transport infrastructure between Laos and its alliance country	Dummy 1 = Yes 0 = No	(+)	Ministry of Public Works and Transport of Laos.
Mt	Multimodal transport infrastructure between Laos and its alliance country	Dummy 1 = Yes 0 = No	(+)	Ministry of Public Works and Transport of Laos.
Paved_Rd	Percentage of the paved roads.	Percentage	(+/-)	Lao Statistic Bureau, Ministry of Planning, and Investment.
No_Mk_Brdg	Number of Mekong bridges	Number	(+/-)	Lao Statistic Bureau, Ministry of Planning, and Investment.
No_Tr_Pn	Number of trade partners to Lao PDR (Signed Agreement).	Varies	(+/-)	World International Trade Solution, World Bank.
Xpect_Tm	Frequency that shipments reach the consignee within the expected time, and how often the shipments to the assessed country reach the consignee within the scheduled or expected delivery time.	Ranging from 1 (hardly ever) to 5 (always)	(+/-)	World Bank Database.
Tariff	Percentage of tariff rate that is the unweighted average of most favored nation rates for all products subject to tariffs	Percentage	(-)	World Bank Database.
Wage_emp	Percentage of total employment that	Percentage	(+)	World Bank Database.

VARIABLE ABR.	DETAILS	PROPERTIES	EXPECTED SIGN	SOURCE
	wage and salaried workers hold the type of jobs defined as "paid employment jobs".			
MODERATED VARIABLES				
Ct	Cost of transport	Varies	(-)	Field survey
Lp	Logistic performance	(Low=1 to Hight=5)	(+)	The World Bank

Sources: Laos' Statistic Department (2021) and STATA analysis.

Finally, outputs from the qualitative step, such as the in-depth interview, and the quantitative, such as the descriptive and regression model analyses, were integrated and resulted in what factors of transport infrastructure impact international trade, including direction and ranking.

5. Analysis of each partner and findings

The analysis results of the structural equation modelling (SEM) regressing nonphysical and physical variables of transportation infrastructure impact international trade as each pair of country trade partners are as follows:

5.1. Between Laos PDR and Thailand

The test of overall goodness of fit for SEM Model 4.1 on the STATA software was done for the purpose of performing the fitting statistic. The likelihood ratio is good ($p > chi2$ of the model versus saturated = 0.544, and $p > chi2$ of the baseline versus saturated equals 0.000). The population error is good (the root mean squared error of approximation. (RMSEA = 0.000) is smaller than 0.05). The information criteria are a good fit for the values of Akaike's information criterion (AIC) and Bayesian information criterion (AIC). The baseline comparison is good because the comparative fit index (CFI) and Tucker-Lewis index (TLI) are both very close to 1.00. Furthermore, the size of residuals is acceptable as the standardized root mean squared residual (SRMR = 0.08) value is very close to 0.000 and the coefficient of determination (CD = 0.995) is 1.00. Therefore, the model is significant, and the results shown in Table 5.

The analysis's findings indicated that the international trade between Laos and Thailand was impacted by the physical transport factors, with a 95% significance, such that the international trade increased 0.20% when the percentage of paved roads increased 1.00% or when transportation infrastructure was improved but decreased 0.08% while the number of Mekong bridges increased 1.00%. The physical transport factors that affected the trade were impacted by the nonphysical transport factors, such as the percentage of wage and salaried workers of total employment and tariff rates, which each increased by 1.00%; then, the percentage of paved roads increased by 0.50% and 0.11%, respectively, but the percentage of paved roads decreased by 0.32% while the shipment on expected times increased by 1.00%, and the number of Mekong bridges increased by 2.48% when the percentage of wage and salaried workers of total employment increased 1.00%. Furthermore, the nonphysical transport factors were impacted by the physical factors, and the trade volumes, such as the shipment on expected time, decreased by 0.26% when the number of Mekong bridges increased by 1.00%, and the number of trade partners increased by 0.19% when the import volumes increased by 1.00%. Additionally,

the import volume and export volume were also impacted by physical and nonphysical factors. For instance, when the Mekong bridges increased by 1.00%, the import volume increased by 0.89%, and the export volume increased by 4.52% and 4.78, respectively, while the shipment on expected times and the percentage of wage and salaried workers in total employment each increased by 1.00%.

Table 5: The Impact of Nonphysical and Physical Factors on the International Trade between Laos PDR and Thailand

Structural	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf. Interval]	
LnNo_MK_Brdg <-						
LnWage_emp						
_cons	2.475836	.1828319	13.54	0.000	2.117492	2.83418
	.0803387	.1323468	0.61	0.544	-.1790562	.3397337
LnPaved_Rd <-						
LnXpect_Tm	-.3226668	.1130185	-2.85	0.004	-.5441789	-.1011547
LnWage_emp	.5043939	.0802622	6.28	0.000	.3470828	.661705
LnTariff	.1094206	.04757	2.30	0.021	.0161851	.2026561
_cons	.295582	.1856525	1.59	0.111	-.0682901	.6594541
LnEX_LATH <-						
LnPaved_Rd	-1.640398	1.753121	-0.94	0.349	-5.076452	1.795657
LnXpect_Tm	4.515603	1.177831	3.83	0.000	2.207098	6.824109
LnWage_emp	4.778334	1.26105	3.79	0.000	2.306721	7.249947
_cons	-4.647315	1.46248	-3.18	0.001	-7.513723	-1.780907
LnNo_Tr_Pn <-						
LnIM_LATH	.1892423	.0754904	2.51	0.012	.0412838	.3372008
_cons	1.430053	.2337572	6.12	0.000	.9718978	1.888209
LnTTrade_LATH <-						
LnNo_MK_Brdg	-.0771156	.01016	-7.59	0.000	-.0970288	-.0572023
LnPaved_Rd	.2013413	.066252	3.04	0.002	.0714897	.3311929
LnEX_LATH	.3773189	.0041722	90.44	0.000	.3691415	.3854964
LnNo_Tr_Pn	.0274711	.011373	2.42	0.016	.0051804	.0497618
LnIM_LATH	.6779664	.0060408	112.23	0.000	.6661267	.6898062
_cons	.4812775	.0351287	13.70	0.000	.4124265	.5501285
LnIM_LATH <-						
LnNo_MK_Brdg	.8862836	.2501975	3.54	0.000	.3959055	1.376662
LnPaved_Rd	-.7016901	.9758484	-0.72	0.472	-2.614318	1.210938
LnTariff	.9776194	.5966302	1.64	0.101	-.1917543	2.146993
_cons	-.3707432	1.359019	-0.27	0.785	-3.034371	2.292884
LnXpect_Tm <-						
LnNo_MK_Brdg	-.2629048	.0923091	-2.85	0.004	-.4438273	-.0819823
LnPaved_Rd	.5979383	.3695359	1.62	0.106	-.1263388	1.322215
_cons	1.186336	.0932197	12.73	0.000	1.003629	1.369044

Sources: Laos' Statistic Department (2021) and STATA analysis.

5.2 Between Laos PDR and China

The SEM Model 6 was used to test the hypothesis, clarifying the relationship between the nonphysical affected physical factor or the quality of transportation infrastructure which influenced international trade; The test of the overall goodness of model fitting was done for the purpose of performing the fitting statistic. The likelihood ratio is good ($p > chi2$ of model versus saturated = 0.684, and $p > chi2$ of baseline versus saturated equals 0.000). The population error is good (root mean squared error of approximation (RMSEA) = 0.000 < 0.05). The information criteria are a good fit for the values of Akaike's information criterion (AIC) and Bayesian information criterion (AIC). The baseline comparison is good because the comparative fit index (CFI) and Tucker-Lewis Index (TLI) values are both very close to 1.00. Furthermore, the size of the residuals is good, as the value of the standardized root mean squared residual

(SRMR = 0.044) is close to 0.000 and the coefficient of determination (CD = 0.998) is 1.00. Therefore, the model is significant, and the results shown in Table 6.

The analysis's results showed that international trade between Laos and China was impacted by nonphysical and physical factors with a 95% level significance. The international trade was positively impacted by the percentage of paved roads or the quality of transportation infrastructure in Laos PDR, which was influenced by nonphysical factors such as the increase in the percentage of paved roads by 1.00%, which caused an increase in the international trade by 1.44%, and the international trade decreased by 0.3% while the number of trade partners increased by 1.00%. The physical factors were impacted by the nonphysical factors, such as the percentages of paved roads increased by 0.65% and 0.16%, when the percentage of wage and salaried workers in total employment and the tariff rate each increased by 1.00%, respectively. Furthermore, the nonphysical factors were also impacted by the physical factors, such as the shipment on expected times decreased by 0.13% when the number of Mekong Bridges increased by 1.00%. Additionally, the import and export volumes were affected by nonphysical factors such as the impart volume from China to Laos increased by 2.99% when the percentage of wage and salaried workers of total employment in Laos increasing by 1.00%, the export volume increased 8.41%, 1.53%, and 1.27% when the percentage of wage and salaried workers of total employment, the number of trade partners, and the tariff rates each increased 1.00%, respectively, but the export decreased 4.62% when the paved roads increased 1.00%.

