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FACTORS AFFECTING THE ROAD FREIGHT TRANSPORT COST IN THE MIDDLE-INCOME COUNTRY IN ASEAN

Jarun Bootdachi[1*], Phathairat Pongpratead [2]

[1,2] Department of Business Administration, Faculty of Interdisciplinary Studies, Khon Kaen University, Thailand

Correspondence: E-mail: jarunbo@kku.ac.th[1]

A B S T R A C T

This study aims to examine the determinants influencing road freight transport costs in a middle-income ASEAN country. It utilizes secondary data from government sources concerning road freight transport costs, logistics sector employee expenses, export-import volume indices, transport energy prices, and road freight transport indices from 2015 to 2022 in Thailand to formulate the mathematical model. The analysis employs Correlation Analysis and Multiple Regression Analysis, with road freight transport costs as the dependent variable and other factors as independent variables. The results indicate that most variables have the positive impacts on road freight transport costs. However, factors such as Employee Cost, Import Volume Index, Road Freight Transport Index for lorries, Public Infrastructure Budget, Vehicle Equipment Price Index, and Communication Services exhibit the negative effects on transport costs, influenced by the specific national context and the COVID-19 pandemic. Notably, three significant predictors including Vehicle Price Index, Road Freight Transport Index for Hazardous Materials Trucks, and Public Infrastructure Budget emerge as critical areas for policymakers. Addressing these factors could help the policy makers optimize road freight transport costs in Thailand.

Keyword: Road Freight Transport Cost, Employee cost, Export-Import Volume Indexes,

1. INTRODUCTION

In contemporary business practices, firms increasingly concentrate on their core competencies to maximize profits and achieve a competitive advantage that ensures long-term sustainability (Siagian & Santosa, 2023; Sterk *et al*., 2021; Falciola *et al*.,2020; Gamache *et al*., 2020). Concurrently, less critical processes are often outsourced to third-party providers, who assume responsibility for these tasks at a cost controlled by the client firms (Sternberg *et al*., 2023; Kulembayeva *et al*., 2022; Rintala *et al*., 2021). For instance, many production companies now rely on freight transport providers to handle distribution. These providers not only deliver products to customers but also offer tracking capabilities, often at a reduced cost compared to the companies' previous in-house operations (Creazza et al., 2024; George et al., 2023; Huma et al., 2020; Joseph & Wilson, 2018). Consequently, while road freight transport is increasingly outsourced, there remains a need to further reduce freight transport costs to enhance overall profitability for firms.

According to the 2022 Gross Domestic Product (GDP) report for Thailand, logistics costs accounted for approximately 14% of GDP (Office of the National Economic and Social Development Council, 2023). Of this, transportation activities represented about 7% of GDP, equating to 32.4 billion USD. Within the transportation sector, road freight transport was the most significant, comprising 3.3% of GDP and dominating with 80% of the freight transport market share in Thailand. Despite a 30% increase in the energy price index in 2021, the volume of road transport continued to grow at an approximate rate of 0.84% (Office of the National Economic and Social Development Council, 2022). Therefore, it is evident that research aimed at improving road freight transport is crucial for enhancing Thailand's national economy. In the past, there have many research articles that studied topics relating the freight transport cost as follows.

To begin with the studies focusing on government policies, Osborne *et al.* (2014) investigated the factors contributing to the high road freight costs in Central Africa. Their research analyzed how specific policies and selective factors impact transportation prices. The findings indicate that government policies have the potential to significantly lower costs while simultaneously enhancing operational efficiency. This study is corroborated by Austin (2015) and Erjavec *et al.* (2014), Austin (2015) explored the relationship between the external costs and the freight transport costs, and Erjavec *et al.* (2014) compared road and rail freight transport costs in Slovenia. Both studies also observed that the development of transportation modes and infrastructure was predominantly influenced by the government sector.

Nocera *et al.* (2018) explored external alternatives for reducing freight transport costs within corridor areas. Their study focused on external costs beyond the control of individual firms and investigated various strategies to mitigate these costs. They found that policymakers play a crucial role in influencing external factors and freight transport costs. Consequently, it can be concluded that government policies significantly impact transportation prices by supporting infrastructure improvements, which in turn affect the operational efficiency of transport providers.

Continuing with research related to energy consumption, Havenga (2015) analyzed freight logistics cost reductions in South Africa amidst high oil prices. Their study assessed logistics costs and identified key factors for developing cost-reduction strategies. They discovered that transportation costs were influenced by client expectations and that oil prices were a major driver of these costs. Moreover, they noted that oil prices were subject to extreme internationalization and dependent on public support policies. This finding is consistent with [19], which reported that logistics firms faced increasing pressures due to rising oil prices, necessitating operational improvements to manage costs rather than allowing abrupt cost increases. Thus, it can be argued that oil prices have a significant relationship with transport costs, particularly in relation with transport energy.

Regarding the freight transport cost model and infrastructure, Izadi *et al.* (2019) developed a comprehensive model for road freight transport costs. Their work involved a review of existing literature and the construction of a cost structure model based on relevant factors using activity-based costing, statistics, and data mining techniques. In parallel, Kaszubowski (2019) examined the factors affecting freight transport costs within the local government sector by developing a cost model grounded in both functionality and theoretical considerations. The results of these studies indicated that freight transport costs are associated with behavioral logistics operations, the characteristics of freight trips, and operational networks influenced by provincial organizations. Additionally, various factors impacting these costs were found to be determined by local government decisions.

Building on this, Persyn *et al.* (2019) estimated road transport costs across European Union countries by analyzing a dataset of road transport information to approximate the costs associated with freight transport for various products. This study corroborates the findings of Izadi *et al.* (2019) and Kaszubowski (2019), highlighting that investment in infrastructure and upgrades to road transport systems significantly impact road transport costs. They noted that such infrastructure investments are typically financed by the government sector. Consequently, it can be reaffirmed that there is a relationship between government involvement and freight transport costs, particularly through the enhancement of infrastructure.

In examining road freight transport cost and competitiveness, Kedzior-Laskowska (2019) and Subiyanto & Suyoto (2020) explored the interplay between economic conditions, service quality, and market competitiveness. Kedzior-Laskowska (2019) investigated the factors influencing road freight transport services, while Subiyanto & Suyoto (2020) focused on the logistics costs within the cement industry in Indonesia, emphasizing the procurement process.

