Study on the effectiveness of using transport routes and transport vehicles through analysing the effects of them on transportation output: The case of China

Scientific Modelling and Research
Vol. 8, No. 1, 1-23, 2023
e-ISSN: 2523-952X

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ABSTRACT

This study investigates the impact of 16 exogenous variables, such as transport routes and vehicles, on two endogenous variables: the growth of transported passengers' output and the growth of carried goods' output in China. The research also delves into how endogenous variables affect the average distance traveled by passengers and goods. The methodology encompasses structural equation modeling (SEM) analysis with goodness of it tests conducted in three steps using Stata 17.0 software. A cargo medium vehicle positively influences the growth of goods shipped and passengers transported, while negatively affecting the average passenger distance traveled. A Heavy Cargo Private Vehicle has a negative impact on the growth of passengers transported. Electrified Railway Length positively influences the growth of passengers transported. Growth of passengers transported positively affects the growth of goods shipped. Positive effects of exogenous variables on endogenous variables result in positive effects on other variables, suggesting an increase in exogenous variables. Negative effects of exogenous variables on endogenous variables lead to positive effects on other variables, suggesting a decrease in exogenous variables. Positive effects of exogenous variables on endogenous variables do not influence other variables, recommending an increase in exogenous variables.

Keywords: *China, Growth of transported goods, Growth of transported passengers, SEM, Transportation output's growth, Transportation routes, Transportation vehicles.*

DOI: 10.55284/smr.v8i1.1012
Citation | Hanh , V. T. K. (2023). Study on the effectiveness of using transport routes and transport vehicles through analysing the effects of them on transportation output: The case of China. *Scientific Modelling and Research, 8*(1), 1–23.

Funding: This study received no specific financial support.
Institutional Review Board Statement: Not applicable.
Transparency: The author confirms that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
Competing Interests: The author declares that there are no conflicts of interests regarding the publication of this paper.
History: Received: 18 October 2023/ Revised: 30 November 2023/ Accepted: 13 December 2023/ Published: 29 December 2023
Publisher: Online Science Publishing

Highlights of this paper

- The article outlines China's transportation scenario, highlighting that boosting Cargo Medium Vehicle numbers positively impacts goods shipped and passengers transported.
- Decreasing Cargo Medium Vehicles is advised for higher average distance in passenger transport.

1. INTRODUCTION

China has experienced significant economic growth since 1978, accompanied by a substantial expansion of its transportation network. The country's economic prosperity has been closely tied to the development of transportation infrastructures, encompassing roadways, railways, ports, airports, and waterways [1-3].

China's transportation industry has experienced rapid growth in recent years. Railway is one of the most environmentally friendly and efficient ways to transport people and goods. As of December 2014, China had the world's largest high-speed railway network with more than 16,000 kilometers of track in operation [4].

By 2015, China had developed a national highway system comprising 35,000 kilometers of toll highways and expressways [5].

Inland waterway transportation plays an important role in China's economic development. Although inland waterway transportation has developed steadily, it is still uncoordinated with the development of market economy in some respects [6]. China had 170 cities with airports and 1,129 air routes in 2012 [7]. The number of airports increased from 135 in 2005 to 202 in 2014. Roadway mileage in China reached 4,463,900 km by the end of 2014. China’s expressways, among the various types of its roadways, cover approximately 111,900 kilometers as of 2014 [8].

2. LITERATURE REVIEW

The literature review was divided into two parts. A background theory is presented first, followed by an analysis and critique of previous studies with similar research scope. From there, we can identify the paper's new points and gaps.

2.1. Background Theory

Transport routes are important, but they must be analysed along with vehicle capacity and frequency to make the best choice. Roadway networks are limited in terms of selecting their routes and schedules. It must be scheduled and calculated based on the capacity of the vehicles [9].
Where,

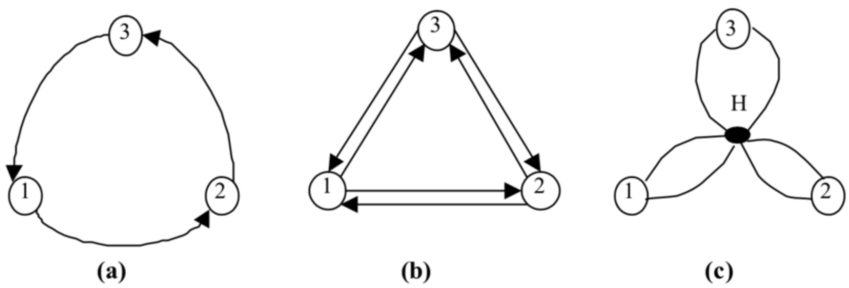

Figure 1. Service structures.

Source: Sergio [9].

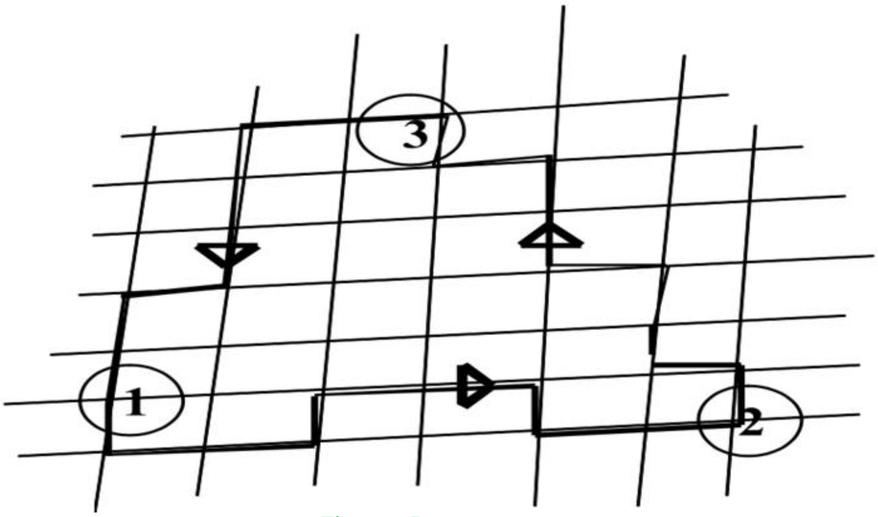

Figure 2. Route structure.

