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Original research article

Analysis of Freight Modal Shift Potential on Railway Infrastructure Development for Cross-Border Trade under the Belt and Road Initiative Strategy

Klairung Ponanan*, Sirikarn Chansombat

Faculty of Logistics and Digital Supply Chain, Naresuan University, Phitsanulok 65000, Thailand

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ABSTRACT

The Chinese government has developed transport infrastructure rapidly under the Belt and Road Initiative (BRI) strategy. The development of transportation infrastructure has been affected by the transportation aspect of ASEAN countries, especially Thailand. Therefore, this study aims to forecast the freight transportation demand of each mode that will be shifted from the existing transportation mode to the railway mode, specifically in the case of a potential new railway route that can link to the China-Laos railway. A questionnaire was used to collect the data for the 180 samples, which sample group consists of entrepreneurs who are related to freight transportation. Then the Mode Choice Model was generated to forecast freight transportation demand, which is the route that can be connected with the China-Laos railway. The results show that the mode shift of freight transportation is separated into 2 sub-models for the decision-making of entrepreneurs on transportation mode, which consist of (1) entrepreneurs who invest in transportation infrastructure by themselves, and (2) entrepreneurs who do not invest in transportation infrastructure by themselves. The group of entrepreneurs belonging to the (1) sub-model will not change the current transportation mode to rail mode on the railway route due to their investment cost of the infrastructure, which this supposed to be energy products. In the group of entrepreneurs that belongs to (2) sub-model, some entrepreneurs will change the current transportation mode to rail mode on the railway route, which this supposed be to the consumer products.

Keywords: Belt and Road Initiative (BRI); Chaina-Laos railway; Freight transportation; Modal shift model

***Corresponding author:** klairungp@nu.ac.th
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1. Introduction

In 2013, Xi Jinping President of the People's Republic of China [1] introduced the strategy of trade routes know as the Silk Road Strategy. This strategy had previously achieved success in terms of expanding trade influence and promoting cultural exchange. Therefore, the Silk Road Strategy has been planned to increase China's trade volume. The Silk Road Strategy was improved in order to enhance China's trade volume and cultural impact, and renamed the Belt and Road Initiative (BRI) Strategy. The BRI strategy is a framework for the regional economic development of China. It consists of two main sub-strategies: 1) the Silk Road Economic Belt and 2) the Maritime Silk Road. On the one hand, the land-based connections would utilize roads and railways that originate from China through Central Asia, West Asia, South Asia, Southeast Asia, and Central and Eastern Europe. On the other hand, the maritime routes would connect from the Chinese seas, heading southward and then westward, linking China with Southeast Asia, South Asia, and Africa [2].

In 2017, the People's Republic of China initiated the land connectivity strategy under the Belt and Road Initiative (BRI) strategy by opening a railway route for trade linking Yiwu City in China to London, England, and other European countries. This route spans over 12,000 kilometers and takes a transportation time of approximately 18 days. This route is the longest railway route for freight transportation in the world [3]. However, the People's Republic of China is still processing to construct a transportation route network, i.e., a high-speed railway network in order to connect to the European network, and regular speed trains to connect all regions. This China-Laos Railway project is one of the railway projects under the BRI strategy with a construction cost of 6 billion US dollars, covering a distance of over 427 kilometers. The China-Laos railway has been in operation since the end of 2021 [4]. The project aligns with Thailand's ongoing development of railway routes connecting Bangkok to various regions, such as the Bangkok-Chiangmai railway route spanning 672 kilometers, and the Bangkok-Nongkhai railway route covering 615 kilometers [5]. The Bangkok-Nongkhai railway route will link with the China-Laos railway route in Nongkhai province.

The development of freight transportation routes under the BRI strategy has impacted the transportation network of countries in the ASEAN region, especially Thailand. The positive impact is in elevating livelihood and stimulating private sector investment. Although there is no direct route passing through Thailand, it is still anticipated to benefit from assisting in the restructuring of industries, developing infrastructure, and boosting the Thai economy. Thailand's geographical location at the center of ASEAN enables it to establish connections with various countries within and outside the region. In addition, the construction project of the Bangkok-Nongkhai railway route is a feasible option for connecting to the Laos-China railway, which supports a freight transportation route between countries under the BRI strategy. Therefore, the main contribution of this study is in forecasting the freight transportation of each mode that will be shifted from the existing transportation mode to the railway mode, specifically in the case of a potential new railway route that can link to the China-Laos railway.

