

The Route Choice Model for Inter-Island Freight Transportation: Case Study in Maluku Archipelago

Hanok Mandaku¹, Muralia Hustim², Muh. Isran Ramli³, Mubassirang Pasra⁴

¹Doctoral Course Student Department of Civil Engineering, Hasanuddin University, Indonesia

^{2,3,4}Department of Civil Engineering, Faculty of Engineering, Hasanuddin University, Indonesia

hanokmandaku30@gmail.com, muraliahustim@yahoo.com, isran2609@gmail.com

Abstract:

This study aimed to build a route choice model for inter-island freight transportation with a case study on the Ambon Island-Seram Island corridor in the Maluku archipelago. In this corridor, 2 routes can be traversed by distribution actors, namely through the Hunimua-Waipirit crossing (Route I) and the Hunimua-Amahai crossing (Route II). In this regard, this study tried to record the preferences of distribution actors through the Conditional Logit Model (CLM) approach. This study analyzed several attributes of distribution actors, goods and services of transportation modes/routes, namely age (X_1), income (X_2), vehicle age (X_3), travel time (X_4), travel costs (X_5), the value of goods (X_6), weight of goods (X_7), waiting for time (X_8) and frequency of trips (X_9), respectively. Data was collected using the revealed preference-based interview method. The results showed that the attributes that significantly influenced the choice of the route were travel time, travel costs, waiting time, and travel frequency. The resulted model was useful for stakeholders in estimating the level of infrastructure needs and the operational pattern of ferry transportation to ensure the smooth distribution of goods between islands.

Keywords: *Route, Choice Model, Freight Transportation*

I. INTRODUCTION

Transportation is an important instrument in the distribution of goods or logistics, both between islands and between cities in an archipelagic country [1]. Smooth transportation, on time, guaranteed safety of goods at relatively low costs, will affect the price or quality of goods distributed to consumers [2].

Goods transportation, especially in the archipelago, played an important role because it related to economic aspects. The problem was that the goods transportation between islands had not been managed effectively and efficiently, causing high transportation costs [3]. The problem of freight transportation and inter-island freight transportation occurred in many areas/regions in various developing countries, including Indonesia [3, 4, 5], Trinidad and Tobago [6], and

Bangladesh [7]. This condition was different from conditions in developed countries such as Russia [8] and Korea [9].

One of the crucial aspects of the problem of inter-island freight transportation was the selection of routes that were limited and unbalanced. Several previous studies that discussed the choice of transportation routes focused more on intra-island transportation, including the choice of routes in residential areas in America [10], tourist trips in Norway [11], Indonesia [12], Philippines [13], and Denmark [14], travel commuting in Malaysia [15], as well as inter-city travel in Japan [16, 17], Indonesia [18], Spain [19], and Canada [20]. As for the previous studies, there were still few that discuss the problem of route selection for inter-island freight transportation. Given the importance of this, further research needs to be done in the context of archipelagic regions such as Indonesia.

Maluku is the largest archipelagic region in Indonesia, consisting of 1,412 islands with a ratio of sea area greater than the inland area [21]. These geographical conditions caused sea transportation modes to play an important role in inter-island freight distribution activities [22]. The Ambon Island-Seram Island corridor is one of the important routes in the freight transportation system in Maluku [23]. In this corridor, there were two alternative routes, namely through the Hunimua-Waipirit crossing (Route I) and Hunimua-Amahai crossing (Route II). The difference between the two routes lied in the characteristics of transportation services such as travel time and travel costs. This caused distribution actors to have a discrete of options. The choice of one route will increase the infrastructure requirements on that route. So far, freight distribution activities in these corridors have often been hampered due to the limitations of the ferry transportation infrastructure due to the absence of accurate information about the preferred route of goods transport vehicles. The choice of route was an important decision in the goods transportation system and had a direct influence on the flow of goods, congestion and logistics costs [24].

This study aims to build a route selection model for inter-island freight transportation based on tracing the preferences of distribution actors to the transportation system. The resulted model was expected to be a source of information for stakeholders to estimate the level of transportation infrastructure needed to support the smooth distribution of goods between islands in the Maluku archipelago.

II. MATERIALS AND METHODOLOGY

A. Research Time and Location

This research was conducted in January – February 2020 on the freight transportation route from Ambon Island to Seram Island, Maluku archipelago.

Data collection takes place at Hunimua Port, the location where distribution actors will choose the route of travel, whether to go through Route I (via Waipirit Port) or through Route II (via Amahai Port). Figure 1 showed the travel route and research location.