Source: Sergio [9].

Figure 1 Jara-Díaz [10] has structure a [11], b, and c, which are a general cyclical system, three simple cyclical systems, and a direct service. Structure c where it is created using a distribution node. Assigning vehicels is a part of the service structure; structure a is for one fleet (one frequency), structure b is for three fleets, and structure c is for with three options. Structure a should be chosen in Figure 1, Figure 2 [9] has only a possible route structure. According to Sergio [9], the output of a transportation process is the following vector;

$$Y = \{ y_{ij}^{kt} \} \epsilon \ R^{KxNxT} \quad (1)$$

Where,

k is a stream of type k.

i is the origin of the Transport Route.

j is the destination of the shipping Route.

t is the travel time from i and j.

K, N, T are the number of types of the stream.

y_{ij}^{kt} is each component represents a stream of type k travelling from origin i to destination j in time t.

2.2. Previous Related Studies

Several studies contribute to the understanding of transportation in China: Ming and Feng [12] emphasize the impact of China's national trunk highway system in enhancing traffic accessibility and connectivity among cities. Xiaoyu and Crookes [13] highlight the remarkable growth in sales of roadway vehicles, especially cars and sport utility vehicles. Riley [14] notes the transition from strict government control over private vehicle ownership to a more open system. Seaman [15] explores the diversification of oil and gas suppliers and transportation routes through pipelines in China. Yu, et al. [16] analyze the varying contribution of transportation to productivity in different regions of China. Anming and Chen [17] discuss the limited air traffic rights due to capacity constraints in domestic airports. Agnieszka, et al. [18] stress the need for transportation systems that cater to the vulnerable population. Na, et al. [19] identify factors contributing to unsustainable years in transportation sustainability in Shaanxi. Chen and Haynes [20] and Liwen and Zhang [21] examine the potential adverse effects of over-saturation of high-speed railway routes/stations. Abhijit, et al. [22] acknowledge the considerable benefits brought by transportation infrastructure to China's economy. Goh and Ling [23] point out the inadequacies in China's transportation networks. Zhang, et al. [24] affirm the timely and safe delivery of goods by railways. Fan, et al.

[25] explore the differential impact of expressways, trunk roadways, and railways on commercial activities in China. Chen [26] examines the substitutional effect of high-speed railway services on domestic air transportation in China. In collecting, reviewing, and producing a structured literature review, we have tried to gather and synthesise information and knowledge from reputable and scientific sources. There have been studies published by reputable journals through reputable publishers related to transportation routes, vehicles, and the economy of China in the past. The literature review achieves certain findings and contributions both in theory and application. That is the significance as the basis for our reference to carry out this study. However, previous studies are not directly related to the measurement an effectiveness of using transport routes, transport vehicles through the transportation output indicator. It is our belief that this study fills a gap in this topic.

2.3. Novel Points of Study

Measuring an effectiveness of using transportation routes, transportation vehicles through the transportation output indicator. The new point is that we have deeply analyzed eight variables about the length of the routes, including Railway length, Electrified railway length, Highway length, Expressway length, Inland waterway length, Air length, International routes length, and Pipelines length, and eight variables about vehicles of transport, including Large buses transport passengers, Small cars transport Passengers, Medium trucks carry cargo, Private large cars transport Passengers, Private medium cars transport passenger, Private minicar cars transport passenger, Private truck carry heavy cargo, and Private trucks carry light cargo. That have never been studied before.

3. METHODOLOGY

3.1. Study Model

Figure 3: Study model.

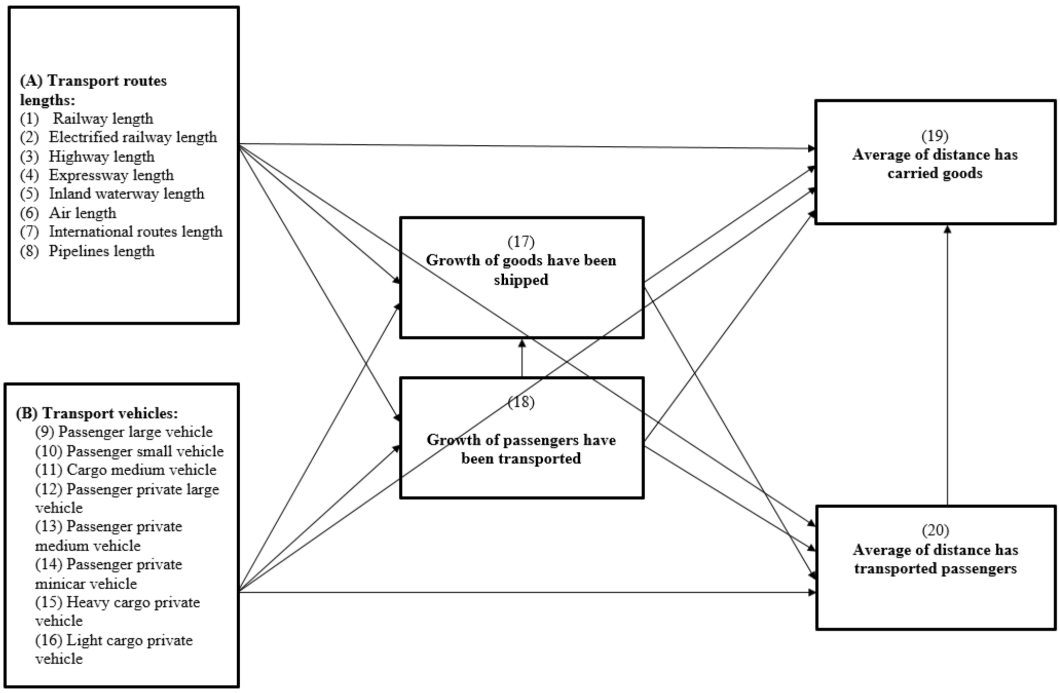

Figure 3. illustrates the comprehensive study model, incorporating sixteen exogenous variables denoting various transport route lengths (1-8) and types of transport vehicles (9-16). Additionally, the model includes four endogenous variables, specifically the growth of goods shipped, growth of passengers transported, average distance of goods transported, and average distance of passengers transported (17-20).