2. Research Background

2.1 Belt and road initiative strategy

The Belt and Road Initiative (BRI) is a strategy for transportation and logistics connectivity in the 21st century, led by the People's Republic of China. The initiative was proposed by Chinese President Xi Jinping during his visit to Indonesia as part of an ASEAN tour in late 2013. The goal is to strengthen relationships with neighboring countries, demonstrate non-threatening intentions towards any country, and build confidence in the security and stability of China's land and sea trade routes. The BRI will be a route that extends both overland and overseas, with the endpoint of the overland route being Europe and the endpoint of the maritime route also being Europe. The BRI consists of two main components:

2.1.1 The silk road economic belt

This is a land transportation route that will connect China and Europe, similar to the ancient Silk Road. This route is connected by China's high-speed railway network, which extends into Central and Eastern Asia, passing through countries such as Kazakhstan, Iran, and Turkey, and entering Europe through major cities such as Frankfurt, Venice, and Amsterdam, all of which are important trade, industrial, and port cities in the world.

2.1.2 The maritime silk road

This is a sea transportation route that is increasingly recognized as a major sea route in the 21st Century Maritime Silk Route Economic Belt. The Maritime Silk Road starts from important Chinese ports such as Xiamen, Tianjin, and Fuzhou. Then this route connects to the countries of ASEAN, crossing the Strait of Malacca, the Indian Ocean and entering the central and eastern parts of the Pacific via the Gulf of Persia to reach the Mediterranean Sea, with the ultimate goal of reaching Europe.

Fig. 1. Belt and Road Initiative Route (Source: https://niice.org.np/archives/8127, retrieved May 9, 2023).

The economic belt under the Belt and Road Initiative (BRI) consists of six economic corridors, which are as follows:

1. China-Mongolia-Russia Economic Corridor (CMREC) is a high-speed railway and road route that is divided into two routes:
   (1) Beijing-Tianjin-Hebei-Mongolia-Russia,
   (2) Dalian-Chita, Russia.
2. New Eurasian Land Bridge (NELB) is an economic corridor that originates at Lianyungang in Jiangsu Province, China, and ends in Rotterdam in Western Europe. It is expected to be a land transportation route for goods from China to Europe. This transcontinental transport route and economic corridor consists of four railway routes:
   (1) Chongqing Duisburg, Germany,
   (2) Wuhan-Munich-Pardubice, Czech,
   (3) Chengdu-Lodz, Poland, and
   (4) Zhengzhou, Hamburg, Germany.
3. China-Central Asia-West Asia Economic Corridor (CCWAEC) is a key transport route for oil and natural gas from the

Arabian Sea, Turkey, and Iran to Xinjiang Region, China.
4. China-Pakistan Economic Corridor (CPEC)
5. Bangladesh-China-India-Myanmar Economic Corridor (BCIMEC) originates from Xinjiang Uygur Autonomous Region of China to Gwadar Port in Pakistan.
6. China-Indochina Peninsula Economic Corridor (CIPEC) connects the Pearl River Delta Economic Zone (PRD) with member countries of the Mekong River sub-region through three high-speed railway routes:
(1) Kunming-Yuxi- Hanoi-Ho Chi Minh-Phnom Penh-Bangkok-Kuala Lumpur-Singapore,
(2) Kunming-Dali-Yangon-Bangkok-Kuala Lumpur-Singapore, and
(3) Kunming-Yuxi-Vientiane-Bangkok-Kuala Lumpur-Singapore.

In this study, the Silk Road Economic Belt is considered for analyzing the freight modal shift potential on land transportation infrastructure development for cross-border trade. Due to the Lao-China railway infrastructure, this railway route can be a connecting route of freight transportation between South-East Asia countries, China, and other regional countries.