Table 6: The Impact of Nonphysical and Physical Factors on the International Trade between Laos PDR and China

Structural	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
LnWage_emp <-						
LnNo_MK_Brdg	.3830169	.0282845	13.54	0.000	.3275804	.4384534
_cons	.0057965	.0529736	0.11	0.913	-.0980298	.1096228
LnPaved_Rd <-						
LnWage_emp	.6507713	.0658073	9.89	0.000	.5217912	.7797513
LnXpect_Tm	.0827237	.0515963	1.60	0.109	-.0184031	.1838505
LnTariff	.1600388	.049686	3.22	0.001	.0626561	.2574216
_cons	-.3458049	.1828973	-1.89	0.059	-.7042771	.0126673
LnIM_LACN <-						
LnWage_emp	2.987403	.927983	3.22	0.001	1.16859	4.806216
LnNo_MK_Brdg	.3526364	.333596	1.06	0.290	-.3011997	1.006473
_cons	1.465281	.3074236	4.77	0.000	.8627422	2.067821
LnEX_LACN <-						
LnWage_emp	8.413023	1.162695	7.24	0.000	6.134183	10.69186
LnPaved_Rd	-4.62348	1.58365	-2.92	0.004	-7.727377	-1.519584
LnNo_Tr_Pn	1.53159	.4752354	3.22	0.001	.6001454	2.463034
LnTariff	1.268094	.6826575	1.86	0.063	-.0698902	2.606078
_cons	-5.302121	1.579038	-3.36	0.001	-8.39698	-2.207263
LnTtrade_LACN <-						
LnPaved_Rd	1.440977	.6568896	2.19	0.028	.1534974	2.728458
LnIM_LACN	.497056	.0541305	9.18	0.000	.3909622	.6031499
LnEX_LACN	.2888256	.0392669	7.36	0.000	.2118639	.3657873
LnNo_Tr_Pn	-.2947651	.0782189	-3.77	0.000	-.4480714	-.1414588
LnNo_MK_Brdg	.0567294	.0598297	0.95	0.343	-.0605347	.1739935
_cons	1.285786	.1997933	6.44	0.000	.894198	1.677373
LnXpect_Tm <-						
LnNo_MK_Brdg	-.1280832	.039438	-3.25	0.001	-.2053803	-.0507861
_cons	1.277199	.0738629	17.29	0.000	1.13243	1.421968

Sources: Laos' Statistic Department (2021) and STATA analysis.

5.3 Between Laos PDR and Viet Nam

The SEM Model 7 has been used to test the hypothesis, clarifying the relationship between the nonphysical affected physical factor or the quality of transportation infrastructure which influenced international trade; The test of the overall goodness of model fitting was done for the purpose of performing the fitting statistic. The likelihood ratio is good (p > chi2 of model versus saturated = 0.549, and p > chi2 of baseline versus saturated equals 0.000). The population error is good (root mean squared error of approximation (RMSEA) = 0.000 < 0.05). The information criteria are a good fit for the values of Akaike's information criterion (AIC) and Bayesian information criterion (AIC). The baseline comparison is good because the comparative fit index (CFI) and Tucker-Lewis Index (TLI) values are both very close to 1.00. Furthermore, the size of residuals is acceptable, as the value of the standardized root mean squared residual (SRMR = 0.058) is close to 0.000 and the coefficient of determination (CD = 0.999) is 1.00. Therefore, the model is significant, and the results shown in Table 7.

The analysis results showed that the total trade between Laos and Vietnam was affected by physical transport factors, such as international trade, which increased by 0.54% due to the rise in the percentage of paved roads by 1.00%, with a 95% significance level. The physical transport factor that impacted international trade was influenced by the nonphysical transport factors, such as the percentage of paved roads, which increased by 0.31%, 0.76%, and 0.34% when the shipment arrived on time, and the percentage of wage and salaried workers of total employment and tariff rates, which each increased by 1.00%, respectively. Moreover, the nonphysical factor was also impacted by the trade; for instance, the number of trade partners increased 0.08% when the export volume increased 1.00%. Additionally, the import and export volumes were also affected by the nonphysical and physical transport factors, such that the export volume increased 1.85% and 0.88% when the percentage of wage and salaried workers of total employment and the number of Mekong bridges each increased 1.00%, and the import volume increased 1.09% when the number of Mekong bridges increased 1.00%, but the import volume decreased 2.79% and 1.66% when the number of trade partners and the shipment on expected times each increased 1.00%.

Table 7: The Impact of Nonphysical and Physical Factors on the International Trade between Laos PDR and Vietnam

Structural	**Coef.**	**OIM Std. Err.**	**z**	**P>|z|**	**[95% Conf. Interval]**
LnPaved_Rd <-					
LnNo_Tr_Pn					
LnXpect_Tm	-.1005115	.1016507	-0.99	0.323	-.2997432 .0987203
LnWage_emp	.3093243	.1605614	1.93	0.054	-.0053702 .6240188
LnTariff	.7564585	.0846000	8.94	0.000	.5906456 .9222714
_cons	.3417842	.1153869	2.96	0.003	.1156300 .5679385
	-.8680727	.3676647	-2.36	0.018	-1.588682 -.1474631
LnIM_LAVN <-					
LnPaved_Rd	1.643672	1.114126	1.48	0.140	-.5399742 3.827318
LnNo_Tr_Pn	-2.795143	.2142401	-	0.000	-3.215046 -2.375240
LnXpect_Tm	-1.658829	.4254207	13.05	0.000	-2.492638 -.8250195
LnWage_emp	-1.023260	1.319393	-3.90	0.438	-3.609224 1.562703
LnNo_MK_Brdg	1.089643	.3596983	-0.78	0.002	.3846471 1.794639
LnTariff	.6906691	.5096011	3.03	0.175	-.3081307 .6894690
_cons	4.847957	1.29654	1.36	0.000	2.306785 7.389129
			3.74		
LnEX_LAVN <-					

Structural	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
LnPaved_Rd	.4409388	.7200366	0.61	0.540	-.970307	1.852185
LnWage_emp	1.851979	.8708282	2.13	0.033	.1451874	3.558771
LnNo_MK_Brdg	.8823305	.2301729	3.83	0.000	.4312000	1.333461
LnTariff	.4475330	.3162226	1.42	0.157	-.1722519	1.067318
_cons	-2.771664	.6823229	-4.06	0.000	-4.108993	-1.434336
LnNo_Tr_Pn <-						
LnEX_LAVN	.0804432	.0375835	2.14	0.032	.0067809	.1541054
_cons	1.898707	.0590245	32.17	0.000	1.783022	2.014393
LnXpect_Tm <-						
LnEX_LAVN	.138161	.1458081	0.95	0.343	-.1476177	.4239397
LnNo_MK_Brdg	-.360037	.2475688	-1.45	0.146	-.8452629	.1251889
_cons	1.505592	.2507842	6.00	0.000	1.014064	1.997120
LnTTrade_LAVN <-						
LnPaved_Rd	.5447159	.1238677	4.40	0.000	.3019396	.7874922
LnIM_LAVN	.4700044	.0182961	25.69	0.000	.4341447	.5058641
LnEX_LAVN	.4593068	.0200754	22.88	0.000	.4199599	.4986538
_cons	.5041645	.0468017	10.77	0.000	.4124349	.5958941

Sources: Laos' Statistic Department (2021) and STATA analysis.

5.4 Between Laos PDR and Cambodia

The SEM Model 8 has been used to test the hypothesis, clarifying the relationship between the nonphysical affected physical factor or the quality of transportation infrastructure which influenced international trade; The test of the overall goodness of model fitting was done for the purpose of performing the fitting statistic. The likelihood ratio is acceptable ($p > chi2$ of model versus saturated = 0.487, and $p > chi2$ of baseline versus saturated equals 0.000). The population error is good (root mean squared error of approximation (RMSEA) = 0.000 < 0.000). The information criteria are a good fit for the values of Akaike's information criterion (AIC) and Bayesian information criterion (AIC). The baseline comparison is good because the comparative fit index (CFI) and Tucker-Lewis Index (TLI) values are both very close to 1.00. Furthermore, the size of residuals is acceptable, as the value of the standardized root mean squared residual (SRMR = 0.086) is close to 0.000 and the coefficient of determination (CD = 0.923) is 1.00. Therefore, the model is significant, and the results shown in Table 8 .