Methodologically, Kedzior-Laskowska (2019) identified key factors impacting road freight services, and Subiyanto & Suyoto (2020)] assessed and monitored procurement activities, noting their impact on logistics costs. Subiyanto & Suyoto (2020) supported Tsekeris (2022) findings by highlighting that competitive practices within procurement, including qualified staff and professional processes, significantly influence freight transport costs.

Chen et al. (2020) investigated various factors affecting road freight transport in China, focusing on the interplay between vehicles, competition, market demand, and freight transport costs. Their study built upon the work of Subiyanto & Suyoto (2020) by highlighting those factors such as overloading, transport type, and load rates are closely linked to road freight transport costs. Consequently, it can be asserted that competition in the road freight transport sector is driven by the growing need to meet customer requirements effectively.

Previously, researchers have sought to elucidate the factors influencing freight transport costs. Camison-Haba & Clemente (2020) developed a model to estimate transport costs, outlining its determinants. Their study found that freight transit, demand, and infrastructure collectively constitute strategic conditions that significantly impact transportation costs. In addition, Wang (2021) identified the key factors affecting highway freight transportation in China. By collecting and analyzing a wide range of factors, Wang's study highlighted that Gross Domestic Product (GDP) emerged as a crucial factor driving improvements in road freight transport.

Subsequently, Tsekeris (2022) examined freight transport costs across urban regions in the European Union, considering various variables that could influence these costs, including government budgets for infrastructure development. The study's findings revealed that government actions had the most significant impact on freight transport costs. This conclusion is supported by de Bok et al. (2022), who analyzed factors affecting vehicle charges in the Netherlands. Their research highlighted the potential impacts of different charging mechanisms on truck costs and provided critical insights to the government. The results indicated that variations in public sector charging policies could significantly influence overall transport costs. Therefore, it can be demonstrated that freight transport costs are closely linked to strategic management practices in various ways.

Recently, Ferraz & Viegas (2023) investigated the relationship between fuel prices and logistics costs in Brazil. Their research highlighted the political pressures associated with rising oil prices, given that oil is a primary fuel for transport trucks. They discovered that even when the state owns the petroleum company, increasing fuel prices remains challenging due to external market pressures. The study also found that any rise in fuel prices would lead to higher product prices and increased costs across the market, as the transportation sector relies heavily on fuel for trucks and lorries.

Gunay (2023) explored the relationship between shipping characteristics and the cost model for road freight transport. This study examined how factors such as shipment size and vehicle choices, along with geographical considerations, influence transport costs. The findings indicated that the size of shipments and associated charging fees significantly impact strategic planning and road freight transport costs.

Subsequently, Mujakachi (2023) developed a transport cost model focused on organizational culture and competitiveness within Zimbabwe's freight transport sector. This model aimed to create a sustainable cost framework for the road transport industry, drawing on data from various road freight companies. The study's results emphasized the importance of considering different cost components before budget allocation. Factors such as staff, charging fees, and resources were identified as key determinants influencing freight transport costs in multiple ways.

Typically, customers prefer to purchase products without bearing the transport costs, as these costs do not add value to the products they consume (Gunay, 2023; Mujakachi, 2023; Tsekeris, 2022). However, the economic environment is continually evolving, and various factors—such as employee costs, export-import volume indexes, transport energy prices, and road freight transport indexes—are shifting to new levels (Mujakachi, 2023; Mousa *et al*., 2023; Wang, 2021; Camison-Haba & Clemente, 2020; Persyn et al., 2019). Therefore, it is crucial to study these factors to gain a comprehensive understanding. While there has been substantial research on structural logistics costs in Thailand, the specific factors affecting road freight transport costs remain underexplored.

Consequently, this study aims to address two key objectives regarding the impact of selective factors on road freight transport costs in Thailand. Firstly, it seeks to determine how specific factors influence road freight transport costs within the country. Secondly, the study aims to identify the most significant factor that could provide valuable insights to policymakers, helping them make informed decisions to enhance road freight transportation and optimize Thailand's logistics cost structure in the future.

2. LITERATURE REVIEW

Based on prior research, it can be concluded that factors such as government policies, transport energy costs, and infrastructure are connected to freight transport costs. These variables are generally interrelated, though the strength and nature of these relationships can vary depending on the specific characteristics of the factors and their contextual settings. This study has derived its set of independent variables from the literature review and the in-depth examination of publicly available information on road freight transport. The selected variables and factors, chosen based on relevant literature, aim to provide a clearer understanding in the context of a developing country like Thailand.

2.1 Road Freight Transportation Cost: RFTC

Road freight transport involves the transfer of physical items, such as goods, containers, and cargo, using vehicles like trucks, lorries, and trailers (Izadi *et al*., 2019; Osborne et al., 2014). It is a crucial method for delivering goods from their origin to their point of use within both domestic and international supply chains (Kedzior-Laskowska, 2019; Erjavec et al., 2014). This transport mode offers time flexibility and rapid access to remote areas compared to other transportation methods (Wang, 2021; Kedzior-Laskowska, 2019). Consequently, road freight transport plays a vital role in supporting the supply chain by facilitating the movement of raw materials, intermediate goods, and finished products to various locations based on customer or consumer needs.

Road freight transport cost refers to the total expenditure incurred in the process of transferring goods via road. This cost encompasses various factors such as distance traveled, weight and volume of the cargo, type of goods, urgency of delivery, power consumption, route, infrastructure, demand, and additional costs. These factors collectively contribute to the overall budget required for conducting road freight operations. Thus, road freight transport cost can be defined as the comprehensive cost of executing transportation activities by road.

For this research, data on road freight transport costs was obtained from the Office of the National Economic and Social Development Council (NESDC), Ministry of Prime Minister (Office of the National Economic and Social Development Council, 2023; Office of the National Economic and Social Development Council, 2022), which are the reliable sources of information on road freight transport costs in Thailand.

2.2 Employee Cost: X_1

In the logistics sector, manpower is responsible for a range of specific tasks related to the transfer and management of goods (Bahrom *et al*., 2024; Kedzior-Laskowska, 2019; Jacyna & Wasiak, 2015). These roles typically encompass key functions such as transportation, administration, and inventory management (Office of the National Economic and Social Development Council, 2023). Besides, logistics personnel involve planning, sourcing, procurement, storage, and distribution (Office of the National Economic and Social Development Council, 2022; Kedzior-Laskowska, 2019). The required skills vary depending on the specific responsibilities of each role. For instance, transportation staff may need expertise in driving, loading and unloading, and route planning, whereas administrative staff require skills in planning, negotiation, accounting, and budgeting (Tsekeris, 2022; Persyn *et al*., 2019). Therefore, it is clear that employees in the logistics sector must possess a diverse set of skills tailored to their particular job functions.