"The Vientiane-Boten railway is a part of the Kunming-Singapore multi-country rail network (or "Pan-Asia Railway"). The Kunming-Singapore multi-country rail network is an anchor investment by the Chinese government's Belt and Road initiative strategy (BRI). The Kunming Singapore rail link was adopted at the 1995 ASEAN summit. The rail network has been proposed to be the backbone of the transportation infrastructure network for the China-Indochina Economic corridor, one of six defined economic main corridors for the BRI strategy. The Vientiane-Boten railway will be part of the central rail link in the Southeast Asia railway network, a direct route from Kunming to Singapore via Vientiane, Lao PDR, and Bangkok, Thailand" [6].

2.2 Freight transportation volume

The freight transportation volume of Thailand is considered based on the National Model (NAM), which the data is adjusted for the year 2019. It was found that the road transportation mode had the highest volume of transportation, 686,223,374 tons per year, accounting for 83.19% of total transportation. Maritime and railway transportation modes had volumes of transportation of 128,270,901 tons and 10,317,310 tons per year, respectively, representing 15.55% and 1.25% of total transportation. The air transportation mode had the lowest volume of all transportation modes, with 55,967 tons per year, accounting for 0.0068% of total transportation. These findings are presented in Table 1 and Fig. 2.

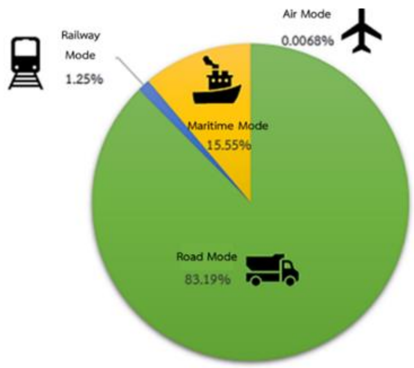
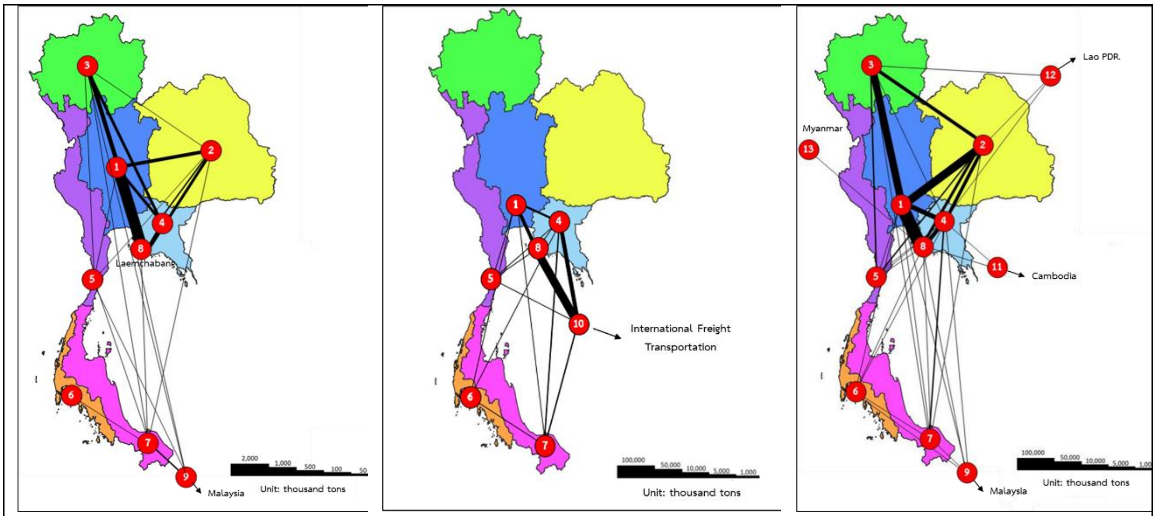


Fig. 2. Proportion of freight transportation volume, 2019 (Source: Office of Transport and Traffic Policy and Planning (OTP), 2020).

Table 1. Thailand Freight Transportation Volume, 2019.

Transportation Mode	Transportation Volume (tons per year)	Domestic Transportation Volume (million tons -km. per year)	Distance (km.)
Road Mode	686,223,374	126,951	185.00
Railway Mode	10,317,310	2,075	201.11
Maritime Mode	128,270,901	22,460	175.10
Air Mode	55,967	35	629.50
Total	824,867,552	151,552	184.13

Source: Office of Transport and Traffic Policy and Planning, 2020



(a) Distribution of freight volume via railway mode | (b) Distribution of freight volume via maritime mode | (c) Distribution of freight volume via road mode

Fig. 3. Distribution of freight transportation volume, 2019 (Source: Office of Transport and Traffic Policy and Planning (OTP), State Railway of Thailand, and Marine Department).