3.2. Formula of Study Model

Depicted in Figure 3, encompasses sixteen exogenous variables representing diverse lengths of transport routes and types of transport vehicles. Additionally, the model incorporates four endogenous variables: the growth of goods shipped, growth of passengers transported, average distance of goods transported, and average distance of passengers transported.

$$X = a_i + A_{iai} + B_i b_i + e.X \quad (2)$$

Where:

X includes growth of goods have been shipped and growth of passengers have been transported.

A is transport routes lengths.

i is from 1 to 8, including railway length, electrified railway length, highway length, expressway length, inland waterway length, air length, international routes length, and pipelines length, respectively.

B is Transport Vehicles.

i is from 9 to 16, including passenger large vehicle, passenger small vehicle, cargo medium vehicle, passenger private large vehicle, passenger private medium vehicle, passenger private minicar vehicle, heavy cargo private vehicle, and light cargo private vehicle, respectively.

$$Y = a_i + A_{iai} + B_i b_i + X_i x_i + e.Y \quad (3)$$

Where:

Y value includes the average distance that goods have been transported and the average distance that passengers have been transported.

From (1), (2), we have:

(A, B, X, Y, e.X, e.Y) ~ i.i.d. with mean vector μ and covariance matrix Σ where i.i.d. means that observations are independent and identically distributed.

We must appreciate that μ and Σ are estimated, just as are a_i, b_i, x_i. Some of the elements of Σ, however, are constrained to be 0; which elements are constrained is determined by how we specify the model [27].

3.3. Explanation of Variables in Study Model

The SEM study model includes seven exogenous variables and fourteen endogenous variables. These are:

The sixteen exogenous variables are:

(1) Railway Length (Km).

(2) Electrified Railway Length (Km).

(3) Highway Length (Km).

(4) Expressway Length (Km).

(5) Inland Waterway Length (Km).

(6) Air Length (Km).

(7) International Routes Length (Km).

(8) Pipelines Length (Km).

(9) Passenger Large Vehicle (Bus).

(10) Passenger Small Vehicle (Car).

(11) Cargo Medium Vehicle (Truck).

(12) Passenger Private Large Vehicle (Car).

(13) Passenger Private Medium Vehicle (Car).

(14) Passenger Private Minicar Vehicle (Car).

(15) Heavy Cargo Private Vehicle (Truck).

(16) Light Cargo Private Vehicle (Truck).

The four endogenous variables are:

(17) Growth of Goods have been shipped (10,000 people).

(18) Growth of Passengers have been transported (10,000 tons).

(19) Average of Distance has carried goods (km).

(20) Average of Distance has transported passengers (km).

3.4. Data Collect and Methodology

3.4.1. Data Collecting

Data was collected through a two-step process. In the first step, secondary data was manually extracted from the National Bureau of Statistics of China.

The intact dataset, comprising 100% of the extracted data, was then tabulated in Excel and imported into Stata 17.0 software for analysis.

3.4.2. Methodology

The methodology involved computing descriptive statistics, checking for collinearity/multicollinearity, and estimating the SEM using observed information matrix (OIM) and expected information matrix (EIM) techniques. Three steps of SEM's Fit Goodness testing, including root mean square error of approximation (RMSEA), comparative fit index (CFI), and Tucker–Lewis index (TLI), were performed.

Table 1. Variables' statistics summary.

Variable name	Variable description	Unit of variables	Number of observed variables	Mean	Standard deviation	Min.	Max.
RW_length	Railway length	Km	14	9.97	2.01	7.54	13.1
ERW_length	Electrified railway length	Km	14	4.50	2.59	1.94	9.22
HW_length	Highway length	Km	14	414	49.8	334	484
EW_length	Expressway length	Km	14	9.07	3.49	4.1	14.2
IWW_length	Inland waterway -length	Km	14	12.5	0.16	12.2	12.71
Air_length	Air length	Km	14	407	208	199	837
IR_length	International routes length	Km	14	172	92.0	85.5	359
PPL_length	Pipelines length	Km	14	8.53	2.71	4.4	12.2
LP_vehicle	Passenger large vehicle	Bus	14	122	24.6	82.1	158
SP_vehicle	Passenger small vehicle	Car	14	884	618	161	201
MC_truck	Cargo medium vehicle	Truck	14	208	53.4	124	269
PLP_vehicle	Passenger private large vehicle	Car	14	7.75	1.97	4.48	11.1
PMP_vehicle	Passenger private medium vehicle	Car	14	46.0	15.4	20.3	62.3
PMNP_vehicle	Passenger private minicar vehicle	Car	14	276	55.1	173	347
CHP_vehicle	Heavy cargo private vehicle	Truck	14	140	53.6	62.5	208
CLP_vehicle	Light cargo private vehicle	Truck	14	766	370	243	132
People transported volume growth	Growth of passengers have been transported	10,000 people	15	0.01	0.15	-0.44	0.28
Freight carried volume growth	Growth of goods have been shipped	10,000 tons	14	0.07	0.05	-0.00	0.14
People carried distance average	Average of distance has transported passengers	Km	14	119	39.2	81	191
Freight carryied distance average	Average of distance has carried goods	Km	14	426	12.8	397	446

3.5. Study Hypothesis

H_1: The exogenous variables, including (1), (2), (3), (4), (5), (6), (7), (8), (9), (10), (11), (12), (13), (14), (15), and (16) affect the endogenous variables, including (17), (18), (19), and (20).

H_2: The endogenous variable (18) affects the endogenous variables, including (17)), (19), and (20).

H_3: The endogenous variable (17) affects the endogenous variable (19) and (20).

H_4: The endogenous variable (20) affects the endogenous variable (19).

4. DATA SOURCE

The data is time series data between 2005 and 2018, which has been collected and extracted by manual method by the authors from National Bureau of Statistics of China.

5. STUDY RESULTS

5.1. Summary of Statistics of Variables Employed

Table 1 is Summary of statistics of variables employed, including Variable Name, Variable Description, Number of Observed variables, Mean, Standard Deviation, Min, and Max.

Variable name is shown in the 1st column on the left.