Employee cost in the logistics sector can be defined as the financial index reflecting the level of employment within the transportation segment. This cost index is influenced by various employment-related factors and is closely tied to budgeting for addressing issues in logistics operations, improving effectiveness, and mitigating unforeseen challenges. Therefore, employee cost in logistics can be understood as the expenditure related to investigating and resolving problems within logistics operations. For this research, data on employee costs in the logistics sector was sourced from the National Statistical Office of Thailand, which was verified in collaboration with the Bank of Thailand. This data provides a reliable measure of employee costs within the logistics sector.

2.3 Export-Import Volume Indexes

Export and import volumes refer to the quantification of goods sent out of and received into a country (Camison-Haba & Clemente, 2020; Jacyna *et al*.,2015). These data groups are typically collected by government agencies and public trade associations and statistically represent the quantities of goods exported from and imported into each country (Bank of Thailand, 2024; Osborne *et al*., 2014). Measured in tons, these volumes are often analyzed in terms of trends and sectoral potential. This data assists policymakers in understanding changes in trade patterns, assessing economic conditions, and making informed decisions based on market demand (Tsekeris, 2022; Persyn et al., 2019). Therefore, it can be asserted that export and import volumes are closely related to the quantities of goods entering and leaving a country and are crucial for evaluating economic status and the impact of regional trade agreements.

Export and import volume indexes are specific indices used to analyze trade structures by examining the physical volume of exports and imports. These indexes are based on data collection, scope of determination, volume quantification, and patterns of change, and are essential for evaluating and assessing the effectiveness of public policies. Essentially, export and import volume indexes are used to appraise the impact of government regulations on trade. For this research, data on export and import volume indexes was originally obtained from the Department of International Trade in Thailand in conjunction with data from the Ministry of Transport, and then literally gathered by the Bank of Thailand. These variables are detailed in **Table 1**.

Table 1. Variable description in Export-Import Volume Indexes.
Source: Bank of Thailand (2024)

Abbreviation	Description
X_2	Export Volume Index: To represent the export volume
X_3	Import Volume Index: To represent the import volume

2.4 Transport Energy Price

Transport energy price refers to the cost of energy required to power vehicles for transporting goods from the source to the customer (Izadi *et al*., 2019; Jacyna & Wasiak, 2015). This encompasses various energy sources used in vehicles, such as diesel, natural gas, gasoline, and electricity (Ferraz & Viegas, 2023; Austin, 2015). The price of transport energy is influenced by the type of fuel due to differing unit costs; for instance, gasoline is typically more expensive than diesel, which is why many trucks use diesel engines rather than gasoline (Izadi *et al*., 2019; Havenga & Simpson, 2014). Market conditions play a significant role in shaping transport energy costs (Gunay, 2023; Guo & Luo, 2022). For example, logistics providers may prefer diesel-powered trucks for inland deliveries due to the lower cost of diesel compared to gasoline. Additionally, infrastructure impacts transport energy prices, as the availability of refueling or charging stations can affect operational efficiency (Tsekeris, 2022; Wang, 2021). Electric trucks, while environmentally friendly, are less common in logistics due to the limited number of charging stations.

Transport energy price significantly affects the budget for transferring goods. The cost of energy is often influenced by government policies and taxation, making the pricing set by the public sector crucial for road freight transport costs. Diesel is the most widely used energy source in road transport globally due to its lower price, greater availability of refueling stations, and higher energy efficiency compared to other sources. Thus, it is essential to consider the various automotive energy prices. For this study, the vehicle energy price index was initially sourced from the Energy Policy and Planning Office and the Ministry of Commerce, and then accurately cross-referenced and collected by the Bank of Thailand. The energy indexes were in **Table 2**.

Table 2. Variable description in Transport Energy Price.
Source: Bank of Thailand (2024)

Abbreviation	Description
X_4	Gasoline 95 is generated from benzine and Octane 95.
X_5	Gasohol 95 is generated from benzine , ethanol , Octane 95.
X_6	Diesel: The fuel is generated from hydrocarbons coupled with having the boiling point from 150-380 degree Celsius.
X_7	Natural gas for Vehicle, which can be called as the NGV, is used for powering engine instead of Gasoline.

2.5 Road Freight Transport Indexes

Road freight transport indexes are metrics used to evaluate performance of transport providers concerning volume and cost of road transport services (Gunay, 2023; Izadi *et al*., 2019). These indexes serve as mathematical indicators that track changes in service costs over time (de Bok *et al*., 2022; Liang & Frosen, 2020; Kaszubowski, 2019). They play a crucial role in the pricing of goods, as the cost of road freight transport becomes a component of the final

price paid by customers for their products (Mujakachi, 2023; Camison-Haba & Clemente, 2020). In practice, road freight transport indexes can fluctuate dynamically over time but may show consistent values during specific periods (Camison-Haba & Clemente, 2020; Havenga, 2015). Typically, these indexes are expressed as ratings that compare the current service level (de Bok et al., 2022; Camison-Haba & Clemente, 2020; Nocera et al., 2018).

The road freight transport index is an indicator of transport service performance that directly affects the final price of products. Hidden costs associated with transportation are accumulated and ultimately reflected in the price paid by the end customer. Therefore, the index can be seen as a measure of the efficiency and effectiveness of logistics operations conducted by service providers. In this study, road freight transport indexes were sourced from the Ministry of Commerce in Thailand, a reliable public source. The details of these indexes are provided as **Table 3**.

Table 3. Variable description in Road Freight Transport Indexes.
Source: (Ministry of Commerce, 2024)

Abbreviation	Description
X_8	Road freight transport index for the pick-up truck
X_9	Road freight transport index for van
X_{10}	Road freight transport index for the liquid Truck
X_{11}	Road freight transport index for the hazardous materials
X_{12}	Road freight transport index for the special trucks
X_{13}	Road freight transport index for trailer
X_{14}	Road freight transport index for lorry

2.6 Public budget in infrastructure: X_{15}

The public budget for infrastructure refers to the national government's financial investment in the construction, development, repair, and maintenance of infrastructure to enhance public facilities (Tsekeris, 2022; Camison-Haba & Clemente, 2020). Such investments are aimed at improving community services, including transportation facilities, utilities, and other public functions that contribute to the overall growth of a community or country (Austin, 2015; Erjavec et al., 2014). The impact of public infrastructure budgets can significantly improve efficiency, reliability, and time savings for both individuals and businesses (Gunay, 2023; Jacyna & Wasiak, 2015). For instance, in Thailand, the national government allocates funds for the construction and maintenance of road networks, which leads to faster transport, enhanced safety, and reduced travel time. Therefore, it might be argued that public investment in infrastructure contributes to a safer and more cost-effective transport system.