2.3 Previous research

Borut Zgonc et al. [7] studied the impact of distance on mode choice for freight transportation on choosing between intermodal railroad and unimodal road transport. The break-even distances for freight transport were analyzed by using a Monte Carlo simulation. The result found the importance of distance for the mode choice and showed there is not only one but in fact many break-even distances between the two options. They vary considerably depending on different travel plans, and the transport infrastructure conditions.

Xinfang Zhang et al. [8] analyzed the spatial patterns and factors influencing international container multimodal hubs under the Belt and Road initiative. There are 12 factors that were selected to analyze by using SEM models. The result of this study shows that each factor has significant spatial heterogeneity with respect to connectivity distribution, especially turnover volume of freight transport (TFT) and fixed assets investment of transportation/ logistics/ warehouse (FAI) that have the most significant positive impact.

HJ Schramm and X Zhang [9] evaluated the development of Eurasian rail freight in the Belt and Road Initiative Era in terms of transit times and transport costs compared to other transport modes in containerized supply chains between Europe and China. Based on cargo type, the modal choice was separated into 4 scenarios, i.e., Scenario I: High-value cargo with high time sensitivity, Scenario II: High-value cargo with low time sensitivity, Scenario III: Low-value cargo with high time sensitivity, and Scenario IV: Low-value cargo with low time sensitivity. The result found that Eurasian rail freight service fits into the sweet spot between the sea and air; it is about 80% cheaper than air with only half of the transit time of conventional sea. Moreover, when shipping time-sensitive goods with cargo values ranging from 1.23 USD/kg to 10.78 USD/kg, rail is cheaper than all other modes of transport and much faster than sea - the same is valid for goods with lower time sensitivity ranging from 2.46 USD/kg to 21.78 USD/kg.

3. Conceptual Framework for Forecasting Shifted Mode of International Freight Transportation

The forecasting freight transportation demand of the target product representatives consists of 1) energy products such as petroleum products and coal, and 2) consumer goods including vegetables and fruits, fresh garlic, and frozen chicken parts.

The forecasting of freight transportation demand has many procedures. Statistical data on import-export quantities, Gross Domestic Product (GDP), and economic growth rates of the member countries along the Silk Road Economic Belt routes under the BRI Strategy are reviewed. In addition, data on product movements of the National Model (NAM) has been investigated by reviewing the study on the Travel Demand Freight Movement Survey for National Transport Planning project [10]. The transportation database for national transport system planning is investigated as well [11]. Then collected data is adjusted to closely match the data obtained from surveys and gathered from a sample group of relevant entrepreneurs. Subsequently, the forecasting freight transportation demand of the target product representatives is calculated based on the adjusted data, incorporating growth rates of international freight transportation and the utilization of traditional transport modes that have the potential to connect to the Lao-China railway. Finally, the Shifted Mode of target product representatives is estimated based on existing transportation modes and the Lao-China railway modes that can connect to member countries along the Silk Road Economic Belt routes under the BRI Strategy.

In this study, the forecasting of international trade volume refers to the prediction of cross-border and transshipment freight transportation resulting from trade activities. These activities require transportation services and impose a burden on the infrastructure in Thailand. The forecasting of international freight transportation volume in each mode has been analyzed by using a cross-border trade model. This model simulates the behavior of trade interactions based on the principle that countries with larger market sizes and higher levels of economic development tend to engage in higher volumes of international trade, including imports and exports. The volume of cross-border and transshipment trade between Thailand and neighboring countries depends on various factors, such as market size and level of economic development.

3.1 Market size

It is a factor that represents the demand of the market. The variables commonly consist of population size and country area. The market size has a positive relationship with the volume of international trade, which means in trading partner countries with a large population, there will be a higher demand for goods.

3.2 Level of economic development

The factors commonly used to represent the level of economic development include Gross Domestic Product (GDP) or GDP per capita. These factors are representative of purchasing power which has a positive relationship with the volume of trade. It assumes that the average income of the trading partner country is high, and there will be a higher demand for goods.

