An Intercity Freight Mode Choice Model : A Case Study of High Speed Rail Link Northern Line Thailand (Bangkok – Chiangmai)

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Abstract. This paper presents a model capturing the intercity freight mode choice behaviour in high-speed rail system from Bangkok to Chiangmai. The model is developed based on the stated preference data collected from 800 freight operators, wholesaler, retailer, and people. The results show that, when the high-speed rail system from Bangkok to Chiangmai are developing in the future, the suitable products for high-speed rail system are types of an express mail service (EMS), air cargo, gold, jewellery, gold accessories, computer circuit boards, high prices agricultural products such as fruit, and flowers. Most of determining the selling price will fluctuate with the speed of transport and damage impairment of the product. With the application of discrete choice models, the results show that, aside from travel cost and time, loading and unloading, delays time, frequency are statistically significant. The application of model indicated that the holder and freight forwarder which in the line of high-speed rail (Bangkok – Chiangmai) tend to use rail-transport such as double-track rail is 27.71%, high-speed rail is 11.18% and the most is trucks 56.51% which is a policy development point loading and unloading, multimodal transportation efficiency and safety of the portion of the freight high-speed rail increased.

1 Introduction

The potential of infrastructure is the scorecard in the economic security and bargaining power of the country. The ranking of efficiency of transport infrastructure system by World Economic Forum (2013-2015) from 144 countries found that Thailand is ranked at 76th (2014-2015) [1] and has a recession trend and lower than other countries in ASEAN. Currently, the government has established a strategic plan of the Ministry of Transport issue 2nd, 2013-2017. That focuses on the development of rail infrastructure which helps reduce transportation costs and increase the country's competitiveness in trade. Since speed is an important factor both of business and lifestyle. So the high speed rails are an alternative way to transport goods, which can connect trade and investment with neighbouring countries and support changes in transportation modes to reduce the cost of logistics and fuel imports of the country.

Thailand also becomes one of the most ambitious countries to develop high speed rail. This transport is under the development of infrastructure and identified as one of the economic development policy. The combination of the project and the development of regional connectivity for social and economic stability provide opportunities for access to economic and social resources. For tourism, trade, education, agriculture and other industries to provide services[1].

From the above data, the researcher has the idea of studying the effect on infrastructure development especially the high speed rail project and the transportation of goods. The purpose is to evaluate and collect the type of goods and develop the behavior modeling of freight vehicle model selection in the future in case of the development of the Bangkok-Chiangmai high speed rail route.

Thus, the objectives of this paper presents a review and explore the behavior of choosing the mode of freight transport under scenario develop a new choice of freight model in the future such as high speed rails Bangkok-Chiangmai route.

2 Literature Review

This research has divided the related literature into 3 topics 1) Review of high speed rail 2) Discrete choice models; and 3) Multinomial logit model (MNL), to guide the development of freight mode choice model, the detail shows as following.

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2.1 High speed rail

High speed trains in Japan and Europe define that high speed trains can reach speed of 200 km/h on the same updated rail and 250 km/h on the new rail, the speed when transporting passengers. High speed trains in various countries mostly used to transport passengers, except Germany and Sweden, which transport people and goods together in the system. Gerhard Troche has determined the type of train according to the speed of service and characteristics of freight train [2].

Table 1. Possible demarcation of different rail freight services

Category	Maximum Speed:	Predominant vehicle concept:
High Speed Rail Freight	>200 km/h	Modified high-speed passenger train
Semi High Speed Rail Freight	140-200 km/h	Both vehicle based on passenger train concepts and further developed freight wagons
Conventional Rail Freight	< 140 km/h	Conventional freight wagons

Source: [3]

Freight experience by high speed train in aboard summarizes from the report "High-Speed Rail Freight" be a part of the study "Efficient train System for Freight Transport" by RTH Railway Group in Sweden in 2015. Which mention Sweden, France, Germany, and international transportation in Europe.