The public budget for infrastructure serves as an indicator of the quality and comfort of community services. This budget typically encompasses various aspects, including construction and development, maintenance and repairs, upgrades and modernization, as well as planning and design. It plays a crucial role in reflecting the economic conditions and investment in infrastructure. Effective allocation of public infrastructure budgets can significantly impact the efficiency and effectiveness of transport facilities managed by providers. In this study, data on public infrastructure budgets were collectively sourced from Bank of Thailand (2024).

2.7 Vehicle and Vehicle operation

A vehicle is a machine used for transporting materials and products from one location to another. In the context of road transport, vehicles include various types such as pickup trucks,

vans, and lorries, each designed to carry and move goods from a supply point to a destination (Wang, 2021; Camison-Haba & Clemente, 2020). Vehicle operation encompasses the activities involved in utilizing these transport machines for business purposes (Subiyanto & Suyoto, 2020; Kaszubowski, 2018). This includes activities such as purchasing vehicles, performing repairs and maintenance, and managing taxes and insurance (Kedzior-Laskowska, 2019; Jacyna & Wasiak, 2015). Therefore, it might be concluded that a vehicle alone is insufficient for transporting goods; it requires supporting operations to ensure effective delivery.

As seen in **Table 4**, vehicles and their operations are the essential parts for successfully transporting goods to their destinations. This encompasses various activities, including cost of vehicles and equipment, securing appropriate insurance, and managing communication related to transport logistics. Thus, it might be argued that both vehicles and their operations are critical for ensuring effective and efficient transport activities. In this study, these data were sourced from Ministry of Commerce (MOC) in Thailand.

Table 4. Variable description in Vehicle and Vehicle operation.
Source: Ministry of Commerce (2024)

Abbreviation	Description
X_{16}	Vehicle price index
X_{17}	Vehicle equipment price index
X_{18}	Motor fuel price index
X_{19}	Maintenance service expenditure
X_{20}	Registration fee
X_{21}	Motor insurance
X_{22}	Communication service
X_{23}	Communication equipment

2.8 Conceptual framework

Based on the literature review, the selective independent factors involve the road freight transport cost, but they might have the different impacts on the road freight transport cost. In order to improve the road freight transport cost in the future, it will need to study the factor affecting the road freight transport cost for making a more understanding which might get the additional contribution for helping the policy maker in developing country. Moreover, the theoretical model can be illustrated as **Figure 1**.

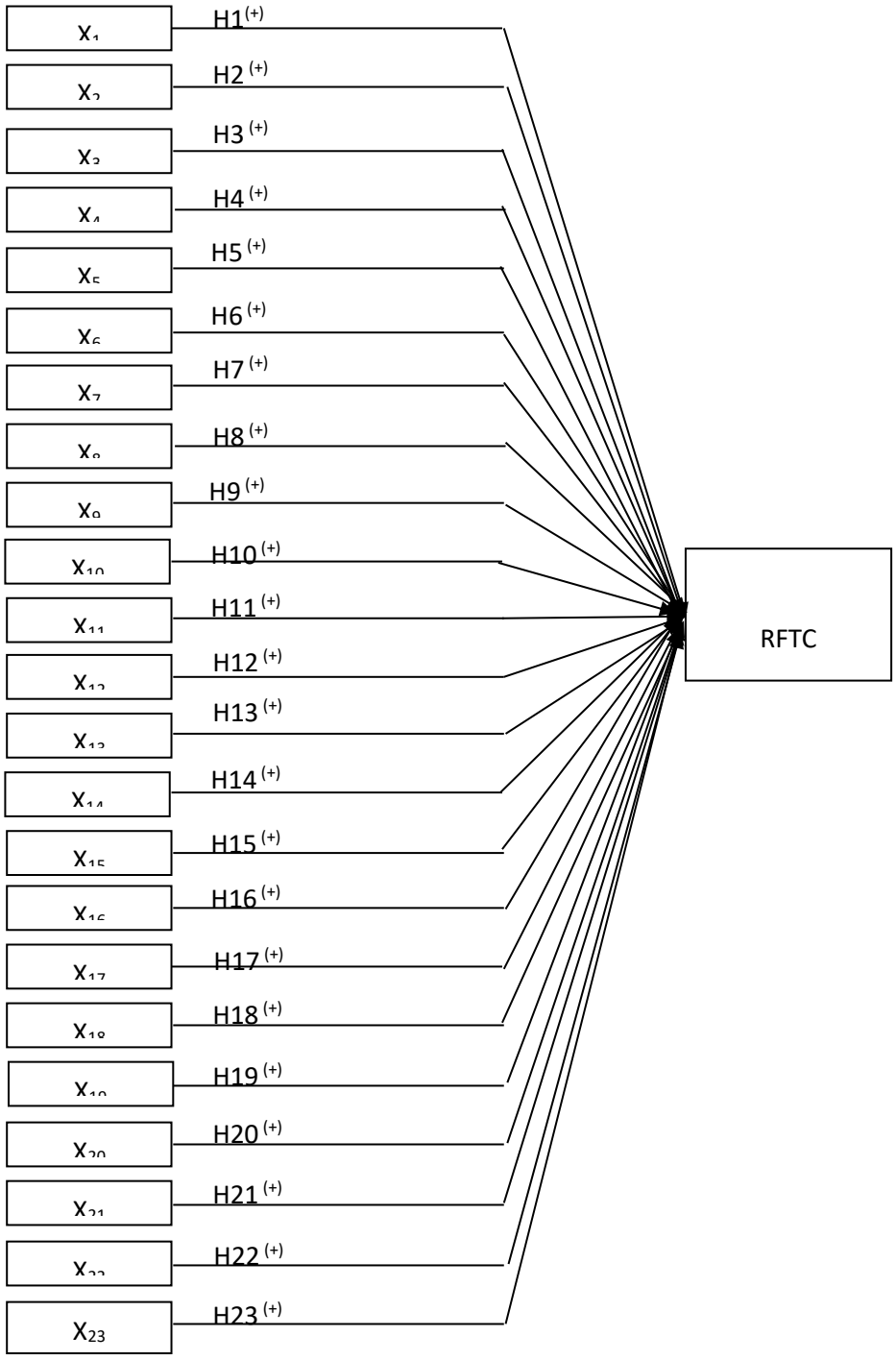

Figure.1 The theoretical model. Source: the Authors

3. RESEARCH METHOD

3.1 Data collection

This research study conducted the secondary data from the public informational sources in Thailand during 2015-2022. Besides, a number of secondary data sets from Office of the National Economic and Social Development Council (NESDC), Ministry of Commerce (MOC), and Bank of Thailand (BOT) were collected, and then quarterly detailed. Notably, these data sets were literally discovered in term of the public open sources such as the civic

reports, the government journal and the municipal database which can be naturally found in their public websites.