In addition, other factors influence international trade volume, such as transportation costs. Transportation cost is a factor of trade barriers, which have a negative relationship with international trade volume. On the one hand, countries with high transportation costs often have lower trade volumes. Common factors related to transportation costs consist of transportation time, distance, and cost. Besides, trade regulations also play a role, such as countries with high tariff barriers leading to higher product costs, which will reduce demand for goods, and countries with strict customs regulations resulting in longer transportation times. These factors contribute to indirect trade costs.

The principle for developing the forecasting model is Parsimony, which refers to using the minimum number of independent variables that can still provide a good representation in the forecasting model. The development of cross-border transportation forecasting models has different characteristics of each border checkpoint, i.e., physical, economic, and social characteristics. It is necessary to have data at the local, regional, and national levels. Due to limitations in data availability across different areas and various factors in neighboring countries, this study will focus on developing the forecasting model at the national level. The forecasting model can be used to forecast future freight transportation volume by utilizing the derived rates of change from the forecasting model at the national level to predict the transportation of goods for each border checkpoint. The international trade data such as the quantity or weight of goods are used as dependent variables. International trade values are reliable and accurately recorded in the customs department's database. In this study, the forecasting international freight transportation model is presented in Eq. (3.1).

$$\text{Import}_{ij} \text{ or } \text{Export}_{ij} = b_0 + b_1 Pop_i + b_2 Pop_j + b_3 GDP_i + b_4 GDP_j + \cdots, \quad (3.1)$$

where i = Exporting country, j = Importing country, Export = Value of exports (million baht), Pop = Number of population (million people), GDP = Gross Domestic Product (billion USD), Density = Population density (people per square kilometer), Income = Average income of the population (USD per year).

4. Materials and Methods

The mode choice model has been used to analyze freight transportation in each mode; the origin of freight transportation is defined as Thailand. Therefore, the sample of this study consists of Thai entrepreneurs who are related to international freight transportation. There are 3 methods in this study, as follows:

4.1 Data collection

Firstly, secondary data has been used in this study; modes of international freight transportation are reviewed. Then the primary data has been used as well, that is international freight transportation demand. The international freight transportation demand is collected by surveying via the questionnaire. The scope of the scenarios in the questionnaire were defined, i.e., Thailand as the origin country and China as the destination country, in order to connect to the infrastructure of the Belt and Road Initiative (BRI) strategy along routes that link Thailand with member countries under the BRI strategy.

4.2 Sample size

The target product representatives are selected based on analyzing secondary data, i.e., value and quantity. The target product representatives must be importing and exporting products, which have the destination countries in the ASEAN region, as well as opportunities for connecting the transportation of raw materials and goods to member countries under the BRI strategy. In this study, the questionnaire has been used to collect data from Thai entrepreneurs who are relevant to importing and exporting products with a sample size of 180 samples. The sample group was selected by using the purposive sampling technique.

4.3 Mode choice model

The demand for international freight transportation has been forecasted by using the target product representatives' data. In this study, a mode choice model is applied for forecasting the demand for existing transportation modes, which consist of maritime, road, and air modes with the new railway mode that is the Lao-China railway. The Lao-China railway was developed by the Chinese government under the BRI strategy. The aim of the Lao-China railway is to connect freight transportation by using railway mode to European countries. Thailand is the neighboring country of Lao PDR and the northern part and north-eastern parts of Thailand have borders with Lao PDR. Moreover, the railway route of Thailand can connect to the Lao-China railway through Nongkhai Province.

In a mode choice model, a utility function is a mathematical representation that quantifies the preferences or utility individuals assign to different transportation modes when making travel choices. It captures the factors that influence mode choice decisions and assigns a numerical value to each alternative based on its attractiveness or desirability. The utility function typically includes various variables such as travel time, cost, comfort, reliability, accessibility, environmental considerations, and personal preferences. These variables are weighted based on their perceived importance and combined to calculate the overall utility or attractiveness of each transportation mode. The utility equation can be expressed as Eq. (4.1) [12- 14].

$$U_{in} = V_{in} + \varepsilon_{in}, \quad (4.1)$$

where U_{in} = utility of alternative i for decision makers n, V_{in} = deterministic utility function of modes i for the individual n, ε_{in} = random error (random error) or stochastic component and a particular distribution function.