2.2.1 Sweden

Currently the high speed trains in Sweden serviced at 160 km/h because the limit of terrain and technologies. Providing freight services under the slogan "High speed freight, faster than by truck cheaper than by air". There are 2 types of products offered: the postal of Swedish Post Office and express parcel service performed by S.J. company. Mail service transportation uses dedicated mail train but express parcel services load parcels with passenger trains. From these services in 2001-2005 found that they can reduce highway transportation 3.4 million-km-truck equivalent to reducing diesel oil 1.36 million liters and reduce carbon monoxide emissions 3,534 tons per year [2].

2.2.2 France

France, like Sweden, provides postal services with dedicated train (TGV Postal Service). Express parcel services are provided by SNCF (Société nationale des chemins de fer français) as TGV-Fret, which uses the same train as TGV Postal Office. It can contain 10 minicontainers. At present, there is a joint service between countries in Europe by Carex (Cargo Rail Express) company with the goal of continuously delivering and distributing goods (Multimodal transport) from air freight between the main airport and domestic areas [3].

2.2.3 Germany

The interCargo Express (ICGE) freight trains provide general cargo services in 1991 at speed 140-160 km/h by dedicated train, which can load a maximum weight of 500 tons. In 2000, DB cargo company provides postal and domestic parcels transportation services with the goal of attracting transportation from 10,000 container trucks per year equal to the increasing in proportion of the company's rail transportation by 20% [2].

3 Methodology

3.1 Mode choice model

The mode choice model is a disaggregate model, which is created for behavior study in modes selection of travel and goods transportation. Choosing the factors for model analysis consist of speed, travel distance, travel expenses, convenience, and number of vehicle.

3.1.1 Random Utility Theory

Random utility theory is a theory with the assumption that decision maker will consider the options that are most beneficial, which satisfaction can be measured with utility function. The utility function is divided into 2 components: 1) determinant component and 2) random component including errors and survey measurement and individual taste, as shown in equation 1 [4].

$$u_{in} = v_{in} + \varepsilon_{in} \tag{1}$$

3.1.2 Discrete Choice Models

Random utility theory contains assumptions about the distribution of variables that cannot be measured, independent and random variables distributed in normal form or other forms such as probit models (normal distribution) and logit models (Gumbel distribution or type 1 extreme value). In mostly recent research, it is assumed that the variables are Gumbel distribution, which the equation is similar to normal distribution. This study use the logit model, which can show the probability of travelers in choosing the mode of travel, as show in equation 2 [5-8].

$$P_n(i) = \frac{e^{v_{in}}}{\sum_{j \in c_m} e^{v_{jn}}} \tag{2}$$

Logit model consist of travel equation utility model. If the model has 2-way travel options, such as transporting goods by truck and train, it is called binary logit model (BNL). However, the model that has more than 2-way travel options, it is called multinomial logit model (MNL).

3.1.3 Estimating coefficient of variables

Estimating coefficient of variables in utility function has many ways. Maximum likelihood (ML) method is the most used statistical method [9], as shown in equation 3.

$$L(\beta) = \prod_{n=1}^{N} \prod_{i} (P_{ni})^{Y_{ni}} \quad (3)$$

3.1.4 Statistical evaluation

Determining model fit, likelihood ratio index is the ability of the model to explain the variance and concordance (Goodness-of-Fit) of dependent variable. That value was developed to compare with the R^2 in linear regression model. However, logit model is non-linear, so R^2 is not equal to ρ^2, which is calculated by equation 4.

$$\rho^2 = 1 - \frac{L(\hat{\beta})}{L(0)} \quad (4)$$

ρ^2 will have a value between 0 to 1, if value is close to 1, meaning the model that be created can explain the relationship between variables as well, if value is close to 0, meaning that model cannot explain the relationship between variables. ρ^2 should greater than 0.2 [10] and if greater than 0.3, shown that it is appropriate [5,11].