The analysis results showed that the total trade between Laos and Cambodia was not directly impacted by the physical transport factors such as the percentage of pave roads and the number of Mekong bridges, but those physical factors impacted the import volume and influenced the total trade between Laos and Cambodia. With a 1.00% increase in import volume, the international trade between Laos and Cambodia increased by 0.27%, and it is not significant that the export volume impacts the total trade. Each 1.00% increase in the percentage of paved roads and the number of Mekong bridges increased the import volume from Cambodia by 25.15% and 2.71%, respectively. Furthermore, with each 1.00% increase in the percentage of wage and salaried workers in total employment, the shipment on expected times, and the tariff rate, the import volume decreased by 24.54%, 14.86%, and 15.17%, respectively. It is not significant that physical and nonphysical factors impacted the export volume. The physical transport factors were impacted by the trades and the nonphysical factors, such as each 1.00% increase in the percentage of wage and salaried workers in total employment and the tariff rate; the percentage of paved roads increased 0.84%, 0.28%, respectively, but a 1.00% increase of the total trade volume of Laos and Cambodia, the percentage of paved roads decreased by 0.04%, and the number of Mekong bridges

increased by 0.30% while the international trade of Laos and Cambodia increased by 1.00%. Additionally, the nonphysical factors were also impacted by the physical transport factors, such as the fact that the percentage of wage and salaried workers in total employment was increased by 0.38% when the number of Mekong bridges increased by 1.00% and the shipment on expected times decreased by 0.15%.

Table 8: The Impact of Nonphysical and Physical Factors on the International Trade between Laos PDR and Cambodia

Structural	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
LnWage_emp <-						
LnNo_MK_Brdg	.3863765	.0297075	13.01	0.000	.3281509	.444602
_cons	-.0003551	.0555253	-0.01	0.995	-.1091827	.108472
LnPaved_Rd <-						
LnWage_emp	.8377538	.0918057	9.13	0.000	.6578179	1.0176
LnTtrade_LAKH	-.0378287	.0132748	-2.85	0.004	-.0638468	-.011810
LnTariff	.2901544	.0977102	2.97	0.003	.098646	.481662
_cons	-.3642132	.2298035	-1.58	0.113	-.8146198	.086193
LnIM_LAKH <-						
LnWage_emp	-24.57306	3.579825	-6.86	0.000	-31.58939	-17.5567
LnPaved_Rd	25.17999	3.104714	8.11	0.000	19.09486	31.2651
LnNo_MK_Brdg	2.714779	.9910094	2.74	0.006	.772436	4.65712
LnXpect_Tm	-14.87751	1.899742	-7.83	0.000	-18.60094	-11.1540
LnTariff	-15.2783	1.444084	-10.58	0.000	-18.10865	-12.4479
_cons	54.23719	4.674469	11.60	0.000	45.0754	63.3989
LnNo_Tr_Pn <-	.4582111	.2662818	1.72	0.085	-.0636915	.980113
LnPaved_Rd	1.75421	.1527203	11.49	0.000	1.454884	2.05353
_cons						
LnEX_LAKH <-						
LnPaved_Rd	-5.435972	4.306949	-1.26	0.207	-13.87744	3.00549
LnNo_Tr_Pn	.7155241	.6665016	1.07	0.283	-.590795	2.02184
LnNo_MK_Brdg	2.429357	1.919806	1.27	0.206	-1.333394	6.19210
LnXpect_Tm	3.791396	3.033212	1.25	0.211	-2.153589	9.73638
_cons	1.549945	5.447156	0.28	0.776	-9.126284	12.2261
LnNo_MK_Brdg <-	.2925952	.0643572	4.55	0.000	.1664574	.41873
LnTtrade_LAKH	-.6723653	.5542578	-1.21	0.225	-1.758691	.4139
_cons						
LnXpect_Tm <-	.0303345	.0314711	0.96	0.335	-.0313478	.092016
LnIM_LAKH	-.1494411	.064954	-2.30	0.021	-.2767486	-.022133
LnNo_MK_Brdg	1.14118	.1517728	7.52	0.000	.843711	1.43864
_cons						
LnTtrade_LAKH <-						
LnIM_LAKH	.2672158	.0283163	9.44	0.000	.211717	.322714
LnEX_LAKH	.1554656	.6138281	0.25	0.800	-1.047615	1.35854
_cons	5.719565	5.11057	1.12	0.263	-4.296968	15.736

Sources: Laos' Statistic Department (2021) and STATA analysis.

5.5 Between Laos PDR and Myanmar

The SEM Model 9 has been used to test the hypothesis; the test of overall goodness of model fitting was done for the purpose of performing the fitting statistic. The likelihood ratio is good (p > chi2 of model versus saturated = 0.452, and p > chi2 of baseline versus saturated equals 0.000). The population error is good (root mean squared error of approximation (RMSEA) = 0.000 < 0.000). The information criteria are a good fit for the values of Akaike's information criterion (AIC) and Bayesian information criterion (AIC). The baseline comparison is good because the comparative fit index (CFI) and Tucker-Lewis Index (TLI) values are both very close to 1.00. Furthermore, the size of residuals is acceptable as the value of the standardized root mean squared

residual (SRMR = 0.062) is close to 0.000 and the coefficient of determination (CD = 1.00) is 1.00. Therefore, the model is significant, and the results shown in Table 9.

The analysis results showed that the total trade between Laos and Myanmar was affected by the physical transport infrastructure, which was influenced by nonphysical factors. The international trade among those nations increased by 3.25% due to the rise in the percentage of paved roads by 1.00%, with 95% significance, but the increase of Mekong bridges number did not affect the international trade. The physical transport factors were impacted by nonphysical factors such as: the number of paved roads significantly increased by 0.62% and 0.36% by the increasing 1.00% of the percentage of wage and salaried workers of total employment, and the tariff rate, respectively. Furthermore, the number of Mekong bridges increased by 2.48% when the percentage of wage and salaried workers of total employment increased by 1.00%. Moreover, the physical factor, such as the number of Mekong bridges also pulled the nonphysical factors, as the shipment on expected time decreased by 0.13% while the number of Mekong bridges increased by 1.00%. Additionally, the import and export volumes were also affected by the physical and nonphysical factors such as: the export volume increased 8.38%, 37.91%, 104.34%, and 33.73%; and decreased 18.54% and 60.27% when a 1.00% increase in the number of trade partners, the shipment on expected time, the percentage of wage and salaried workers of total employment, the percentage of tariffs, the number of Mekong bridges, and the percentage of paved roads, respectively. The import volume increased 4.31%, 1.52%, decreased 2.60%, 0.80%, and 0.38% while 1.00% increasing of the wage and salaried workers in total employment, the percentage of tariff, the percentage of paved roads, the number of trade partners, and the shipment on expected times, respectively.

Table 9: The Impact of Nonphysical and Physical Factors on the International Trade between Laos PDR and Myanmar

Structural	Coef.	OIM Std. Err.	z	P>|z|	[95% conf.	Interval]
LnNo_MK_Brdg <-						
LnWage_emp	2.475836	.1828319	13.54	0.000	2.117492	2.83418
_cons	.0803388	.1323468	0.61	0.544	-.1790562	.3397337
LnPaved_Rd <-						
LnWage_emp	.6218727	.0616466	10.09	0.000	.5010476	.7426977
LnTariff	.3583759	.097137	3.69	0.000	.1679908	.548761
_cons	-.6904693	.2357519	-2.93	0.003	-1.152535	-.228404
LnIM_LAMM <-						
LnPaved_Rd	-2.596355	.1587807	-16.35	0.000	-2.90756	-2.285151
LnNo_Tr_Pn	-.8039782	.0533344	-15.07	0.000	-.9085117	-.6994448
LnXpect_Tm	-.3822331	.094735	-4.03	0.000	-.5679104	-.1965559
LnWage_emp	4.309762	.1279346	33.69	0.000	4.059015	4.56051
LnTariff	1.515926	.0795713	19.05	0.000	1.359969	1.671883
_cons	5.32151	0.231752	22.96	0.000	4.867284	5.775735
LnEX_LAMM <-						
LnNo_MK_Brdg	-18.54039	2.457492	-7.54	0.000	-23.35699	-13.72379
LnPaved_Rd	-60.27538	7.472649	-8.07	0.000	-74.9215	-45.62925
LnNo_Tr_Pn	8.380813	2.614744	3.21	0.001	3.256009	13.50562
LnXpect_Tm	37.90582	4.726224	8.02	0.000	28.64259	47.16905
LnWage_emp	104.3437	8.4506	12.35	0.000	87.78087	120.9066
LnTariff	33.73215	3.700693	9.12	0.000	26.47892	40.98538
_cons	-136.338	10.8262	-12.59	0.000	-157.5569	-115.119
LnNo_Tr_Pn <-						
LnXpect_Tm	-1.032264	0.6544112	-1.58	0.115	-2.314886	0.2503583
_cons	3.08933	0.6831322	4.52	0.000	1.750415	4.428244