The Variable description is the 2nd column from the left.

The 3rd column from the left is Unit of Variables.

The 4th column from the left is Number of Observed variables: There is a total of 15 Observed variables.

The 5th column from the left is Mean: The Mean is between 0113368 and 8840.191 in which .0113368 is Mean of Growth of Passengers have been transported, and 8840.191 is Mean of Passenger Small Vehicle.

The 6th column from the left is Standard Deviation: The values of Standard Deviation are fluctuated from .0556709 to 6181.705 in which .0556709 is the Standard Deviation of Growth of Goods have been shipped, and 6181.705 is the Standard Deviation of Passenger Small Vehicle.

The 2nd column from the right is Min: The values of Min are fluctuated between -.4419105 and 1618.35 in which -.4419105 is the Min of Growth of Passengers have been transported, and 1618.35 is the Min of Passenger Small Vehicle.

The 1st column on the right is Max: The values of Max are from .1474521 to 20135.22 in which .1474521 is the Max of Growth of Goods have been shipped, and 20135.22 is the Max of Passenger Small Vehicle.

5.2. Collinearity / Multicollinearity

We built a multivariate regression model for collinearity / multicollinearity checking, a multivariate regression model has 16 independent exogenous variables, including railway length, electrified railway length, highway length, expressway length, inland waterway length, air length, international routes length, pipelines length, passenger large vehicle, passenger small vehicle, cargo medium vehicle, passenger private large vehicle, passenger private medium vehicle, passenger private minicar vehicle, heavy cargo private vehicle, and light cargo private vehicle and one dependent endogenous variable of a group includes four endogenous variables, which has a direct correlation with 16 independent exogenous variables mentioned above, that is growth of volume transported passenger.

The results of multivariate regression are shown in Table 2.

Table 2. Collinearity/multicollinearity of exogenous independent variables.

1st Multivariate regression			2nd after removed railway length, expressway length, inland waterway length, and passenger large vehicle			3rd multivariate regression after removed passenger small vehicle, passenger private minicar vehicle, and light cargo private vehicle			4th multivariate regression after removed highway length and pipelines length		
R-squared = 1.0000	Independent exogenous variable	VIF	R-squared = 1.0000	Independent exogenous variable	VIF	R-Squared = 0.7222	Independent exogenous variable	VIF	R-squared = 0.6410	Independent exogenous variable	VIF
	Rail way length	Collinearity									
	Electrified railway length	8050.87		Electrified railway length	8050.87		Electrified railway length	55.77		Electrified railway length	44.55
	Highway length	7165.63		Highway length	7165.63		Highway Length	1266.64			
	Expressway length	Collinearity									
Adjusted R-squared = …	Inland waterway length	Collinearity	Adjusted R-squared = …			Adjusted R-Squared = 0.0971			Adjusted R-squared = 0.2221		
	Air length	2483.95		Air length	2483.95		Air Length	448.49		Air Length	362.69
	International routes length	5134.37		International routes length	5134.37		International routes length	513.08		International routes length	370.37
	Pipelines length	8434.79		Pipelines length	8434.79		Pipelines Length	2003.56			
	Passenger large vehicle	38433.91									
	Passenger small vehicle	352299.38		Passenger small vehicle	352299.38						
	Cargo medium vehicle	1545.82		Cargo medium vehicle	1545.82		Cargo medium	98.92		Cargo medium	76.95
	Passenger private large vehicle	11.58		Passenger private large vehicle	11.58		Passenger private large vehicle	6.73		Passenger private large vehicle	5.28
	Passenger private medium vehicle	2699.84		Passenger private medium vehicle	2699.84		Passenger private medium vehicle	197.74		Passenger private medium vehicle	119.93
	Passenger private minicar vehicle	20440.85		Passenger private minicar vehicle	20440.85						
	Heavy cargo private vehicle	3592.52		Heavy cargo private vehicle	3592.52		Heavy cargo private vehicle	118.31		Heavy cargo private vehicle	13.54
	Light cargo private vehicle	267064.78		Light cargo private vehicle	267064.78						

Table 2. (Continuing): Collinearity/multicollinearity of exogenous independent variables.

			6[th] Multivariate regression after removed passenger Private medium vehicle			7[th] Multivariate regression after removed air length		
R-squared = 0.5518	Independent exogenous variable	VIF	R-squared = 0.5514	Independent exogenous variable	VIF	R-squared = 0.5222	Independent exogenous variable	VIF
	Electrified railway length	22.44		Electrified railway length	14.86		Electrified railway length	7.42
Adjusted R-squared = 0.1677	Air length	30.21	Adjusted R-squared = 0.2711	Air length	30.18	Adjusted R-squared = 0.3098		
	Cargo medium vehicle	76.58		Cargo medium vehicle	8.04		Cargo medium vehicle	7.03
	Passenger private large vehicle	4.50		Passenger private large vehicle	3.73		Passenger private large vehicle	3.01
	Passenger private medium vehicle	119.93						
	Heavy cargo private vehicle	5.51		Heavy cargo private vehicle	4.04		Heavy cargo private vehicle	2.38

Table 2 shows the results of three multivariate regressions conducted by the authors.

The results of the first multivariate regression: R-Squared = 1.00. Three independent exogenous variables have VIF > 10, including railway length, expressway length, and inland waterway length are collinearity, and passenger large vehicle has VIF = 38433.91. Thus, railway length, expressway length, inland waterway length, and passenger large vehicle were removed.

The results of the second multivariate regression after removed railway length, expressway length, inland waterway length, and passenger large vehicle: R-Squared = 1.0000. There are 12 independent exogenous variables with VIF > 10 but they are the smallest VIF values, including VIFs of electrified railway length = 8050.87, highway length = 7165.63, air length = 2483.95, international routes length = 5134.37, pipelines length = 8434.79, passenger small vehicle = 352299.38, cargo medium vehicle = 1545.82, passenger private large vehicle = 11.58, passenger private medium vehicle = 2699.84, passenger private minicar vehicle = 20440.85, heavy cargo private vehicle = 3592.52, light cargo private vehicle = 267064.78. Therefore, these 12 independent exogenous variables were kept for the third multivariate regression.