3.1.5 Freight mode choice factor

From the study and survey of shippers in Florida (CUTR, 2004) have ranked the influences of various factors that affect the selection of mode of transportation of goods by entrepreneurs. Found that, main factors are overall cost of logistics and mode of transport. As shown in Table 2 [12].

Table 2. Factors that affect freight mode choice

Category	Factor
Total logistics cost	Transportation charges
	Capital carrying cost in transit
	Service reliability costs
Modal characteristics	Trip time and reliability
Physical attributes of goods	Shipment size
	Package characteristics
	Shipment shelf life
	Shipment value
	Shipment density
Flow & spatial distribution of shipper	Distance of shipment
Firm characteristics	Shippers and receivers situated on rail line
	Shippers near highway
	Firms own small trucks
Flow & spatial distribution of shipper	Shipment frequency
Modal characteristics	Capacity
	Equipment availability
	Order and handling costs
Total logistics cost	Loss and damage costs
	Inventory carrying cost at destination
	Unavailability of equipment costs
	Intangible service costs

Source: [2]

Survey of opinions of government and private freight specialists in the provinces of the Bangkok-Chiangmai high speed rail line found that the affected factors for the modes selection of transportation are 1) Reliability 32.82%; 2) In-vehicle travel time 25.25%; 3) Frequency 18.74%; and 4) Transportation cost 15.33%.

3.2 Sample size

Normally, the sample size 200-500 samples were enough to analyse the disaggregate model but small sample size, 50-70 can give reasonable results also [13]. This study collected 400 samples in the study area, each sample have to answer the question 9 situations. The samples consist of production enterprises, freight forwarders, wholesaler, and retailers in the provinces along the Bangkok-Chiangmai high speed railway. Moreover, the samples have been screened as the authority to decide to choose the type of vehicle to transport products only.

4 Case Study

This research developed the multinomial logit model for reflect the decision, to select a freight transportation vehicle model in Chiangmai and Bangkok according to possibility of goods transportation including 1) high speed rail, 2) Truck, 3) Double track rail, and 4) Plane. Estimation results of the mode selections of freight transport route show details as following.

Asc_tr = Alternative specific constant (Truck)
Asc_pl = Alternative specific constant (Plane)
Asc_hsr = Alternative specific constant (HSR)
Asc_dtr = Alternative specific constant (DTR)
b_cost = Cost coefficient (Baht)
b_time = Time coefficient (Hour)
b_delay = Delay coefficient (Hour)
b_freq = Frequency coefficient (Trip/Day)

Table 3. Estimation results of MNL freight mode choice models.

Variable	Mode	Coefficient	p-value
Asc_tr	Truck	0	-
Asc_pl	Plane	-6.547	0.000
Asc_hsr	HSR	-3.988	0.000
Asc_dtr	DTR	-1.986	0.077
B_Cost	Truck	-0.045	0.000
B_Time	Truck	-0.652	0.000
B_Delay	Truck	-1.379	0.000
B_Freq	Truck	0.104	0.067
B_Cost	Plane	-0.018	0.093
B_Time	Plane	-0.379	0.035
B_Delay	Plane	-1.275	0.000
B_Freq	Plane	0.015	0.884
B_Cost	HSR	-0.040	0.000
B_Time	HSR	-0.762	0.000
B_Delay	HSR	-0.959	0.000
B_Freq	HSR	0.166	0.001
B_Cost	DTR	-0.055	0.000
B_Time	DTR	-0.468	0.000
B_Delay	DTR	-0.869	0.000
B_Freq	DTR	0.095	0.354
Number of observations		7,200	
Adjusted Rho-Squared		0.333	

U_{truck} = - 0.045*Cost - 0.652*Time - 1.379*Delay
U_{plane} = - 6.547 - 0.018*Cost - 0.379*Time - 1.275*Delay
U_{hsr} = -3.988 - 0.040*Cost - 0.762*Time - 0.959*Delay + 0.166*Frequency
U_{dtr} = -1.986 - 0.055*Cost - 0.468*Time -0.869*Delay

Parameters that are used to analyse the influence on the mode of transportation in case of the development of the Bangkok-Chiangmai high speed train system including travel expenses, time travel, belatedness, and round of service shown as Table 4.