This utility is defined as functions in the model as shown in Eq. (4.2).

$$V_{in} = \beta_0 + \beta_1 X_{in1} + \beta_2 X_{in2} + \cdots + \beta_n X_{ink}, \quad (4.2)$$

where $\beta_0, \beta_1, \beta_2, \ldots, \beta_n$ are parameters or constants that are obtained from modeling $X_1, X_2, \ldots, X_k$ are variables that are related to the utility of the i of n persons.

Due to the uncertain utility value, it is not possible to determine with certainty which alternative will provide the highest utility. However, it can be expressed in terms of probabilities that alternative i in a set of all alternatives of individual n will choose the highest utility alternative. This can assume that utility follows Eq. (3.1) with the set of alternatives denoted as C_n, the probability of individual n choosing option i from set C_n can be obtained as specified in Eq. (4.3)

$$\mathrm{P}_n(i) = \mathrm{Prob}\left(U_{in} \geq U_{in} : \forall j \in C_n, i \neq j\right), \quad (4.3)$$

5. Results and Discussion

This section presents the results of the mode choice model's analysis. Based on Section 3, the Linear Regression model has been employed in the forecasting international freight transportation model by verifying the significance level of each independent variable using t-tests. If a variable has a significance level greater than 0.05 or 0.10, and/or it has a valid +/- sign, it can effectively explain the relationship. These significant independent variables will be included in the international freight transportation forecasting model, while other variables that do not meet the aforementioned criteria will be excluded. The result of the international freight transportation forecasting model is shown in Table 2.

Table 2. The forecasting international trade value from Thailand to Lao PDR. and China.

International Trade Value	Country	2019	2022	2027	2032	2037
Value of exports (million baht)	People's Republic of China	914,562	1,148,894 (4.67%)	1,588,388 (6.69%)	2,177,878 (6.52%)	2,967,145 (6.38%)
	Lao PDR.	150,610	207,822 (6.65%)	270,677 (5.43%)	339,732 (4.65%)	415,599 (4.11%)
Value of exports (million baht)	People's Republic of China	1,513,889	2,000,376 (5.73%)	2,618,950 (5.54%)	3,369,806 (5.17%)	4,290,337 (4.95%)
	Lao PDR.	66,894	106,272 (9.70%)	162,392 (8.85%)	246,709 (8.72%)	373,387 (8.64%)

Note: Values in parentheses refer to percentage change per year.

In this study, the volume of transported goods is examined due to a shifted mode of international transportation, specifically focusing on the target product representatives that have the potential to transition to railway mode along the Laos-China railway route. The two scenarios under consideration are (1) a shift from road mode to railway mode and (2) a shift from maritime mode to railway mode.

A simple model of the forecasting shifted mode of international freight transportation is used. The model verifies the accuracy assessment by using face validation through additional interviews with relevant entrepreneurs. The interviews employed purposive sampling to select representative entrepreneurs from the target product representatives for capturing the behaviors of transportation mode selection. The two target product representatives are 1) energy products and 2) consumer products. A simplified model for selecting transportation modes consists of two sub-models, as shown in Figs. 4-5:

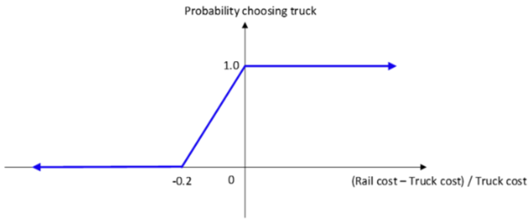


Fig. 4. The model for products for which entrepreneurs are not investing in their own transportation infrastructure.

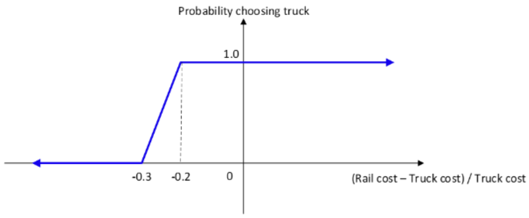


Fig. 5. The model for products for which entrepreneurs are investing in their own transportation infrastructure.

Table 3. Cost of transportation and transshipment per unit.