The results of the third multivariate regression after removed passenger small vehicle, passenger private minicar vehicle, and light cargo private vehicle: R-Squared = 0.7222, Adjusted R-Squared = 0.0971. There are two independent exogenous variables, including Highway Length has VIF = 1266.64 and Pipelines Length has VIF = 2003.56 were removed. The remaining seven variables were kept for the 4th Multivariate Regression.

The results of the fourth multivariate regression after removed highway length and pipelines length: R-squared = 0.6410 and Adjusted R-squared = 0.2221. One independent exogenous variable hasVIF > 10 is international routes length with FIV = 370.37 was removed. The six variables were kept for the fifth multivariate regression.

The results of the fifth multivariate regression after removed the international routes length: R-Squared = 0.5518, Adjusted R-Squared = 0.1677. There are six variables were kept for the sixth multivariate regression, including railway length has VIF = 22.44, air length has VIF = 30.21, cargo medium vehicle has VIF = 76.58, passenger private large vehicle has VIF = 4.50, passenger private medium vehicle has VIF = 119.93, and heavy cargo private vehicle has VIF = 5.51.

The results of the sixth multivariate regression after removed the passenger private medium vehicle: R-Squared = 0.5514, Adjusted R-Squared = 0.2711. There is one air length has VIF = 30.18 was removed. The other ones, including electrified railway length, cargo medium vehicle, passenger private large vehicle, and heavy cargo private vehicle were kept for the seventh multivariate regression.

The results of the seventh multivariate regression after removed the air length: R-Squared = 0.5222, Adjusted R-Squared = 0.3098. All four independent exogenous variables, including electrified railway length has VIF = 7.42, cargo medium vehicle has VIF = 7.03, passenger private large vehicle has VIF = 3.01, and heavy cargo private vehicle has VIF = 2.38 were kept for the exploratory factor analysis.

Table 3. Kaiser-Meyer-Olkin (KMO) analysis results.

Exogenous variables: Electrified railway length, cargo medium vehicle, passenger private large vehicle, and heavy cargo private vehicle	
Bartlett test of sphericity	
Chi-square	40.308
Degrees of freedom	6
p-value	0.001
Kaiser-Meyer-Olkin (KMO)	0.797

5.3. Result of EFA Analysis.

Table 3 is the KMO result on ensuring the completeness of the sampling. KMO = 0.797, P-value = 0.001.

According to Hair, et al. [28] and Tabachnick and Linda [29], KMO > = 0.5 is considered appropriate. But Netemeyer, et al. [30] consider that KMO is above than 0.60 - 0.70 is considered appropriate.

Thus, the results are consistent with the theory mentioned above.

Table 4. Results of factor analysis and correlation.

Variables	Factor	Eigenvalue	Difference	Proportion	Cumulative
Electrified railway length	Factor 1	3.27	2.83	0.81	0.81
Cargo medium vehicle	Factor 2	0.43	0.22	0.10	0.92
Passenger private large vehicle	Factor 3	0.21	0.13	0.05	0.98
Heavy cargo private vehicle	Factor 4	0.07	0.02	0.01	1.00

Table 4 is the result of factor analysis and correlation. The method is principal-component factors. It shows the eigenvalues of Factor 1 is greater than 1, all factors have stopped at 100% of the explained variance.

The total variance of the Factor 1 was extracted is 0.8180, showing that this Factor 1 explains 81.80% of the data variation of the four observed variables in the factor analysis.

According to K1 - Kaiser's method [31], only structures with Eigenvalues are greater than one (1) are kept for interpretation [32-34]. And, according to Hair, et al. [28] and Pett, et al. [35], factors should be stopped when at least 95% of the variance is explained.

Thus, the results are consistent with the theory mentioned above.

Table 5. Result of factor loading and unique variance.

Variables	Factor 1	Uniqueness
Electrified railway length	-0.95	0.08
Cargo medium vehicle	0.94	0.10
Passenger private large vehicle	0.87	0.22
Heavy cargo private vehicle	-0.83	0.30

Table 5 is the result of factor loading and unique variance, the result shows that the factor loading coefficients of four observed variables have large magnitude.

According to Robert [36], "Because factor loadings can be positive or negative, the averages computed and analyzed were the averages of the absolute values of the loadings reported".

According to Hair, et al. [37] and Anderson and Gerbing [38], 0.3 <= Factor loading <= 0.4 is considered minimal, factor loading >= 0.5 is considered to be of practical significance.

The average of the absolute values of factor loading coefficients of the four observed variables is (|-0.9556| + 0.9467 + 0.8782 + |-0.8314|) = 0.9030 .

Thus, the results are consistent with the theory mentioned above.