Structural	Coef.	OIM Std. Err.	z	P>|z|	[95% conf.	Interval]
LnTtrade_LAMM <-						
LnNo_MK_Brdg	-0.1005662	0.2255126	-0.45	0.656	-0.5425628	0.3414303
LnPaved_Rd	3.247649	1.025015	3.17	0.002	1.238657	5.25664
LnIM_LAMM	0.4585501	0.1665475	2.75	0.006	0.132123	0.7849772
LnEX_LAMM	0.0030671	0.0058674	0.52	0.601	-0.0084328	0.014567
_cons	2.908384	1.028218	2.83	0.005	0.8931135	4.923655
LnXpect_Tm <-						
LnNo_MK_Brdg	-0.1280832	0.039438	-3.25	0.001	-0.2053803	-0.0507861
_cons	1.277199	0.0738629	17.29	0.000	1.13243	1.421968

Sources: Laos' Statistic Department (2021) and STATA analysis.

5.6 Between Laos PDR and Australia

The SEM Model 10 has been used to test the hypothesis; the test of overall goodness of model fitting was done for the purpose of performing the fitting statistic. The likelihood ratio is good (p > chi2 of model versus saturated = 0.902 and p > chi2 of baseline versus saturated equals 0.000). The population error is good (root mean squared error of approximation (RMSEA) = 0.000). The information criteria are a good fitting for the values of Akaike's information criterion (AIC) and Bayesian information criterion (AIC). The baseline comparison is good because the comparative fit index (CFI) and Tucker-Lewis Index (TLI) values are both very close to 1.00. Furthermore, the size of the residuals is good, as the value of the standardized root mean squared residual (SRMR = 0.047) is close to 0.000 and the coefficient of determination (CD = 1.00) is 1.00. Therefore, the model is significant, and the results are shown in Table 10.

The analysis results showed that the international trade between Laos and Australia was affected by physical transport factors such as the quality of transport infrastructure or the percentage of paved roads. International trade among those nations increased by 5.59%, while the percentage of paved roads increased by 1.00%, with 95% of significance. The physical transport factors were impacted by nonphysical factors such as: the number of paved roads significantly increased by 0.28%, 0.96, and 0.19% by the increasing 1.00% of the shipment on expected times, the percentage of wage and salaried workers of total employment, and the tariff rate, respectively, but a 1.00% of the number of trade partners pulled down the percentage of paved roads by 0.12%. Moreover, 0.015% of paved roads were increased by the push of the export volume to 1.00%. Furthermore, the nonphysical factors were also impacted by the physical factors, such as: the shipment on expected time decreased by 0.16%, while there was a 1.00% increase in Mekong bridges numbers. Additionally, the import and export volumes were also affected by physical and nonphysical factors such as: expanding 1.00% paved roads increased the import by 9.13%; the import volume decreased 6.16% when a 1.00% shipment on expected time increased; and the export volume decreased 13.92% and increased 10.89% while the percentage of wage and salaried workers of total employment and the percentage of tariff increased 1.00%.

Table 10: The Impact of Nonphysical and Physical Factors on the International Trade between Laos PDR and Australia

Structural	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
LnPaved_Rd <-						
LnEX_LAAU	.0149345	.0036244	4.12	0.000	.0078308	.0220381
LnNo_Tr_Pn	-.1205882	.0552102	-2.18	0.029	-.2287982	-.0123783
LnXpect_Tm	.278184	.0939037	2.96	0.003	.0941362	.4622318
LnWage_emp	.9572792	.0673168	14.22	0.000	.8253407	1.089218

Structural	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
LnTariff	.1877646	.0783324	2.40	0.017	.034236	.3412932
_cons	-.6690967	.2239181	-2.99	0.003	-1.107968	-.2302252
LnEX_LAAU <-						
LnWage_emp	-13.91789	2.784713	-5.00	0.000	-19.37583	-8.45995
LnTariff	10.89096	4.84721	2.25	0.025	1.390604	20.39132
_cons	-9.425081	11.56223	-0.82	0.415	-32.08663	13.23646
LnNo_Tr_Pn <-						
LnXpect_Tm	-1.12207	.6903331	-1.63	0.104	-2.475099	.2309576
_cons	3.182968	.7205906	4.42	0.000	1.770637	4.5953
LnIM_LAAU <-						
LnPaved_Rd	9.125937	2.086728	4.37	0.000	5.036025	13.21585
LnXpect_Tm	-6.160503	1.651667	-3.73	0.000	-9.397711	-2.923294
LnNo_MK_Brdg	-.9656434	.5924541	-1.63	0.103	-2.126832	.1955452
_cons	7.830518	2.110372	3.71	0.000	3.694265	11.96677
LnTtrade_LAAU <-						
LnPaved_Rd	5.591581	1.281752	4.36	0.000	3.079393	8.103769
LnEX_LAAU	.6376645	.030784	20.71	0.000	.5773291	.698
LnIM_LAAU	-0.0862976	0.0984096	-0.88	0.381	-.2791769	0.1065816
LnNo_MK_Brdg	-0.532615	0.324073	-1.64	0.100	-1.167786	0.1025564
LnTariff	-4.116852	0.6321213	-6.51	0.000	-5.355787	-2.877917
_cons	10.87065	1.312336	8.28	0.000	8.298523	13.44278
LnXpect_Tm <-						
LnEX_LAAU	-0.0059269	0.0070189	-0.84	0.398	-.0196837	0.0078298
LnNo_MK_Brdg	-0.1576545	0.0571332	-2.76	0.006	-.2696335	-0.0456755
_cons	1.364049	0.1357013	10.05	0.000	1.098079	1.630018

Sources: Laos' Statistic Department (2021) and STATA analysis.

5.7 Between Laos PDR and Japan

The SEM Model 11 has been used to test the hypothesis; the test of overall goodness of model fitting was done for the purpose of performing the fitting statistic. The likelihood ratio is good (p > chi2 of model versus saturated = 0.930 and p > chi2 of baseline versus saturated equals 0.000). The population error is good (root mean squared error of approximation (RMSEA) = 0.000). The information criteria are a good fit for the values of Akaike's information criterion (AIC) and Bayesian information criterion (AIC). The baseline comparison is good because the comparative fit index (CFI) and Tucker-Lewis Index (TLI) values are both very close to 1.00. Furthermore, the size of the residuals is good, as the value of the standardized root mean squared residual (SRMR = 0.064) is close to 0.000 and the coefficient of determination (CD = 0.998) is 1.00. Therefore, the model is significant, and the results are shown in Table 11.

The analysis results showed that the international trade between Laos and Japan as a whole was affected by the import and export volumes, which were pushed by the physical and nonphysical transport factors, with 95% significance, such as: international trade between Laos and Japan increased by 0.42% when the export volume increased by 1.00%, and international trade increased by 0.60% when there was a 1.00% increase in import volume. Those increases were influenced by the nonphysical and physical transport infrastructures. For instance, the export factor increased 1.00% by the increase of the Mekong bridges number by 1.39%, the import volume increased 1.00% by the increase of the percentage of paved roads, and the number of trade partners by 0.22% and 0.94%, respectively, but the import decreased 1.00% by the increase of the shipment on expected times and the tariff rate by 0.15% and 0.37%, respectively. Furthermore, the physical transport infrastructure was also impacted by nonphysical factors. The percentage of paved roads increased by 0.75% and 0.34% when the percentage of wage

and salaried workers in total employment and the tariff rate increased by 1.00%, respectively. Additionally, the export volume increased by 1.00%, and the number of trade partners increased by 0.16%.