- | | | | |
|-------------------------|-----------------------|-----------------------|--|
| A = Latuhalat Storage | G = Wayame Storage | PH = Port of Hunimua | P = Pasanea City |
| B = Port of Yos Sudarso | H = Waiheru Storage | PW = Port of Waipirit | Q = Wahai City |
| C = Ambon Storage | I = Nania Storage | PA = Port of Amahai | R = Kobisonta City |
| D = Tantui Storage | J = Passo Storage | M = Awaya City | S = Bula City |
| E = Halong Storage | K = Waitatiri Storage | N = Masohi City | — = Route I |
| F = Riang Storage | L = Suli Storage | O = Tehoru City | — = Route II |

Fig 1: research location

B. Method of Collecting Data

The data in this study were collected from a survey with an interview method using a questionnaire. Respondents were chosen randomly, namely, the actors of the freight distribution of goods travel by truck and will take the Hunimua-Waipirit crossing and Hunimua-Amahai crossing routes. There was 120 respondent who participated in providing answers on the questionnaire sheet.

The questionnaire used in this study was designed to obtain data on the characteristics of the freight transportation system in the study area, namely the characteristics of the distribution actors (age, income, and vehicle age), route attributed (travel time and travel costs), goods characteristics (goods value and goods weight) and trip characteristics (waiting time and trip frequency). The data on the characteristics of the transportation system was a variable in this study. Table I presents the categories of each characteristic and variable to be studied.

TABLE I. Research characteristics and research variables

NO.	VARIABLE	CATEGORY				
A. Characteristic of distributors						
X ₁	Age (years)	a) 20 – 29	b) 30 – 39	c) 40 – 49	d) 50 – 59	e) ≥ 60
X ₂	Income (IDR, million)	a) 2.0 – 2.9	b) 3.0 – 3.9	c) 4.0 – 4.9	d) 5.0 – 5.9	e) ≥ 6.0
X ₃	Age of vehicle (years)	a) 0.0 – 4.9	b) 5.0 – 9.9	c) 10.0 – 14.9	d) ≥ 15.0	
B. Attributes of Route						
X ₄	Travel time (hours)					
X ₅	Travel cost (IDR)					
C. Characteristic of freight						
X ₆	Value of freight (IDR, million)	a) 50.0 – 74.9	b) 75.0 – 99.9	c) 100.0 – 124.9	d) 125.0 – 149.9	e) ≥ 150.0
X ₇	Weight of freight (ton)	a) 2.0 – 3.9	b) 4.0 – 5.9	c) 6.0 – 7.9	d) 8.0 – 9.9	e) ≥ 10.0
D. Characteristic of travel						
X ₈	Waiting time (hours)	a) < 1	b) 1.0 – 1.9	c) 2.0 – 2.9	d) ≥ 3.0	
X ₉	Frequency of trips (/week)	a) 1	b) 2	c) 3	d) ≥ 4	

C. Model Construction

This study applied a discrete model for binary options in analyzed route choices to maximize traveler satisfaction in utilizing services [25]. This model was expressed by equation [25]:

$$V_{in} = f(x_{in}) \quad (1)$$

or

$$V_{jn} = f(x_{jn}) \quad (2)$$

Where:

V_{in}, V_{jn} = traveler satisfaction value that reflects consumer behavior.

x_{in}, x_{jn} = variables that affect behavior to maximize satisfaction.

f = mathematical function.

So that the regression equation of the intended satisfaction function can be formed as:

$$V_{in}/U = a + \beta_1 x_{in\ 1} + \dots + \beta_k x_{in\ k} + e_{in} \quad (3)$$

Where:

- V_{in}/U = the satisfaction value of travelers using transportation route i (maximum satisfaction).
 $x_{in1} - x_{ink}$ = independent variables that affect maximum satisfaction.
 β_1 s. d β_k = regression coefficient/independent variable parameter.
 e_{in} = random variable that is stochastic and follows a certain distribution.

After the values V_{in}/U dan V_{jn}/U were obtained then these values can be entered into the Binomial Logit Model [25]. The general form of this model was

$$P_{(i)} = \frac{e^{\beta x_{in}}}{e^{\beta x_{in}} + e^{\beta x_{jn}}} = \frac{1}{1 + e^{-\beta(x_{in} - x_{jn})}} \quad (4)$$

and,

$$P_{(j)} = 1 - P_{(i)} \quad (5)$$

The application of the Binomial Logit Model had been carried out in previous studies, namely for the selection of daily travel modes in Indonesia [26] and Malaysia [27] and the selection of container transportation modes in Thailand [28].

Estimation of discrete choice model parameters using the Conditional Logit Model (CLM) approach with the help of STATA 16. This approach had been discussed in research on freight transport in Europe [29], the free-floating car-sharing model in Switzerland [30], travel time savings in the Czech Republic [31], and mode selection in Brazil [32].

III. DATA ANALYSIS AND INTERPRETATION

A. Characteristics of Inter-Island Freight Transport

The characteristics of inter-island freight transportation reviewed in this study included the characteristics of distribution actors, characteristics of goods, and characteristics of travel. Table II contains the profile and composition of the characteristics of the distribution actors.