Transportation Mode	Value of Time (baht/ton/minute)	Shipping rate per distance (baht/ton/kilometre)	Handing Cost (baht/ton)
Road Mode	0.14	1.47	-
Railway Mode	0.14	0.95	80
Maritime Mode	0.14	0.26	64

Table 4. Forecasting shifted mode of international freight transportation.

Year	**Product**	**Shifted mode of international freight transportation volume (ton/year)**			
		Total	**Road Mode**	**Railway Mode**	**Railway Mode (%)**
2022	Energy products	64,849,080	64,276,477	572,603	0.88
	Consumer products	28,765,645	28,704,319	61,326	0.21
2027	Energy products	71,480,817	70,853,271	627,546	0.88
	Consumer products	31,894,765	31,605,504	289,260	0.91
2032	Energy products	79,914,562	79,216,954	697,608	0.87
	Consumer products	35,876,023	35,203,818	672,204	1.87
2037	Energy products	89,739,600	88,964,269	775,331	0.86
	Consumer products	40,408,855	39,398,078	1,010,777	2.50
2042	Energy products	101,499,449	100,617,737	881,712	0.87
	Consumer products	45,862,361	44,427,104	1,435,257	3.13

The proposed sub-models for capturing the behaviors of transportation mode selection have found that energy products are suitable for the model for products for which entrepreneurs are investing in their own transportation infrastructure, and consumer products are suitable for the model for products that entrepreneurs are not investing in their own transportation infrastructure. Based on the results, that can agree with Xinfang Zhang et al. [8], who conducted a study on "connectivity-based spatial patterns and factors influencing international container multimodal hubs in China under the Belt and Road initiative". The results indicated that turnover volume of freight transport (TFT) and fixed assets investment of transportation/ logistics/ warehouse (FAI) are factors that have the most significant positive impact on international container multimodal hubs. Borut Zgonc et al. [7] studied "the impact of distance on mode choice in freight transport". Findings of the Monte Carlo simulation, the result revealed the importance of distance for the mode choice and showed there is not only one but in fact many break-even distances between the two options. They vary considerably depending on different travel plans, and the transport infrastructure conditions. In addition, HJ Schramm and X Zhang [9] evaluated the development of Eurasian rail freight in the Belt and Road Initiative Era in terms of transit times and transport costs compared to other transport modes in containerized supply chains between Europe and China . The results of this research align with the analysis of the model of the forecasting shifted mode of international freight transportation, which is that Eurasian rail freight service fits into the sweet spot between the sea and air; it is about 80% cheaper than air with only half of the transit time of conventional sea mode.

6. Conclusion

The aim of this study is to analyze freight modal shift potential on railway infrastructure development for cross-border trade, i.e., the China-Lao railway. A simple model of the forecasting shifted mode of international freight transportation is used for calculating the volume of transportation that will be shifted from traditional mode to railway mode. The two target product representatives are 1) energy products and 2) consumer products. A simplified model for selecting transportation modes consists of two sub-models.

1) The model for products is that entrepreneurs are not investing in their own transportation infrastructure. This model is similar to the model used in the study of the master plan of railway network development to support special economic zones tourism and area development [10]. The difference between the models is that entrepreneurs will choose railway transportation mode when the overall transportation costs are lower than road or maritime transportation mode by 20%. However, the cost of choosing a railway transportation mode differs by less than 20% from other modes; the proportion of railway transportation mode will gradually decrease until it reaches zero when the cost of road or maritime transportation mode equals the cost of rail transportation mode. This model is often applied to consumer products.

2) The model is for products for which entrepreneurs are investing in their own transportation infrastructure. This model differs from the 1) model where entrepreneurs have not invested in their own infrastructure. In this model, entrepreneurs will select railway transportation when the overall transportation costs are lower than road or maritime transportation modes by 30%. However, the cost of selecting a railway transportation mode differs by less than 20% from other transportation modes, the proportion of selecting the railway transportation mode will gradually decrease until it reaches zero when the cost of the road or maritime transportation modes equals the cost of rail transportation mode. Additionally, if the cost of selecting other modes is less than 20% of the cost of selecting the rail transportation mode, entrepreneurs will not select the rail transportation mode due to sunk costs the entrepreneurs have invested in their existing infrastructure, such as port terminals transportation vehicles and equipment. This model is often applied to energy-related products, such as petroleum products and coal.

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