Table 11: The Impact of Nonphysical and Physical Factors on the International Trade between Laos PDR and Japan

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf. Interval]	
Structural						
LnPaved_Rd <-						
LnNo_Tr_Pn	-.1052018	.1028172	-1.02	0.306	-.3067197	.0963162
LnXpect_Tm	.2981344	.1679703	1.77	0.076	-.0310813	.6273502
LnWage_emp	.7545046	.0853239	8.84	0.000	.5872728	.9217364
LnTariff	.3411086	.1156215	2.95	0.003	.1144947	.5677224
_cons	-.8440445	.3811246	-2.21	0.027	-1.591035	-.097054
LnIM_LAJP <-						
LnPaved_Rd	4.537181	1.590551	2.85	0.004	1.419757	7.654604
LnNo_Tr_Pn	1.059581	.309052	3.43	0.001	.4538499	1.665311
LnXpect_Tm	-6.569332	.6595786	-9.96	0.000	-7.862082	-5.276582
LnWage_emp	-1.264233	.98746	-1.28	0.200	-3.199619	.671153
LnNo_MK_Brdg	-.6018969	.4450675	-1.35	0.176	-1.474213	.2704195
LnTariff	-2.729227	.4232652	-6.45	0.000	-3.558811	-1.899642
_cons	12.47052	1.416178	8.81	0.000	9.694865	15.24618
LnNo_Tr_Pn <-						
LnEX_LAJP	.1588001	.0628507	2.53	0.012	.035615	.2819851
_cons	1.74491	.10874	16.05	0.000	1.531784	1.958037
LnEX_LAJP <-						
LnPaved_Rd	.6085105	1.29605	0.47	0.639	-1.931701	3.148722
LnNo_MK_Brdg	.7212921	.3217758	2.24	0.025	.0906231	1.351961
_cons	.0239067	.3200347	0.07	0.940	-.6033499	.6511632
LnTtrade_LAJP <-						
LnPaved_Rd	.00975	.0649382	0.15	0.881	-.1175266	.1370266
LnIM_LAJP	.6044162	.0123901	48.78	0.000	.580132	.6287004
LnEX_LAJP	0.4164132	0.0170784	24.38	0.000	0.3829401	0.4498862
LnNo_MK_Brdg	-0.0356781	0.020316	-1.76	0.079	-0.0754968	0.0041407
_cons	0.7045856	0.0164193	42.91	0.000	0.6724044	0.7367667

Sources: Laos' Statistic Department (2021) and STATA analysis.

5.8 Between Laos PDR and Germany

The SEM Model 12 has been used to test the hypothesis; the test of overall goodness of model fitting was done for the purpose of performing the fitting statistic. The likelihood ratio is good ($p > chi2$ of model versus saturated = 0.914 and $p > chi2$ of baseline versus saturated equals 0.000). The population error is good (root mean squared error of approximation (RMSEA) = 0.000). The information criteria are a good fit for the values of Akaike's information criterion (AIC) and Bayesian information criterion (AIC). The baseline comparison is good because the comparative fit index (CFI) and Tucker-Lewis Index (TLI) values are both very close to 1.00. Furthermore, the size of the residuals is good, as the value of the standardized root mean squared residual (SRMR = 0.044) is close to 0.000 and the coefficient of determination (CD = 0.999) is 1.00. Therefore, the model is significant, and the results are shown in Table 12.

The analysis results showed that the international trade between Laos and Germany was directly affected by nonphysical transport factors but not by physical factors, with 95% significance. However, the physical factors impacted a part of the import and export volumes and then influenced the international trade, such as the percentage of paved roads increased by1.00%, the import volume increased by 3.16%, the export volume increased by 0.51% when the number of Mekong bridges increased by 1.00% affecting the increase in the import volume. The physical factors were

impacted by the nonphysical factors, such as the percentage of paved roads increased by 0.72% and 0.31% when the percentage of wage and salaried workers of total employment and the tariff rate increased by 1.00% and 1.00%, respectively, and the 1.00% increase in the percentage of wage and salaried workers of total employment impacted the number of Mekong bridges increased by 2.48%. Furthermore, the physical transport factor also impacted the nonphysical factor, as the shipment on expected times decreased by 0.13% with a 1.00% increase in the Mekong bridges number. Additionally, the physical and nonphysical transport factors directly impacted the import and export volumes, such as the export volume increased by 1.66% and 0.93% while the number of trade partners and the tariff rate increased by 1.00%, respectively, and a 1.00% increase of the shipment on expected times, then the import volume decreased by 2.60%.

Table 12: The Impact of Nonphysical and Physical Factors on the International Trade between Laos PDR and Germany

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
Structural						
LnNo_MK_Brdg <-						
LnWage_emp	2.475836	.1828319	13.54	0.000	2.117492	2.83418
_cons	.0803387	.1323468	0.61	0.544	-.1790562	.3397337
LnPaved_Rd <-						
LnXpect_Tm	.2907001	.1620427	1.79	0.073	-.0268977	.608298
LnWage_emp	.7165279	.0744323	9.63	0.000	.5706433	.8624126
LnTariff	.3076526	.1141027	2.70	0.007	.0840155	.5312897
_cons	-.9450766	.3778094	-2.50	0.012	-1.685569	-.2045837
LnEX_LAGM <-						
LnNo_MK_Brdg	.5083606	.1614682	3.15	0.002	.1918887	.8248325
LnNo_Tr_Pn	1.655257	.6714202	2.47	0.014	.3392971	2.971216
LnTariff	.9321779	.323409	2.88	0.004	.298308	1.566048
_cons	-2.391022	1.142614	-2.09	0.036	-4.630504	-.151539
LnTtrade_LAGM <-						
LnPaved_Rd	-.0275433	.1280288	-0.22	0.830	-.2784751	.2233885
LnEX_LAGM	.6436578	.0390811	16.47	0.000	.5670603	.7202554
LnIM_LAGM	.2600135	.0297412	8.74	0.000	.2017218	.3183053
LnNo_Tr_Pn	.3214251	.1223664	2.63	0.009	.0815914	.5612588
_cons	.3389282	.1407548	2.41	0.016	.0630538	.6148026
LnXpect_Tm <-						
LnNo_MK_Brdg	-.1280832	.039438	-3.25	0.001	-.2053803	-.0507861
_cons	1.277199	.0738629	17.29	0.000	1.13243	1.421968
LnIM_LAGM <-						
LnPaved_Rd	3.164923	.66176	4.78	0.000	1.867897	4.461949
LnXpect_Tm	-2.600699	.939943	-2.77	0.006	-4.442953	-07584444
_cons	3.710947	1.227472	3.02	0.003	1.305145	6.116749

Sources: Laos' Statistic Department (2021) and STATA analysis.

5.9 Between Laos PDR and India

The SEM Model 13 has been used to test the hypothesis; the test of overall goodness of model fitting was done for the purpose of performing the fitting statistic. The likelihood ratio is good ($p > chi2$ of model versus saturated = 0.633 and $p > chi2$ of baseline versus saturated equals 0.000). The population error is good (root mean squared error of approximation (RMSEA) = 0.000). The information criteria are a good fit for the values of Akaike's information criterion (AIC) and Bayesian information criterion (AIC). The baseline comparison is good because the comparative fit index (CFI) and

Tucker-Lewis Index (TLI) values are both very close to 1.00. Furthermore, the size of the residuals is good, as the value of the standardized root mean squared residual (SRMR = 0.034) is close to 0.000 and the coefficient of determination (CD = 0.999) is 1.00. Therefore, the model is significant, and the results are shown in Table 13.

The analysis results showed that the international trade between Laos and India was directly affected by both nonphysical and physical factors, with 95% significance. The international trade increased 1.28% when the paved road increased 1.00%, but while the number of Mekong bridges increased 1.00% and the tariff rate increased 1.00%, the international trade decreased 1.24% and 1.96%, respectively. The physical factors that impacted international trade were also affected by the nonphysical factors, such as the percentage of paved roads, which increased 0.42%, 0.50%, and 0.87% when the tariff rate, the shipment on expected times, and the percentage of wage and salaried workers of total employment each increased by 1.00%, but the percentage of paved roads increased 0.26% while the number of trading partners increased by 1.00%. However, the physical factors were not affected by nonphysical transport factors. Furthermore, the import volumes and the export volumes were impacted by the physical and nonphysical transport factors, such as the export volumes increased by 26.73% when the percentage of wage and salaried workers in total employment increased by 1.00%, and the export decreased by 21.87% while the percentage of paved roads increased by 1.00%, and the import volumes increased by 6.79% when the percentage of paved roads increased by 1.00%. Additionally, the nonphysical factor as the shipment on expected times decreased by 0.07% while the import volumes increased by 1%.