3.2 Data evaluation

After collecting the whole data form the trustable various sources from the public sectors, the research team had checked the correction across the data sources. For example, the data of the employee cost in logistics sector from National Statistical Office in Thailand was initially gathered, and then was verified by the information from the Bank of Thailand. In case of gathering the data of export and import volume indexes from the Department of International Trade in Thailand, this data was subsequently quantified with the data of the transport ministry in Thailand. As a result, these activities can facilitate increasing a more confident ability for the collective data before entering to the analytical process.

3.3 Data analysis

The data analysis was based on the parametric test. The collected data were analyzed to identify situations which extended the relationships between a number of independent variables and a dependent variable. These situations were to significantly show evidence of the impact of the selective variables on the road freight transport cost in Thailand. The data investigation in this research had been implemented through the SPSS for Window version 21 (Statistical package for the social science) as follows.

The first step, each secondary data set was initially described by using the descriptive statistics for making a greater understanding their backgrounds. Particularly, all secondary data were transformed to be the index based on the data of the first quarter in 2015, so all indexes had their unit in percentage. Following this, the subsequent data can be interpreted as the changeable level comparing with their starting points.

The second step, the whole secondary data set was tested by using the correlation analysis for checking the problem of Multicollinearity. Remarkably, the Pearson Correlation in this research was regulated under 0.8.

The third step, these secondary data sets was methodically conducted into Multiple Regression Analysis (MRA). Besides, the multiple regression analysis is an advanced statistical analytic technique to reveal the effects of a number of independent variables on the dependent variable (Okinyi et al., 2024; Black & Babin, 2019; Hair et al., 2019). Moreover, the applicable function or the mathematical model was formulated in the equation 1 as follows.

$$RFTC = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \beta_{13} X_{13} + \beta_{14} X_{14} + \beta_{15} X_{15} + \beta_{16} X_{16} + \beta_{17} X_{17} + \beta_{18} X_{18} + \beta_{19} X_{19} + \beta_{20} X_{20} + \beta_{21} X_{21} + \beta_{22} X_{22} + \beta_{23} X_{23} \quad (1)$$

Whereas β_0 is the constant coefficient while β_1, β_2, β_3… β_{23} are the regression coefficients which will explain the effect of each variable on the road freight transport cost. On the other hand, RFTC is the independent variables in this multiple regression model, and its change is depended on the condition of the employee cost (X_1), the export-import volume index (X_2 - X_3), the transport energy price (X_4 – X_7), the road freight transport index (X_8 - X_{14}), the public budget in infrastructure (X_{15}), and Vehicle and vehicle operation (X_{16} - X_{23}). Consequently, this multiple regression analysis is modeled by consisting of the twenty-three independent variables which produce the changeable level on the road freight transport cost (RFTC). Notably, the statistical significance in this study is $p \leq 0.05$.

Finally, with the aim of focusing on the research purpose, after analyzing by MRA, the impacts of the selective variables on the road freight transport cost were discussed thought β_1-β_{23}, and the factors affecting the road freight transport cost in the middle-income country were exposed. In this session, each significant variable with its impact were discussed in order to make the important suggestion for the policy maker improving the road freight transport cost in the middle-income country.

Variable	Abbreviation	Mean	SD	N
Road Freight Transportation Cost	RFTC	114.82	8.26	32
Employee Cost	X_1	97.02	4.09	32
Export Volume Index	X_2	107.68	7.59	32
Import Volume Index	X_3	104.20	8.02	32
Gasoline 95	X_4	100.01	13.19	32
Gasohol 95	X_5	93.30	15.32	32
Diesel	X_6	100.55	13.18	32
Natural gas for Vehicle	X_7	111.44	10.19	32
Road freight transport index for the pick-up truck	X_8	104.05	4.50	32
Road freight transport index for van	X_9	102.56	3.25	32
Road freight transport index for the liquid Truck	X_{10}	99.39	3.26	32
Road freight transport index for the hazardous materials truck	X_{11}	104.73	3.91	32
Road freight transport index for the special trucks	X_{12}	101.53	3.34	32
Road freight transport index for trailer	X_{13}	102.61	3.73	32
Road freight transport index for lorry	X_{14}	106.77	12.73	32
Public budget in infrastructure	X_{15}	134.00	58.87	32
Vehicle price index	X_{16}	100.81	0.40	32
Vehicle equipment price index	X_{17}	100.37	0.27	32
Motor fuel price index	X_{18}	99.41	14.31	32
Maintenance service expenditure	X_{19}	96.86	17.66	32
Registration fee	X_{20}	100.00	0.00	32
Motor insurance	X_{21}	100.00	0.00	32
Communication service	X_{22}	99.99	0.03	32
Communication equipment	X_{23}	95.80	2.18	32

4. RESULTS

4.1 Descriptive statistic

The present study reported on the average cost index in term of percentage of the road freight transport cost and its predictive variables in Thailand during 2015- 2022 based on the data in the first quarter of 2015, which can be explained as follows.

Table 5. Distribution of cost variables indexes during 2015-2022. Source: the Authors

As seen in **Table 5**, the road freight transport cost was increased approximately 14.82% in average. Initially, the highest variable index was the public infrastructure which its growth rate was a more value than 30%, and the second place was the natural gas for vehicle which its

increase rate around 10%. Besides this, the decreased indexes were the employee cost, gasohol 95, road freight transport for the liquid truck, motor fuel price, maintenance service expenditure, communication service and equipment while the others had the growth rate in rage of 0-10 %. Notably, the registration fee (X20) and motor insurance (X21) had not been changed during the analytic period because of their standard deviation were 0.00, so they were eliminated out from the equation 1. Based on these data, it might be stated that the road freight transport cost in Thailand was continuously increase coupled with expanding of almost relative variables, and that is the reason why the government has increasingly financed to improve the road.