Table 4. Application of stated choice experiment

Mode	Cost (Baht)	In-vehicle travel time (hour)	Delay (min)	Frequency (hour)
Truck	50 - 70	6 - 7	0 - 30	2 - 3
Plane	90 - 120	2 - 3	0 - 30	5 - 8
High speed rail	80 - 100	2 - 3	0 - 30	5 - 8
Double track rail	40 - 60	6 - 7	0 - 30	2 - 3

Remark: Freight price per 10 kg
I. Truck calculated from the average shipping rates postal products of Thailand Post Office and private entrepreneurs.
II. Plane calculated from freight rates in warehouses of Chiangmai International Airport.
III. High speed train calculated from 8-10 baht per kg distance from Bangkok to Chiangmai
IV. Double track rail calculated from parcel shipping rate by the State Railway of Thailand

From the proportion of selecting the transportation type found that the most freight forwarders tend to use double track trains (27.71%), truck (56.51%) and high speed train (11.18%), as show in Table 5.

Table 5. Prediction mode share %

Mode	Mode Share %
Truck	45 - 60
Plane	4 - 5
High speed rail	11 - 13
Double track rail	26 - 28

5 Results

The results of the analysis of the potential of goods that have the opportunity to transport by high speed train found that urgent postal products, air freight, jewellery and gold, computer equipment, electrical circuits and agricultural products, such as fruit and high priced flowers. Which mostly needs the transportation speed and some types are easily traumatized. Low priced agricultural products and One Tambon One Product no need the speed to transport and the current shipping cost by truck is much lower than high speed trains. Thus, these goods have low potential for transport by high speed trains. The results of model development by analysing factors such as delivery cost, time travel, loading time, belatedness and service frequency found that these factors has a statistically significant effect on the decision to select a mode of transportation.

The application of the model suggestion a sample group that is more likely to choose to use rail transportation such as double track trains (27.71%), high speed train (11.18%), and most still use freight transportation by truck (56.51%). Because of entrepreneur are still familiar with road transport and mainly used handling time more than transit time. If there is a policy to develop a connection point for handling and modify transportation modes to be efficient and safe. These will increase the proportion of high speed rail transport. Researchers have suggested that the transporting small quantities of goods by high speed train should be made in passenger-designed containers that can be modified to accommodate the transportation of passengers or goods as needed and should choose a period of non-urgent for the best value and efficiency.

6 Conclusions and suggestions

This research focuses on the development and application of the transport and tourism model to select modes of transport. Nowadays, Thailand does not have a high-speed rail system. The researchers used the utility function survey technique by stated preference combined with logit model to develop the model for predicting the decision-making behavior of entrepreneurs in the future, if there are the development of double-track rail and high-speed rail for cargo transportation. The result of model development found that the factors of price, travel

time, delay, and frequency of service are factors that freight forwarders are interested. Double-track rail is suitable for capacity. High-speed rail is suitable for travel speed. The modes of transportation are suitable for different products, which gives entrepreneurs a variety of choices. The developed model also helps relevant government agencies to apply for pricing and service policies aim to change mode of low cost transportation and effective, as well as applying to the strategy of the warehouse distribution center and facility to support linking neighboring countries and future needs.

Application of model in this study analyzed initial survey data by multinomial logit models. Some features of the model are limited to simulating the traveler behavior in real situations. The future study will apply advanced discrete choice models both of GEV and mixed logit models to analyzed behavior and taste of travelers caused by taste heterogeneity.

Acknowledgment

This research was supported by Faculty of Industrial Technology, Pibulsongkram Rajabhat University and Excellence Center in Infrastructure Technology and Transportation Engineering (ExCITE), Faculty of Engineering, Chiang Mai University, Thailand.

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