Table 13: The Impact of Nonphysical and Physical Factors on the International Trade between Laos PDR and India

	Coef.	**OIM Std. E rr.**	**z**	**P>|z|**	**[95% Conf. Interval]**	
Structural						
LnPaved_Rd <-						
LnNo_Tr_Pn	-.2639349	.0948972	-2.78	0.005	-.4499299	-.0779398
LnTariff	.4250985	.132453	3.21	0.001	.1654954	.6847015
LnXpect_Tm	.4967373	.1356212	3.66	0.000	.2309248	.7625499
LnWage emp	.8660394	.0972993	8.90	0.000	.6753363	1.056743
_cons	-1.001593	.327844	-3.06	0.002	-1.644155	-.3590304
LnEX_LAID <-						
LnPaved_Rd	-21.87217	3.664922	-5.97	0.000	-29.05528	-14.68905
LnWaqe_emp	26.73062	4.778019	5.59	0.000	17.36587	36.09536
LnNo_Mx_Brdg	2.366641	1.446748	1.64	0.102	-.4689331	5.202215
_cons	-4.72535	.7998386	-5.91	0.000	-6.293005	-3.157695
LnNo_Tr_Pn <-						
LnEX_LAID	-.0155088	.0108742	-1.43	0.154	-.0368219	.0058044
LnXpect_Tm	-2.218362	1.087941	-2.04	0.041	-4.350686	-.0860375
_cons	4.421512	1.171632	3.77	0.000	2.125156	6.717869
LnTtrade_LAID <-						
LnPaved_Rd	1.285042	.5252125	2.45	0.014	.2556441	2.314439
LnEX_LAID	.4436368	.019816	22.39	0.000	.4047982	.4824754
LnTariff	-1.961286	.4134549	-4.74	0.000	-2.771643	-1.150929
LnIM_LAID	.4967609	.0349545	14.21	0.000	.4282513	.5652705
LnNo_MK_Brdg	-l.23708	.1252314	-9.88	0.000	-1.482529	- .9916314
_cons	7.749399	.9160658	8.46	0.000	5.953943	9.544855
LnTariff <-						
LnNo_MK_Brdg	-.0273173	.0603963	-0.45	0.651	-.1456919	.0910573
_cons	2.325706	.1131154	20.56	0.000	2.104004	2.547408
LnIM LAID <-	6.792984	1.439939	4.72	0.000	3.970755	9.615214
LnPaved_Rd	3.43036 9	.8250837	4. 16	0.000	1.813235	5.047504
_cons						

	Coef.	OIM Std. E rr.	z	P>|z|	[95% Conf. Interval]	
LnXpect_Tm <-						
LnIM_LAID	-.0719121	.0238097	-3.02	0.003	-.1185783	-.0252459
_cons	1.56527	.1738672	9.00	0.000	1.224497	1.906044

Sources: Laos' Statistic Department (2021) and STATA analysis.

5.10 Between Laos PDR and South Korea

The SEM Model 14 has been used to test the hypothesis; the test of overall goodness of model fitting was done for the purpose of performing the fitting statistic. The likelihood ratio is good (p > chi2 of model versus saturated = 0.866 and p > chi2 of baseline versus saturated equals 0.000). The population error is good (root mean squared error of approximation (RMSEA) = 0.000 < 0.050). The information criteria are a good fit for the values of Akaike's information criterion (AIC) and Bayesian information criterion (AIC). The baseline comparison is good because the comparative fit index (CFI) and Tucker-Lewis Index (TLI) values are both very close to 1.00. Furthermore, the size of the residuals is acceptable, as the value of the standardized root mean squared residual (SRMR = 0.08) is close to 0.000 and the coefficient of determination (CD = 0.924) is 1.00. Therefore, the model is significant, and the results are shown in Table 14.

The analysis results showed that the international trade between Laos and South Korea was directly affected by the physical transport factors, which were impacted by the nonphysical factors, with 95% significance, such as when the international trade decreased by 0.15% and the percentage of paved roads increased by 1.00%. The physical transport factors were impacted by nonphysical factors such as the roads being paved by 0.43%, 0.76%, and 0.40% when the shipment arrived on time, the percentage of wage and salaried workers of total employment, and the tariff rates each increasing by 1.00%, respectively. Furthermore, the nonphysical transport factors were also impacted by the trade, as the shipment on expected times decreased 0.10% when the export volume increased 1.00%. Additionally, the import volume was impacted by the physical factor since the import volume increased by 0.77% when the number of Mekong bridges increased by 1.00%.

Table 14: The Impact of Nonphysical and Physical Factors on the International Trade between Laos PDR and South Korea

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf. Interval]	
Structural						
LnPaved_Rd <-						
LnXpect_Tm	.4316007	.1275094	3.38	0.001	.181687	.6815145
LnWage_emp	.756273	.0736692	10.27	0.000	.6118841	.9006619
LnTariff	.3961209	.0786202	5.04	0.000	.2420281	.5502137
_cons	-1.32142	.3185691	-4.15	0.000	-1.945804	-.6970362
LnNo_Tr_Pn <-						
LnPaved_Rd	-.3884837	1.738904	-0.22	0.823	-3.796674	3.019706
LnXpect_Tm	-1.647109	3.317318	-0.50	0.620	-8.148933	4.854714
_cons	3.949835	4.417895	0.89	0.371	-4.70908	12.60875
LnEX_LAKR <-						
LnPaved_Rd	7.653873	5.782169	1.32	0.186	-3.678969	18.98672
LnNo_Tr_Pn	-8.140747	10.57285	-0.77	0.441	-28.86315	12.58166
LnNo_MK_Brdg	.447565	2.191131	0.20	0.838	-3.846973	4.742103
_cons	14.87197	18.96692	0.78	0.433	-22.30251	52.04645
LnIM_LAKR <-						

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
LnNo_MK_Brdg	.7667492	.2520494	3.04	0.002	.2727414	1.260757
_cons	4.959124	.4720598	10.51	0.000	4.033904	5.884344
LnTtrade_LAKR <-						
LnPaved_Rd	-.1522174	.0725197	-2.10	0.036	-.2943533	-.0100814
LnEX_LAKR	.0679203	.0034406	19.74	0.000	.0611769	.0746638
LnIM_LAKR	.9328539	.0054097	172.44	0.000	0.9222511	.9434567
LnNo_MK_Brdg	.0214657	.017393	1.23	0.217	-0.012624	.0555555
_cons	.3046294	.0370625	8.22	0.000	0.2319882	.3772706
LnXpect_Tm <-						
LnEX_LAKR	-.0987982	.0428045	-2.31	0.021	-.1826934	-.014903
_cons	1.401021	.1560903	8.98	0.000	1.09509	1.706953

Sources: Laos' Statistic Department (2021) and STATA analysis.

5.11 Between Laos PDR and United State

The SEM Model 15 has been used to test the hypothesis; the test of overall goodness of model fitting was done for the purpose of performing the fitting statistic. The likelihood ratio is good ($p > chi2$ of model versus saturated = 0.570 and $p > chi2$ of baseline versus saturated equals 0.000). The population error is good (root mean squared error of approximation (RMSEA) = 0.000 < 0.050). The information criteria are a good fit for the values of Akaike's information criterion (AIC) and Bayesian information criterion (AIC). The baseline comparison is good because the comparative fit index (CFI) and Tucker-Lewis Index (TLI) values are both very close to 1.00. Furthermore, the size of the residuals is good, as the value of the standardized root mean squared residual (SRMR = 0.053) is close to 0.000 and the coefficient of determination (CD = 0.965) is 1.00. Therefore, the model is significant, and the results are shown in Table 15.

The analysis results showed that the international trade between Laos and the United States as a whole was not directly affected by the physical transport factors, which influenced by the nonphysical factors, but the physical factors impacted import and export volumes, forwarding the impact on the international trade between Laos and the United States, with 95% significance, such as when the international trade increased 0.39% and 0.69% when the import volume and the export volume each increased by 1.00%, respectively. The import volume increased by 1.00%, the percentage of paved roads increased by 0.18%, and/or the number of trade partners increased by 0.40%. The export volume increased 1.00% when the number of Mekong bridges increased by 0.48%, the number of trade partners increased by 0.50%, the shipment on expected times increased by 0.13%, and the tariff rates increased by 0.35%, but the export volume decreased 1.00% while the percentage of paved roads increased by 1.18%. Furthermore, the physical factors were impacted by the nonphysical factors, such as when the percentage of wage and salaried workers of total employment in Laos increased 1.00% then the percentage of paved roads and the number of Mekong bridges increased 0.71% and 2.55%, respectively, and the percentage of pave roads increased 0.31% while the tariff rates increased 1.00%. Additionally, the international trade between Laos and the United States 1.00% affected the physical factor as the number of trade partners increased 0.18%.