4.2 Correlation test

The coefficient of correlation between variables in this research can be shown as **Table 6(a)** to **Table 6(b)**. These analytic results had presented the relationship among the residual variables in the regression model. Initially, Pearson correlation had totally shown 231 pairs. Besides, all correlation coefficients situated at a lower value than 0.8, so there did not have the problem of Multicollinearity. Furthermore, the internal variables had the significant relation 172 pairs. Based on this result, these variables were suitable for analyzing by MRA.

As seen in **Table 6(a)** and **Table 6(b)**, these analytic results had presented the relationship among the residual variables in the regression model. Initially, Pearson correlation had totally shown 231 pairs. Besides, all correlation coefficients situated at a lower value than 0.8, so there did not have the problem of Multicollinearity. Furthermore, the internal variables had the significant relation 172 pairs. Based on this result, these variables were suitable for analyzing by MRA.

Table 6(a). Correlation. Source: the Authors

	RFTC	**X_1**	**X_2**	**X_3**	**X_4**	**X_5**	**X_6**	**X_7**	**X_8**	**X_9**	**X_{10}**	**X_{11}**
RFTC	1	0.43*	0.65*	0.59*	0.58*	0.52*	0.64*	0.78*	0.74*	0.68*	0.11*	0.79*
X_1		1	-0.08	-0.15	-0.14	-0.17	-0.08	0.54*	0.16	0.08	-0.38*	0.31*
X_2			1	0.78*	0.76*	0.73*	0.72*	0.41*	0.52*	0.58*	0.13	0.72*
X_3				1	0.75*	0.73*	0.78*	0.35*	0.5*	0.51*	0.28*	0.66*
X_4					1	0.79*	0.8*	0.47*	0.78*	0.72*	0.58*	0.77*
X_5						1	0.79*	0.42*	0.75*	0.78*	0.6*	0.72*
X_6							1	0.5*	0.8*	0.75*	0.56*	0.72*
X_7								1	0.67*	0.59*	0.09	0.77*
X_8									1	0.76*	0.55*	0.79*
X_9										1	0.54*	0.78*
X_{10}											1	0.24
X_{11}												1

Remark: * mean $p \leq 0.05$

Table 6(b). Correlation. Source: the Authors

	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{22}	X_{23}
RFTC	0.44*	0.66*	0.55*	0.27	0.77*	0.72*	0.6*	0.04	-0.54*	-0.87*
X_1	0.06	0.01	0.05	0.14	0.53*	0.34*	-0.09	-0.18	-0.11	-0.55*
X_2	0.15	0.49*	0.42*	0.35*	0.53*	0.49*	0.75*	0.14	-0.66*	-0.59*
X_3	0.21	0.55*	0.39*	0.17	0.48*	0.32*	0.71*	0.12	-0.47*	-0.44*
X_4	0.53*	0.72*	0.75*	0.18	0.25	0.46*	0.76*	0.24	-0.76*	-0.4*
X_5	0.52*	0.8*	0.73*	0.16	0.18	0.4*	0.75*	0.26	-0.74*	-0.32*
X_6	0.6*	0.73*	0.74*	0.32*	0.38*	0.59*	0.78*	0.21	-0.63*	-0.49*
X_7	0.51*	0.58*	0.5*	0.19	0.66*	0.66*	0.43*	0.13	-0.52*	-0.74*
X_8	0.79*	0.72*	0.74*	0.34*	0.48*	0.75*	0.77*	0.09	-0.69*	-0.63*
X_9	0.75*	0.78*	0.73*	0.39*	0.4*	0.77*	0.72*	0.11	-0.76*	-0.61*
X_{10}	0.73*	0.76*	0.59*	-0.11	-0.19	-0.02	0.48*	0.34*	-0.21	0.23
X_{11}	0.58*	0.77*	0.78*	0.43*	0.7*	0.74*	0.78*	0.07	-0.73*	-0.86*
X_{12}	1	0.71*	0.78*	0.19	0.21	0.45*	0.48*	0.17	-0.38*	-0.28
X_{13}		1	0.76*	0.17	0.37*	0.52*	0.77*	0.23	-0.58*	-0.4*
X_{14}			1	0.33*	0.29	0.68*	0.74*	0.07	-0.66*	-0.5*
X_{15}				1	0.35*	0.6*	0.26	-0.26	-0.41*	-0.49*
X_{16}					1	0.65*	0.29	-0.09	-0.3*	-0.87*
X_{17}						1	0.52*	-0.1	-0.63*	-0.87*
X_{18}							1	0.19	-0.79*	-0.46*
X_{19}								1	-0.06	0.11
X_{22}									1	0.57*
X_{23}										1

Remark: * mean $p \leq 0.05$

4.3 Multiple Regression Analysis: MRA

MRA had revealed impacts of the independent variables 21 items on the road freight transport cost as in **Table 7**. Originally, F statistic was a value at 21.742 coupled with having the significant level at $p \leq 0.01$. Following this, the adjusted R square had situated at 93.4%. Accordingly, it can be interpreted that the mathematical model in this research had an ability to explain the dependent variables, so the remaining variables in this model was suitable to employ for predicting the road freight transport cost.

Table 7. The Result of Multiple Regression Analysis. Source: the Authors

Variable	**Road freight transport cost (RFTC)**			
(N = 32)	**β**	**t**	**Sig.**	**Std.Error**
(Constant)	-4286.694	-0.964	0.358	4445.588
X_1	-0.003	-0.023	0.981	0.32
X_2	0.004	0.058	0.954	0.274
X_3	-0.043	-0.669	0.509	0.228
X_4	0.059	0.994	0.329	1.572
X_5	0.041	0.844	0.406	1.294
X_6	0.018	0.303	0.764	0.216
X_7	0.003	0.05	0.961	0.12
X_8	0.121	0.558	0.581	1.923
X_9	0.209	0.616	0.543	1.608
X_{10}	0.141	0.994	0.329	1.03
X_{11}	1.281	9.169	0.000**	0.14
X_{12}	0.06	0.402	0.691	0.399
X_{13}	0.267	1.543	0.135	1.498
X_{14}	-0.037	-0.622	0.539	0.214
X_{15}	-0.024	-3.476	0.002**	0.007
X_{16}	10.666	8.054	0.000**	1.324
X_{17}	-26.82	0.394	0.381	8.482
X_{18}	0.628	0.287	0.936	0.201
X_{19}	0.006	0.99	0.449	0.034
X_{22}	-116.363	0.706	0.406	47.437
X_{23}	2.883	0.453	0.86	2.929
Adjusted	R^2= 0.934	F= 21.742	Sig. = 0.000	