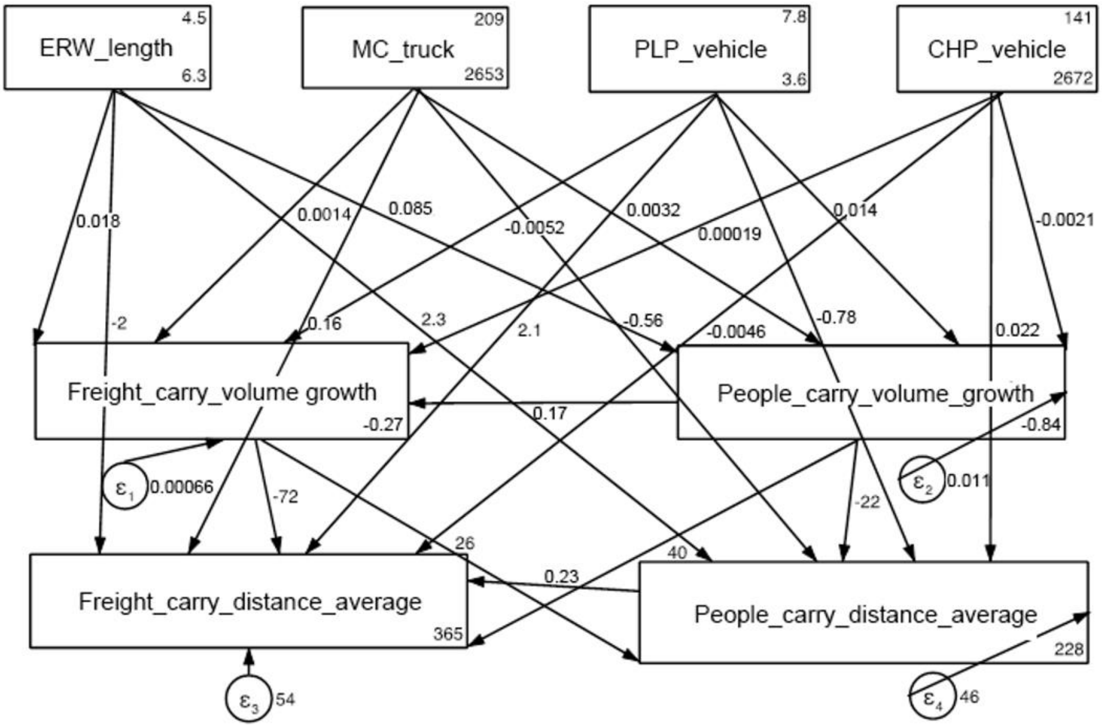

Figure 4. Depiction of SEM estimation.

5.4. SEM Estimation Result

5.4.1. SEM Estimation Depiction

Figure 4 is a depiction of the SEM estimation according to the maximum likelihood estimation method. The depiction illustrates the cause-and-effect relationship between exogenous variables and endogenous variables. Exogenous variables and endogenous variables are in the boxes, latent variables are in the circles.

The four exogenous variables are:

ERW_Length (Electrified Railway Length).

MC_Truck (Cargo Medium Vehicle).

PLP_Vehicle (Passenger Private Large Vehicle).

CHP_Vehicle (Heavy Cargo Private Vehicle).

The four endogenous variables are:

Freight_carry_volume_Growth (Growth of Goods have been shipped).

People_carry_volume_Growth (Growth of Passengers have been transported).

Freigth_carry_Distance_Average (Average of distance has carried goods).

People_carry_Distance_Average (Average of distance has transported passengers).

5.4.2. SEM Estimation's Results

Appendix 1 is the SEM estimation result was processed by observed information matrix (OIM) technique and by expected information matrix (EIM) technique. Figure 4 illustrates the cause-and-effect relationship between four exogenous variables and four endogenous variables.

1: The H1 hypothesis: Exogenous variables affect endogenous variables

The effects of electrified railway length, cargo medium vehicle, passenger private large vehicle, and heavy cargo private vehicle on growth of goods have been shipped:

The result is cargo medium vehicle positively affects growth of goods have been shipped.

the effects of electrified railway length, cargo medium vehicle, passenger private large vehicle, and heavy cargo private vehicle on growth of passengers have been transported:

First result: Cargo Medium Vehicle positively affects Growth of Passengers have been transported.

Second result: Heavy Cargo Private Vehicle negatively affects Growth of Passengers have been transported.

Third result: Electrified Railway Length positively affects Growth of Passengers have been transported.

The effects of Electrified Rail Way Length, Cargo Medium Vehicle, Passenger Private Large Vehicle, and Heavy Cargo Private Vehicle on Average of Distance has carried goods:

There is no effects on Average of Distance has carried goods.

The effects of Electrified Rail Way Length, Cargo Medium Vehicle, Passenger Private Large Vehicle, and Heavy Cargo Private Vehicle on Average of Distance has transported passengers:

The only result is Cargo Medium Vehicle negatively affects Average of Distance has transported passengers.

2: The H2 hypothesis: Growth of Passengers have been transported affects Growth of Goods have been shipped, Average of Distance has carried goods, and Average of Distance has transported passengers.

The result is Growth of Passengers have been transported positively affects Growth of Goods have been shipped.

3: The H3 hypothesis: Growth of Goods have been shipped affects Average of Distance has carried goods and Average of Distance has transported passengers.

The growth in goods shipped has no impact on the average distance goods have been transported nor does it affect the average distance passengers have been transported.

4: The H4 hypothesis: Average of Distance has transported passengers affects Average of Distance has carried goods.

Consequently, the average of distances traveled by passengers has no impact on the average of distances traveled by goods.

Table 6. RMSEA, CFI, and TLI test results.

Probability RMSEA	**<= 0.05**
Comparative fit index (CFI)	1.000
Tucker–Lewis index (TLI).	1.000

5.5. Testing the Goodness of Fit of SEM

5.5.1. Root Mean Square Error of Approximation (RMSEA)

Table 6 is RMSEA, CFI, and TLI test results of SEM: Probability RMSEA of SEM <= 0.05, CFI = 1.000, and TLI = 1.000.

Browne and Cudeck [39] define 'close match' as an RMSEA value less than or equal to 0.05. And, according to Hu and Bentler [40], a good model–data fit is indicated by RMSEA < .06, CFI > .95, and TLI > .95.

Thus, this result satisfies the theory mentioned above.

6. DISCUSSION

Upon checking for Collinearity/Multicollinearity, four exogenous variables that had a VIF less than 10 (VIFs < 10) were selected for the EFA analysis, namely electrified railway length, cargo medium vehicle, passenger private large vehicle and heavy cargo private vehicle.

The EFA analysis: KMO = 0.797. The total variance of the Factor 1 extracted is 0.8180 that explains 81.80% of the data variation of the four observed variables in the factor analysis. The average of the absolute values of factor loading coefficients of the four observed variables is 0.9030 .

Based on the results of Collinearity/Multicollinearity checking and EFA analysis, four exogenous variables mentioned above were chosen for SEM estimation.

The results of SEM estimated by OIM technique and EIM technique give the same results on the effects between four exogenous variables and four endogenous variables. Four exogenous variables, including electrified railway length, cargo medium vehicle, passenger private large vehicle, and heavy cargo private vehicle. There are four endogenous variables, including the growth of goods shipped, the growth of passengers transported, the average distance of goods transported and the average distance of passengers transported.

The results of SEM estimation are as follows:

1. Hypothesises H_3 and H_4 are rejected.

2. The H_1 hypothesis, in which exogenous variables affect endogenous variables, has following effects:

First result: Cargo medium vehicle positively affects growth of goods have been shipped at coefficient = .0013615.