Table 15: The Impact of Nonphysical and Physical Factors on the International Trade between Laos PDR and United State

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf. Interval]	
Structural						
LnWage_emp <-						
LnTtrade_LAUS	-.2660799	.8939272	-0.30	0.766	-2.018145	1.485985
_cons	1.728113	3.430946	0.50	0.614	-4.996416	8.452643
LnNo_MK_Brdg <-						
LnWage_emp	2.546033	.2540376	10.02	0.000	2.048128	3.043937
_cons	.030701	.1818848	0.17	0.866	-.3257867	.3871887
LnPaved_Rd <-						
LnWage_emp	.7068713	.0971501	7.28	0.000	.5164606	.897282
LnXpect_Tm	.3212441	.1956318	1.64	0.101	-.0621872	.7046753
LnTariff	.3067874	.11875	2.58	0.010	.0740417	.5395331
_cons	-.9681265	.4405911	-2.20	0.028	-1.831669	-.1045838
LnNo_Tr_Pn <-						
LnTtrade_LAUS	.176677	.03892	4.54	0.000	.1003952	.2529588
LnXpect_Tm	-.3109695	.2220972	-1.40	0.161	-.746272	.1243331
_cons	1.659321	.2397578	6.92	0.000	1.189405	2.129238
LnIM_LAUS <-						
LnPaved_Rd	5.390755	.8694809	6.20	0.000	3.686604	7.094907
LnNo_Tr_Pn	2.499145	.8946257	2.79	0.005	.745711	4.252579
_cons	-5.131925	1.688273	-3.04	0.002	-8.44088	-1.822971
LnEX_LAUS <-						
LnNo_MK_Brdg	2.063245	.2765476	7.46	0.000	1.521222	2.605268
LnPaved_Rd	-5.625026	.7924371	-7.10	0.000	-7.178175	-4.071878
LnNo_Tr_Pn	1.991368	.4048917	4.92	0.000	1.197795	2.784941
LnXpect_Tm	7.545756	.8937816	8.44	0.000	5.793976	9.297536
LnTariff	2.832338	.3821096	7.41	0.000	2.083417	3.581259
_cons	-15.74911	1.930844	-8.16	0.000	-19.5335	-11.96473
LnTtrade_LAUS <-						
LnIM_LAUS	.3932719	.0634498	6.20	0.000	.2689127	.5176312
LnEX_LAUS	.6861453	.0869573	7.89	0.000	.5157122	.8565785
_cons	.5019247	.3140526	1.60	0.110	-.1136071	1.117456
LnXpect_Tm <-						
LnIM_LAUS	-.0495132	.0604334	-0.82	0.413	-.1679604	.0689341
_cons	1.188424	.1788329	6.65	0.000	.8379176	1.53893

Sources: Laos' Statistic Department (2021) and STATA analysis.

5.11 Between Laos PDR and United Kingdom

The SEM Model 16 has been used to test the hypothesis; the test of overall goodness of model fitting was done for the purpose of performing the fitting statistic. The likelihood ratio is good ($p > chi2$ of model versus saturated = 0.720 and $p > chi2$ of baseline versus saturated equals 0.000). The population error is good (root mean squared error of approximation (RMSEA) = 0.000 < 0.050). The information criteria are a good fit for the values of Akaike's information criterion (AIC) and Bayesian information criterion (AIC). The baseline comparison is good because the comparative fit index (CFI) and Tucker-Lewis Index (TLI) values are both very close to 1.00. Furthermore, the size of the residuals is acceptable, as the value of the standardized root mean squared residual (SRMR = 0.085) is close to 0.000 and the coefficient of determination (CD = 0.910) is 1.00. Therefore, the model is significant, and the results are shown in Table 16.

The analysis results showed that the international trade between Laos and the United Kingdom was directly affected by the physical transport factors, which were

influenced by the nonphysical factors, with 95% significance, such that the international trade decreased 32.01% and 3.63% when the percentage of paved roads and the number of Mekong bridges each increased 1.00%. These physical factors were influenced by nonphysical factors such as the percentage of paved roads, which increased 0.41% when the percentage of wage and salaried workers in total employment increased by 1.00% but decreased 0.24% when the percentage of shipment on time increased by 1.00%, and the number of Mekong bridges increased by 2.67% when the number of trading partners increased by 1.00%. Furthermore, the physical factor also affected the nonphysical factor; for instance, a 1.00% increase in the Mekong bridges number pushed the percentage of wage and salaried workers in total employment up by 0.31%, and the shipment on expected times decreased by 0.28%. Additionally, the import volume and the export volume were impacted by physical and nonphysical transport factors. For instance, a 1.00% increase in paved roads influenced an 8.29% increase in import volumes and decreased the export volume by 16.99%; the export volume increased 3.37% when the number of Mekong bridges increased by 1.00%; the export volume increased 0.78% and 0.281% when the number of trade partners and the tariff rates each increased 1.00%, respectively.

Table 16: The Impact of Nonphysical and Physical Factors on the International Trade between Laos PDR and United Kingdom

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
Structural						
LnWage_emp <-						
LnPaved_Rd	.3750663	.2031939	1.85	0.065	-.0231865	.7733191
LnNo_MK_Brdg	.3063343	.0517956	5.91	0.000	.2048167	.4078519
_cons	-.0656391	.0528133	-1.24	0.214	-.1691513	.0378732
LnPaved_Rd <-						
LnWage_emp	.4152101	.1726133	2.41	0.016	.0768943	.7535259
LnNo_MK_Brdg	.0355219	.0885736	0.40	0.688	-.1380792	.209123
LnXpect_Tm	-.2450742	.1138996	-2.15	0.031	-.4683133	-.0218352
_cons	.4617067	.1635837	2.82	0.005	.1410886	.7823248
LnNo_Tr_Pn <-						
LnTtrade_LAGB	.1492374	.0950221	1.57	0.116	-.0370026	.3354774
_cons	1.453912	.3567643	4.08	0.000	.7546664	2.153157
LnNo_MK_Brdg <-						
LnNo_Tr_Pn	2.668286	1.284484	2.08	0.038	.1507435	5.185829
_cons	-3.540246	2.587834	-1.37	0.171	-8.612306	1.531815
LnEX_LAGB <-						
LnPaved_Rd	-16.99876	5.123252	-3.32	0.001	-27.04015	-6.957367
LnNo_Tr_Pn	.7786535	.2959297	2.63	0.009	.198642	1.358665
LnNo_MK_Brdg	3.366009	1.250096	2.69	0.007	.9158664	5.816151
LnTariff	2.812422	.5376163	5.23	0.000	1.758713	3.86613
_cons	-1.109609	1.64087	-0.68	0.499	-4.325655	2.106438
LnTtrade_LAGB <-						
LnPaved_Rd	-32.00712	11.8727	-2.70	0.007	-55.27718	-8.737051
LnNo_MK_Brdg	-3.629118	1.469215	-2.47	0.014	-6.508727	-.7495092
LnEX_LAGB	1.708409	.4193581	4.07	0.000	.886482	2.530336
LnIM_LAGB	6.234164	1.354205	4.60	0.000	3.579971	8.888358
_cons	10.02916	5.093195	1.97	0.049	.0466778	20.01163
LnXpect_Tm <-						
LnPaved_Rd	.5621177	.386102	1.46	0.145	-.1946283	1.318864
LnNo_MK_Brdg	-.2774594	.1003536	-2.76	0.006	-.4741489	-.08077
_cons	1.233219	.103374	11.93	0.000	1.03061	1.435828

	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf. Interval]	
LnIM_LAGB <-						
LnPaved_Rd	8.292386	1.057965	7.84	0.000	6.218813	10.36596
LnXpect_Tm	.1516955	.0976721	1.55	0.120	-.0397383	.3431293
LnTariff	-.4507158	.2610933	-1.73	0.084	-.9624494	.0610178
_cons	-1.795439	.8627538	-2.08	0.037	-3.486405	-.1044728

Sources: Laos' Statistic Department (2021) and STATA analysis.

6. Conclusions and Policy Inferences

The development of transport infrastructure in Laos PDR is primarily based on the ASEAN Economic Corridor or Great Mekong Subregion Economic Corridor (GMS Economic Corridor), also called the North-South and East-West Economic Corridors. In the past ten years, most of the North-South Corridor routes have been completely upgraded and/or under construction to ASEAN Highway Standard, such as National Road No. 3 (NR 3) or AH3, connecting Thailand, Laos PDR, and the southern regions of China (Kunming); AH132 or NR 18, Savannakhet-Xeno-Deansavanh; and AH16 or NR 9, connecting Thailand, Laos (Savannakhet), and Vietnam. It also links the South China Sea and the Andaman Sea; AH11 or NR 13S and NR 13N from north to south of Laos PDR; AH13 or NR 2W, Bandarn (Muanggnuen)-Pakbeng-Oudomxay. However, several East-West Corridor routes still require upgrading to meet the ASEAN Highway Standard, such as AH131 or national route no. 12, connecting Thailand, Laos (Khammouan), and Vietnam; and AH15, or NR 8, connecting Thailand, Laos (Nakhonphanom-Ban Lao), and Vietnam. To support the country's land-link policy, Laos PDR will also need to build, upgrade, and restore land transport infrastructure, as well as create a comprehensive transportation service network in the nine logistics hubs or dry ports. This will involve connecting the local transport infrastructure to the Laos-China railway, the ASEAN route network, the Singapore-Kunming Rail Link, and regional and global networks (Trans-Asian Railway). Together with moving forward the Vientiane Capital (Laos)-Thakhek-Vung Ang (Vietnam) and the Thakhek-Muya (Laos-Viet Nam border) railways, inland water transport along the Mekong River and the Heuang River. In addition, airports and aviation facilities should be constructed and improved to ensure safety and security in accordance with international standards. Furthermore, the Vung Ang Sea Port Projects in Vietnam must be improved for an efficient and comprehensive maritime transport system, as well as to increase regional competition. All roads need to be updated to international standards and smart levels by 2030.