Remark: * mean $p \leq 0.05$, ** mean $p \leq 0.01$

The mathematic equation of investigating in factor affecting the road freight transport cost in the middle income county can be rewritten as equation 2.

$$RFTC = -4286.694 - 0.003X_1 + 0.004X_2 - 0.043X_3 + 0.059X_4 + 0.041X_5 + 0.018X_6 + 0.003X_7 + 0.121X_8 + 0.209X_9 + 0.141X_{10} + 1.281X_{11} + 0.06X_{12} + 0.267X_{13} - 0.037X_{14} - 0.024X_{15} + 10.666X_{16} - 26.82X_{17} + 0.628X_{18} + 0.006X_{19} - 116.363X_{22} + 2.883X_{23} \quad (2)$$

Regarding concentrating on the coefficient (β) in the multiple regression analysis, the regression coefficient of Road freight transport index for the hazardous materials truck (X11) was 1.281 coupled with the significant level at $p \leq 0.01$. In addition, the regression coefficient

of Public budget in infrastructure (X15) was -0.024 coupled with the significant level at $p \leq 0.01$. Moreover, the regression coefficient of Vehicle price index (X16) was 10.666 coupled with the significant level at $p \leq 0.01$. Furthermore, the other independent variables did not have the statistical significant level even if there had the coefficients in the mathematical model. As a result, it can be stated that the important variables affecting the road freight transport cost in Thailand were Road freight transport index for the hazardous materials truck, Public budget in infrastructure, and Vehicle price index. The theoretical model after the statistical testing was ably rewritten as follow **Figure 2**.

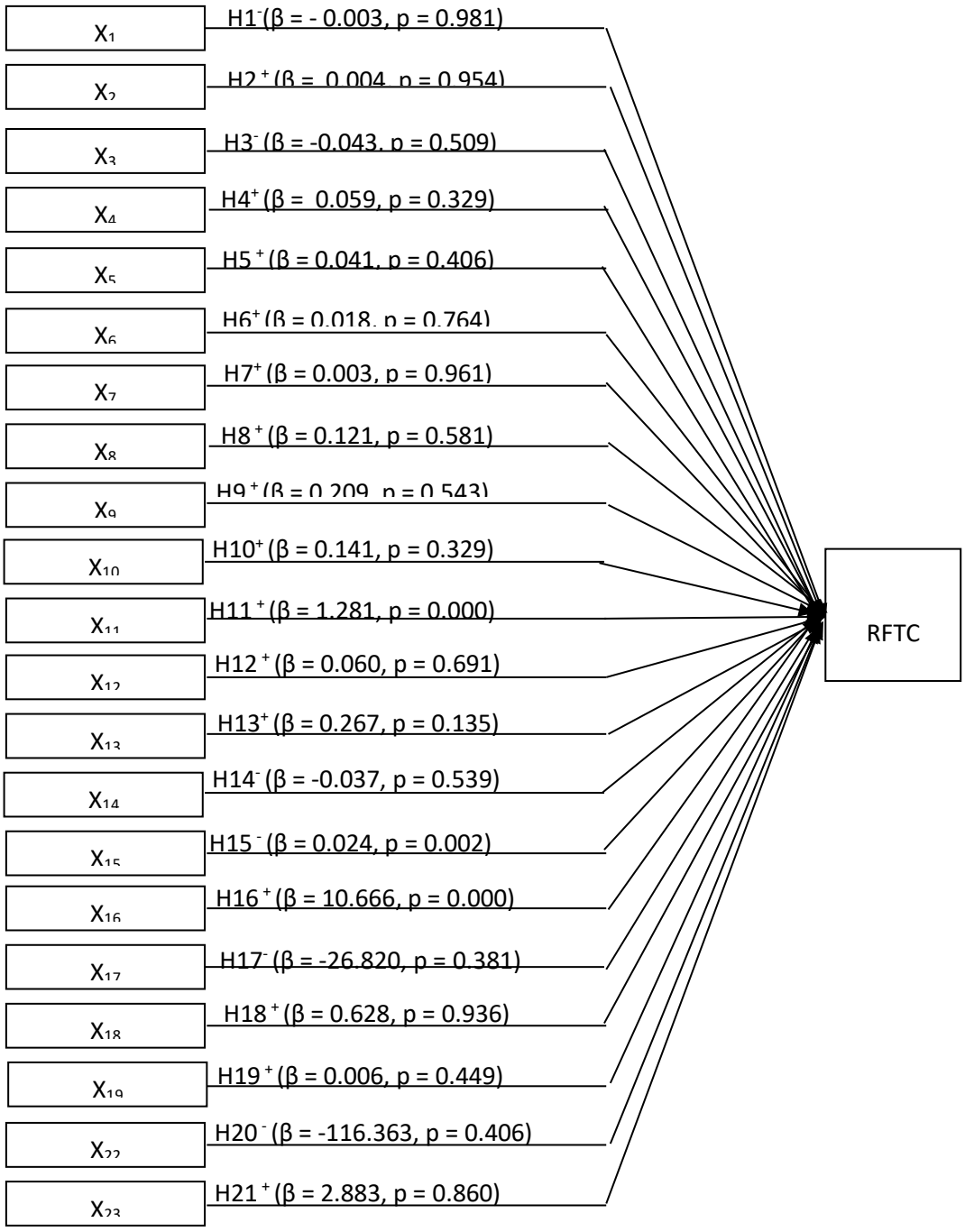

Figure 2. The theoretical model after MRA testing. Source: the Authors

5. DISCUSSION

This study aimed to investigate the influence of selective factors on road freight transport costs in Thailand and identify key determinants that could inform strategic decision-making for organizations in the future. To achieve this objective, a comprehensive theoretical framework was developed and analyzed, leading to the creation of theoretical models and their corresponding empirical tests. The analytical findings also revealed the outcomes of these tests. The factors influencing road freight transport costs in Thailand were found to align with existing literature and offered new insights to further improve public policy and operational practices.

5.1 Research implications

To address the first research question concerning how selective factors affect road freight transport costs in Thailand, the study employed descriptive statistics, correlation tests, and multiple regression analysis. The analysis initially revealed that registration fees and motor insurance did not impact road freight transport costs, as these variables remained stable over the period studied. When examining residual variables through correlation and multiple regression analyses, it was found that most variables positively influenced road freight transport costs, consistent with existing literature. However, several factors—specifically, employee costs, import volume index, road freight transport index for lorries, public infrastructure budgets, vehicle equipment price index, and communication services—were found to have a negative impact on road freight transport costs. These findings are further elucidated through additional literature review as discussed below.