Second result: Cargo medium vehicle positively affects growth of passengers have been transported at coefficient = .0031671.

Third result: Heavy cargo private vehicle negatively affects growth of passengers have been transported at coefficient = -.0021221.

Fourth result: Electrified railway length positively affects growth of passengers have been transported at coefficient = .0852954.

Fifth result: Cargo medium vehicle negatively affects average of distance has transported passengers at coefficient = -.5638614.

3. The H_2 hypothesis in which growth of passengers have been transported affects growth of goods have been shipped, average of distance has carried goods, and average of distance has transported passengers has following effect:

The only result is growth of passengers have been transported positively affects growth of goods have been shipped at coefficient = .1723231.

7. CONCLUSION

Theory: The paper supports the theory of Sergio [9] that transport routes are important, and they must be analysed in conjunction with vehicle capacity and frequency so that the best option can be selected. Road networks are restricted in their ability to choose their routes and schedules. It should be scheduled and calculated according to the capacity of the vehicles.

7.1. Practicality

7.1.1. First

Hypothesises H3 is rejected; This means that the growth in the number of goods shipped has neither an impact on the average distance of goods transported nor the average distance of passengers transported. This shows that the growth of goods volume can be reduced or increased depending on practical needs.

Hypothesises H4 is rejected; In this case, the average of distance travelled by passengers can be increased or decreased according to actual needs without affecting the dependent variable, which is average of distance travelled by goods.

7.1.2. Second

The H1 hypothesis; Exogenous variables affect endogenous variables; there are five effects in this case, they are following:

Because the Cargo medium vehicle variable positively affects the growth of goods have been shipped variable, but the growth of goods have been shipped variable neither affects the average of distance has carried goods variable and nor affects the average of distance has transported passengers variable. So the solution is an increase in the Cargo medium vehicle will increase the growth of goods have been shipped (1).

Because the Cargo medium vehicle variable positively affects the growth of passengers have been transported variable, and the growth of passengers have been transported variable positively affects the growth of goods have been shipped variable. In this case, the only proposal of ours is to increase the cargo medium vehicle to have an increase in both of the growth of passengers have been transported and the growth of goods have been shipped (2).

Because the Cargo medium vehicle variable negatively affects the average of distance has transported passengers variable, but the average of distance has transported passengers variable does not affect the average of distance has carried goods variable. So the solution is if we want to increase the average of distance has transported passengers, it is necessary to decrease the cargo medium vehicle (3).

Based on (1), (2), and (3), we recommend increasing cargo medium vehicles in order to increase the number of goods shipped and the number of passengers transported.

A heavy cargo private vehicle negatively affects the growth of passengers transported, but a growth in passengers transported positively affects the growth of goods shipped. According to our opinion, heavy cargo private vehicles should be decreased in order to increase the number of passengers transported, and the number of goods shipped will also increase according to (4).

Electrified railway length positively affects growth of passengers have been transported, growth of passengers have been transported positively affects growth of goods have been shipped. In this case, it is clear that an increase in electrified railway length will increase both growth of passengers have been transported and growth of goods have been shipped (5).

7.1.3. Third

In accordance with the H2 hypothesis, the growth of passengers has been transported positively affects the growth of goods has been shipped, whereas the growth of goods has been shipped does not affect the average distance has carried goods nor does it affect the average distance has transported passengers. Accordingly, an increase in the number of passengers transported will result in an increase in the number of goods shipped (6).

7.2. Implications

The first: When one exogenous variable influences endogenous variables, these endogenous variables in turn influence other variables in a positive manner. Our recommendation is to increase an exogenous variable. A cargo medium vehicle, for instance, positively affects the growth of passengers who have been transported, and the growth of passengers who have been transported positively affects the growth of goods that have been shipped (2). Our idea is to increase the number of cargo medium vehicles.

The Second: In the event that one exogenous variable negatively affects an endogenous variable, those endogenous variables will positively affect other variables. We recommend a decrease in an exogenous variable. A heavy cargo private vehicle, for example, negatively affects the growth of passengers who have been transported while a growth in passengers who have been transported positively affects the growth of goods that have been shipped (4). We propose a reduction in heavy cargo private vehicles in this instance.

The Third: if one exogenous variable positive affects on endogenous variables, these said endogenous variables do not affect any other variables. It is recommended that an exogenous variable be increased. For instance, cargo medium vehicle positively affects growth of goods have been shipped, growth of goods have been shipped neither affects average of distance has carried goods and nor affects average of distance has transported passengers (1). In this case, our advice is to increase cargo medium vehicle.

The Fourth: if one exogenous variable negatively affects endogenous variables, these said endogenous variables do not affect any other variables. The advice is to decrease an exogenous variable. For example, cargo medium vehicle negatively affects average of distance has transported passengers, average of distance has transported passengers does not affect average of distance has carried goods (3). In this case, our advice is to decrease cargo medium vehicle.

Limitations: At the step of Factor loading and Unique variance analysis of EFA, we have found that Factor loading coefficients of Factor 1 and Factor 4 are negative, they are -0.9556 and -0.8314, respectively. Thus, we had to use the theory of Robert [36], in terms of negative factors to do the averages of the absolute values of the Factor loadings coefficients".

Next study: We will study 'Factors affect the development of transportation and warehousing: the case of Ho Chi Minh, Vietnam'.

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APPENDIX

Appendix 1. Results of analysis of direct, indirect and total effects of SEM estimation processed by the expected information matrix (EIM) technique.