The chance for Laos to develop smart transportation infrastructure is feasible. Laos is a landlocked country, so raising the level can boost Laos' economy. The Laos government has been attempting to recover from investment constraints and the country's sensitive macroeconomic climate. However, some of the following paths regarding transportation may be required to achieve the desired outcomes:

Firstly, upgrade several national highways that are part of the ASEAN Highway to meet the ASEAN Highway Standard, especially, infrastructure such as signals systems, equipment, early warning systems or internet application, etc. just make up a smart level. The data and analysis show in detail that most important variable is distance, so the neighbours are 95% for Thailand, China, and Vietnam. But the road of trade flows from ASEAN to China just via Thai, Laos or Vietnam. So national highways are an important part of these roads.

Secondly, continue to connect all transportation means together. Especially infrastructure of different transportation modes. Build local roads connecting the local economic development zones to the Laos-China railway, allowing local products to reach both domestic and international markets while also strengthening local agriculture (local people, businesses, and industry) and tourism. With the help of China, Laos has a high-speed railway that will be expanded and connected to Cambodia, Thailand, and Vietnam. It is good for both commodities and passengers. The results of Thailand increasing 4 times in exports if Mekong bridges connect the two countries.

Thirdly, improve logistic services by lowering costs, increasing reliability, ensuring that shipments arrive on time, ensuring that the Work Bank's Logistic Performance Index (LPI) improves year after year, and matching neighbouring countries that perform best in LPI, such as Thailand and Vietnam. The best way is equipped with a modern infrastructure system for transportation. Furthermore, Laos' government should sign more bilateral agreements for the transportation of agricultural goods between Laos PDR and its neighbours, especially the GMS nations.

Fourth, enhance the effectiveness of the current dry ports (Thanaleng, Savannakhet), as well as the development of the remaining seven dry ports and other inland container deports (ICD), prioritizing these efforts in accordance with the marketing regions and existing transportation infrastructure (road, rail, water, and air transport). The logistics hub is very important to Laos because the direction between Thailand, Cambodia, and Vietnam via Laos needs a logistics service that Laos can do in ICD, Laos. Furthermore, other partners request sufficient logistics hubs in Laos for the allocation and distribution of commodities.

Fifth, develop grand plan for the development of multimodal transportation. Including the land preserved for underground transportation or pipeline transportation in the city for future development. Due to public investment constraints, the Laos government may seek to expand opportunities through public-private partnerships (PPP). With the help from USA, Germany, France, Japan, and Australia needs to use multimodal transportation but these service in Laos is not good enough but Laos Government do not have enough money to invest. The best way is only public-private partnerships.

Sixth, pushing digital transformation for all transportation infrastructure including signals system, internet app or others document for transportation. It is very important to change to smart level if all customers, service provider and government can connect via digital systems. Logistics service providers have to digital transformation as soon as possible. The feasible transportation system is digital and internationally. The ASEAN highway or high-speed railway need digital control and synchronized international level. Almost road needs to be shown AH (Asean highway) in their countries event Laos PDR.

References

Bialynicka-Birula, J. (2015). Modelling international trade in art – Modified gravity approach. *Procedia Economics and Finance*, *30*, 91-99. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3838894.

Duc, D.A, Loi, V.T, Dung, C.C, Tuan, T.Q, & Huu, V.L. (2020). A new integrated generalized multi-criteria group decision making approach for green supplier selection. *Uncertainty Supply Chain Management Magazine, 8* (2020), 813–820.

Evans, C.L., & Harrigan, J. (2003). Distance, time and specialization. *National Bureau of Economic Research Working Paper* No. 9729. Retrieved from https//: www.nber.org/papers/w9729.

Global Energy Monitor (2022, July 15). *Hon La- Thakek Oil Pipeline.* Retrieved from https://www.gem.wiki/Hon_La-Thakhek_Oil_Pipeline/.

Hummels, D., Ishii, J., & Yi, K.-M. (2001). The nature and growth of vertical specialization in world trade. *Journal of International Economics*, *54* (1), 75-96.

Kim, B., Kyophilavong, P., & Bouthchanthalath, S. (2013). *Effects of road access on household production, expenditure and savings in rural areas: Based on the rural survey of Vientiane Province in Lao PDR*. Retrieved from https://www.econ.shiga-u.ac.jp/risk/10/2/3/res.9/DPA5Kim201302.pdf

Laos Statistic Bureau (2020). *Statistical Yearbook*. Retrieved from https://www.lsb.gov.la/

Laos Statistic Bureau (2021). *Statistical Yearbook* Retrieved from https://www.lsb.gov.la/

Loi V.T, Lanh B.T, Huong N.T.X, Duc T.T, Nga N.T, Ngoc N.B, Cuong M.T, & Ngoc N.M. (2020). *Greening seafood export supply chain in Vietnam to 2030*. Report code KX445. Retrieved from https://khoahoc.neu.edu.vn/vi/ket-qua-nghien-cuu/thong-tin-ket-qua-nghien-cuu-ma-so-b2019-kha-37-pgs-ts-ta-van-loi

Loi V.T, Nhuong B.H, Dung C.C, Dung D.T, & Duc D.A. (2020). Green supply chain management practice of FDI companies in Vietnam. *Journal of Asian Finance, Economics, and Business*, *7* (10), 1025-1034.

Ministry of Planning and Investment of Laos PDR (2020). *The ninth national social and economic development plan of Lao PDR*. Retrieved from https://data.laos.opendevelopmentmekong.net/

Ministry of Planning and Investment of Lao PDR (2010). *The seventh national social and economic development plan of Lao PDR* 2011-2015. Retrieved from https://policy.asiapacificenergy.org/sites/default/files/7thSEDP20112015.pdf

Ministry of Planning and Investment of Lao PDR (2005). *The sixth national social and economic development plan of Lao PDR 2006-2010*. Retrieved from https://faolex.fao.org/docs/pdf/lao158893.pdf

Ministry of Public Works and Transport of Lao PDR (2020). *The country public works, and transport development plan for five years 2021-2025 and vision 2030*. Retrieved from https://drive.google.com/file/d/1Th6dfLeh0KEX-zvGXaQE9cL80b3fzTa1/view?usp=drive_link

Oraboune, S. (2008). Infrastructure (rural road) development and poverty alleviation. *Institute of Developing Economies Discussion Paper* No. 151. Retrieved from https://www.researchgate.net/publication/5141160.

Phadouangdeth, O., Phommason, S., Kyophilavong, P., & Sayvaya, I. (2013). The impact of road on poverty reduction in Lao PDR. *International Journal of Economics and Empirical Research*, *1* (11), 125-134.

The Association of Southeast Asian Nations – ASEAN (2017). *ASEAN Transport Development*. Retrieved from https://asean.org/wp-content/uploads/2017/10/ASEAN-Transport-Development-1.pdf

The Laotian Time (2022, July 15). *Laos to link to Vietnamese oil pipeline*. Retrieved from https://laotiantimes.com/2017/05/22/laos-link-vietnamese-oil-pipeline/.

The state council information office, The People's Republic of China (2024, June 6). *The belt and road initiative progress, contributions and prospects*. Retrieved from https://eng.yidaiyilu.gov.cn/p/86739.html

UNCTAD (2003). *World investment report 2003 – FDI policies for development: National and international perspectives*. Retrieved from https://unctad.org/system/files/official-document/wir2003_en.pdf

Warr, P. (2010). Differentials activation of judgments in employee well-being. *Journal of Occupational and Organizational Psychology, 79*(2), 225-244.

World bank (2020). *From landlocked to land-linked: Unlocking the potential of Lao-China rail connectivity.* Retrieved from https://documents1.worldbank.org/curated/en/648271591174002567/pdf/Main-Report.pdf.

Yeaple, S.R. & Golub, S.S. (2007). International productivity differences, infrastructures, and comparative advantage. *Review of International Economics, 15*(2), 223-242.