In Thailand, road transport dominates the logistics sector, accounting for approximately 80% of distribution channels. The logistics service industry experienced a remarkable growth rate of nearly 100% in 2022 compared to 2018, with substantial government support enhancing the sector (Office of the National Economic and Social Development Council, 2023). To remain competitive, logistics firms are increasingly adopting price strategies to attract clients, necessitating significant cost reductions. These firms are focusing on improving labor productivity, optimizing container utilization, enhancing digital communication, and investing in durable equipment. As a result, factors such as employee costs, public infrastructure budgets, and the vehicle equipment price index negatively affects the transport costs.

The global business landscape has been significantly influenced by COVID-19 since 2019. In response to the pandemic, public sectors have encouraged the consumption of domestic materials and products rather than relying on imported goods to mitigate the risk of the virus entering their countries. This trend has continued to affect global trade patterns (Office of the National Economic and Social Development Council, 2023). For instance, lorries, which are typically used to transport bulk goods across borders, have seen reduced demand due to pandemic-related restrictions. Consequently, this decreases in the use of lorries, along with a lower import volume index, explains why these factors have a negative impact on road freight transport costs.

To address the second research question—identifying the key factors that could guide policymakers in enhancing road freight transportation and improving Thailand's logistics cost structure—the research results indicated that the most significant variables are the vehicle price index, the road freight transport index for hazardous materials trucks, and public infrastructure budgets. These factors warrant further discussion as follows.

To begin with the most significant factor, the vehicle price index (X_{16}) had a notably positive impact on road freight transport costs, with statistical significance. Vehicles are essential assets for road transport services, and their acquisition constitutes a major expenditure for transport

providers. Since businesses aim to maximize profits which defined as the difference between service prices and operational costs (Charlampowicz & Mankowski, 2024; Burykin *et al*., 2023; Png, 2022) which the cost of vehicles directly affects transport pricing. Typically, logistics service providers incorporate vehicle costs into their service pricing, which in turn affects the overall transport costs borne by clients. Therefore, road freight transport costs are heavily influenced by the vehicle price index. Consequently, to achieve lower road freight transport costs, government interventions should focus on controlling vehicle prices.

The second significant factor, the road freight transport index for hazardous materials trucks (X_{11}), also has a positive impact on road freight transport costs, with statistical significance. Hazardous materials transport involves the movement of dangerous substances—such as flammable materials, corrosive agents, waste products, allyl alcohol, adhesives, gasoline, and substances requiring elevated temperature control—which necessitate special permits and stringent safety measures as mandated by state regulations (Mohri *et al*., 2022; Department of Land transport, 2020; Holeczek, 2019). Transport service providers must ensure the highest level of protection for these materials, utilizing specialized truck shields made from costly materials such as fire-resistant, blast-resistant, and corrosion-resistant substances (Guo & Luo, 2022; Mohri *et al*., 2022). These added safety measures contribute to higher transport service costs, which subsequently affect the overall road freight transport cost. Therefore, to reduce road freight transport costs, public sectors should consider investigating ways to lower the expenses associated with protective equipment for hazardous materials trucks.

The third significant factor, the public budget for infrastructure (X_{15}), exhibits a negative effect on road freight transport costs, with statistical significance. Existing literature indicates that investments in transport infrastructure typically enhance transport efficiency in terms of time, cost, and reliability (Tsekeris, 2022; Wang, 2021; Chen *et al*., 2020). For example, expanding a road from two lanes to four lanes allows for smoother truck movement, which reduces travel time and energy consumption during road freight operations. This improved efficiency can lead to lower operational costs, including reductions in fuel consumption, labor costs, and other related expenses, thereby decreasing the overall road freight transport cost. Consequently, to effectively reduce road freight transport costs, public sectors should focus on increasing budget in improving transport infrastructure.

Lately, the impacts of the selective factors on the road freight transport cost in the middle country, which was Thailand, had been revealed. In additional, the main important variables had been indicated, so this result contributes to the literature in improving the road freight transport for the policy makers.

5.2 Practical implications

Table 7 and equation 2 obviously illustrate the selective factors affecting the road freight transport cost in the middle country. Firstly, the policy makers should mainly concentrate on the vehicle price index for controlling the gigantic predictor of road freight transport cost. Secondly, the governors should focus on the requirement of transporting the hazardous materials by improving the protective shield on the truck for lowering it. Thirdly, the policy planners should consider to put a more budget to improve the road freight infrastructure, since it can help reducing the road freight transport cost in the national level.

5.3 Limitation and future direction

This paper has limitations. The secondary data relating the selective factors and the road freight transport cost was collected, based on the public informational sources in Thailand, it must be noted that the factors affecting the road freight transport cost in different countries or other regions might have the different results. Besides, this study will not confirm that these

selective factors will have the similar impact on other situation due to the differentiation of the economic environment. Additionally, there might require a more research study in another country in the future.

6. CONCLUSION

This study examined the impact of selective factors on road freight transport costs in a middle-income country, specifically Thailand. Despite a growing interest in understanding freight transport dynamics from various perspectives, there has been limited research on the factors influencing road freight transport costs in middle-income countries like Thailand. This study aimed to address this gap by investigating how selective factors affect road freight transport costs. To explore this, a comprehensive set of factors was developed based on existing literature. Subsequently, all relevant variables and road freight transport costs were analyzed using descriptive statistics, correlation testing, and multiple regression analysis, with secondary data collected from public information sources in Thailand. The results indicate that these variables effectively describe road freight transport costs. The key findings of this study are summarized as follows.

Firstly, the study identified 21 independent variables capable of explaining road freight transport costs. While most of these variables positively affect road freight transport costs, certain factors—namely Employee Cost, Import Volume Index, Road Freight Transport Index for Lorries, Public Budget in Infrastructure, Vehicle Equipment Price Index, and Communication Services—exert a negative impact. This negative effect can be attributed to specific national contexts and the ongoing repercussions of the COVID-19 pandemic.

Secondly, three significant predictors were identified: Vehicle Price Index, Road Freight Transport Index for Hazardous Materials Trucks, and Public Budget in Infrastructure. Policymakers should critically consider and manage these factors, as they have the potential to significantly improve road freight transport costs in Thailand.

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6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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