Direct effects							
Endogenous variables	**Exogenous variables**	**Coefficient**	**EIM std. err.**	**z**	**P > |z|**	**[95% conf. interval]**	
Growth of goods have been shipped	Electrified railway length	0.02	0.01	1.89	0.05	-0.00	0.03
	Cargo medium vehicle	0.01	0.00	3.31	0.00	0.00	0.00
	Passenger private large vehicle	-0.01	0.01	-0.82	0.41	-0.01	0.00
	Heavy cargo private vehicle	0.01	0.00	0.75	0.45	-0.00	0.00
	Growth of passengers have been transported	0.17	0.07	2.63	0.00	0.04	0.30
Growth of passengers have been transported	Electrified railway length	0.09	0.03	2.79	0.00	0.02	0.14
	Cargo medium vehicle	0.00	0.00	2.19	0.02	0.00	0.00
	Passenger private large vehicle	0.01	0.03	0.54	0.58	-0.03	0.06
	Heavy cargo private vehicle	-0.00	0.00	-2.53	0.01	-0.00	-0.00
Average of distance has carried goods	Electrified railway length	-2.02	3.06	-0.66	0.51	-8.02	3.98
	Cargo medium vehicle	0.16	0.23	0.69	0.48	-0.28	0.60
	Passenger private large vehicle	2.10	1.87	1.12	0.26	-1.56	5.77
	Heavy cargo private vehicle	-0.00	0.07	-0.06	0.94	-0.14	0.13
	Growth of goods have been shipped	-72.0	76.6	-0.94	0.34	-222	78.2
	Growth of passengers have been transported	40.3	23.7	1.70	0.08	-6.16	86.7
	Average of distance has transported passengers	0.23	0.29	0.78	0.43	-0.34	0.79
Average of distance has transported passengers	Electrified railway length	2.29	2.75	0.83	0.40	-3.10	7.68
	Cargo medium vehicle	-0.56	0.14	-3.91	0.00	-0.84	-0.28
	Passenger private large vehicle	-0.78	1.71	-0.46	0.64	-4.13	2.57
	Heavy cargo private vehicle	0.02	0.07	0.33	0.74	-0.10	0.15
	Growth of goods have been shipped	25.5	70.2	0.36	0.71	-112	163
	Growth of passengers have been transported	-21.6	21.0	-1.03	0.30	-62.8	19.5
Indirect effects							
Structural		Coefficient	EIM std. err.	z	P > |z|	[95% conf. interval]	
Endogenous variables	Exogenous variables						
	Electrified railway length	0.01	0.01	1.91	0.05	-0.00	0.02

Growth of goods have been shipped	Cargo medium vehicle	0.00	0.00	1.68	0.09	-0.00	0.00
	Passenger private large vehicle	0.00	0.00	0.53	0.59	-0.00	0.01
	Heavy cargo private vehicle	-0.00	0.00	-1.82	0.06	-0.00	0.00
Average of distance has carried goods	Electrified railway length	1.39	2.41	0.58	0.56	-3.32	6.11
	Cargo medium vehicle	-0.14	0.21	-0.68	0.49	-0.55	0.27
	Passenger private large vehicle	0.50	0.99	0.51	0.61	-1.43	2.44
	Heavy cargo private vehicle	-0.05	0.05	-1.15	0.25	-0.15	0.04
	Growth of goods have been shipped	5.81	17.6	0.33	0.74	-28.7	40.3
	Growth of passengers have been transported	-16.3	15.7	-1.04	0.29	-47.1	14.4
Average of distance has transported passengers	Electrified railway length	-1.02	2.00	-0.51	0.61	-4.94	2.90
	Cargo medium vehicle	-0.02	0.11	-0.18	0.86	-0.24	0.20
	Passenger private large vehicle	-0.37	0.65	-0.58	0.56	-1.64	0.89
	Heavy cargo private vehicle	0.04	0.04	0.99	0.32	-0.04	0.12
	Growth of passengers have been transported	4.39	12.2	0.36	0.71	-19.5	28.3
Total effects							
Structural		Coefficient	EIM std. err.	z	P > |z|	[95% conf. interval]	
Endogenous variables	Exogenous variables						
Growth of goods have been shipped	Electrified railway length	0.03	0.01	3.53	0.00	0.01	0.05
	Cargo medium vehicle	0.00	0.00	4.40	0.00	0.00	0.00
	Passenger private large vehicle	-0.00	0.01	-0.37	0.71	-0.02	0.01
	Heavy Cargo private vehicle	-0.00	0.00	-0.72	0.47	-0.00	0.00
	Growth of passengers have been transported	0.17	0.07	2.63	0.00	0.05	0.30
Growth of passengers have been transported	Electrified railway length	0.09	0.03	2.79	0.00	0.02	0.15
	Cargo medium vehicle	0.00	0.00	2.19	0.02	0.00	0.01
	Passenger private large vehicle	0.01	0.02	0.54	0.58	-0.03	0.064
	Heavy cargo private vehicle	-0.00	0.00	-2.53	0.01	-0.00	-0.00
Average of distance has carried goods	Electrified railway length	-0.62	2.36	-0.26	0.79	-5.25	4.00
	Cargo medium vehicle	0.01	0.11	0.13	0.89	-0.20	0.23
	Passenger private Large Vehicle	2.61	1.98	1.32	0.18	-1.28	6.48
	Heavy Cargo Private Vehicle	-0.06	0.06	-0.97	0.33	-0.18	0.06
	Growth of goods have been shipped	-66.2	77.9	-0.85	0.39	-219	86.6
	Growth of passengers have been transported	23.9	19.5	1.22	0.22	-14.4	62.3
	Average of distance has transported	0.23	0.29	0.78	0.43	-0.34	0.79

	passengers						
Average of distance has transported passengers	Electrified railway length	1.26	2.04	0.62	0.53	-2.74	5.28
	Cargo medium vehicle	-0.58	0.09	-6.02	0.00	-0.77	-0.39
	Passenger Private Large Vehicle	-1.15	1.71	-0.67	0.50	-4.52	2.21
	Heavy cargo private vehicle	0.06	0.05	1.13	0.26	-0.04	0.17
	Growth of goods have been shipped	25.5	70.2	0.36	0.71	-112	163
	Growth of passengers have been transported	-17.2	17.2	-1.00	0.31	-51.1	16.6

Appendix 1 is the results of Direct effects, Indirect effects, and Total effects of SEM estimation was processed by EIM. Detailing the result of the cause-and-effect relationship between four exogenous variables and four endogenous variables described in Figure 1.

Four exogenous variables, including Electrified Railway Length, Cargo Medium Vehicle, Passenger Private Large Vehicle, and Heavy Cargo Private Vehicle.

Four endogenous variables, including Growth of Goods have been shipped, Growth of Passengers have been transported, Average of Distance has carried goods, and Average of Distance has transported passengers.