The data in Table II illustrate that the distribution actors were dominated by the productive age group, the income level was by the provisions of the Provincial Minimum Wage (UMP) and the vehicles were in decent condition.

The characteristics of the goods in this study were described based on the condition of the goods that have been loaded for distribution to their respective destination locations. The profile and composition are shown in Table III.

The data in Table III illustrate that the value of goods distributed between islands was dominant at the interval of IDR 100 million – IDR 125 million, and the weight was in the interval of 6.0 – 7.9 tons. This value was related to the types of goods which were generally the basic needs of the community.

TABLE II. Profile and composition of characteristics of distributors

NO.	CATEGORY	FREQUENCY	%
1	Age (years)		
a)	20 – 29	20	16.67
b)	30 – 39	54	45.00
c)	40 – 49	30	25.00
d)	50 – 59	14	11.67
e)	≥ 60	2	1.67
Sum		120	100.00
2	Income (IDR, million)		
a)	2.0 – 2.9	84	70.00
b)	3.0 – 3.9	20	16.67
c)	4.0 – 4.9	8	6.67
d)	5.0 – 5.9	4	3.33
e)	≥ 6.0	4	3.33
Sum		120	100.00
3	Age of vehicle (years)		
a)	0.0 – 4.9	34	28.33
b)	5.0 – 9.9	68	56.67
c)	10.0 – 14.9	17	14.17
d)	≥ 15.0	1	0.83
Sum		120	100.00

TABLE III. Profile and composition of item characteristics

NO.	CATEGORY	FREQUENCY	%
1	Value of freight (IDR, million)		
a)	50.0 – 74.9	32	26.67
b)	75.0 – 99.9	30	25.00
c)	100.0 – 124.9	33	27.50
d)	125 – 149.9	12	10.00
e)	≥ 150.0	13	10.83
Sum		120	100.00
2	Weight of freight (ton)		
a)	2,0 – 3,9	13	10.83
b)	4,0 – 5,9	32	26.67
c)	6,0 – 7,9	46	38.33
d)	8,0 – 9,9	21	17.50
e)	≥ 10,00	8	6.67

Sum	120	100.00
-----	-----	--------

The characteristics of the trip were reviewed and related to the factors that arise along the journey process. The profile and composition characteristics were listed in Table IV.

TABLE IV. Profile and composition of travel characteristics

NO.	CATEGORY	FREQUENCY	%
1	Waiting time (hours)		
a)	< 1	22	18.33
b)	1.0 – 1.9	41	34.17
c)	2.0 – 2.9	25	20.83
d)	≥ 3.0	32	26.67
Sum		120	100.00
2	Frequency of travel (/week)		
a)	1	62	51.67
b)	2	48	40.00
c)	3	8	6.67
d)	≥ 4	2	1.66
Sum		120	100.00

The data above illustrated that in the aspect of waiting time, the dominant was at intervals of 1-1.9 hours, while in the aspect of travel frequency the dominant was 1 time/week.

B. Route Choice Modeling

The route choice modeling was carried out by considering 9 variables, namely age, income, vehicle age, the value of goods, weight of goods, travel time, travel costs, waiting time, and travel frequency, respectively. The modeling process was carried out using Route I as an alternative base. The data input process using the Conditional Logit Model (CLM) technique, produces model parameters as shown in Table V.

The model parameter data in table V shows that there was at least 1 independent variable that affects the choice of route ($\text{Prob.} > \text{Chi}^2 < \alpha$). In the partial test, travel time (X_4), travel costs (X_5), waiting for time (X_8), and travel frequency (X_9) statistically significantly affect route choice ($P > |z| < \alpha$). Meanwhile, the other variables did not statistically significantly affect the choice of route. In addition, the direction (sign) of the coefficients on each variable is as expected.

C. Sensitivity Analysis

The sensitivity test was intended to see how the probability of route choice by distribution actors changes due to changes in travel time and travel costs attributes. The results are shown in

Figures 2 and 3.

TABLE V. Model of parameter

VARIABLES	COEF.	P > z
Route I (base alternative)		
Age (X ₁)	0.0332	0.417
Income (X ₂)	0.3668	0.348
Vehicle age (X ₃)	0.0636	0.614
Travel time (X ₄)	-3.3531	0.027*
Travel cost (X ₅)	-2.1394	0.014*
Value of freight (X ₆)	-0.0040	0.765
Weight of freight (X ₇)	-0.1658	0.448
Waiting time (X ₈)	2.8236	0.000*
Frequency of travel (X ₉)	1.7472	0.009*
Constant	-9.3456	0.016
Number of observation	240	
Number of cases	120	
Wald chi2 (9)	29.72	
Prob > chi2	0.0005*	
Log. Likelihood	-28.94	

Note: *) Significant at 95% confidence interval

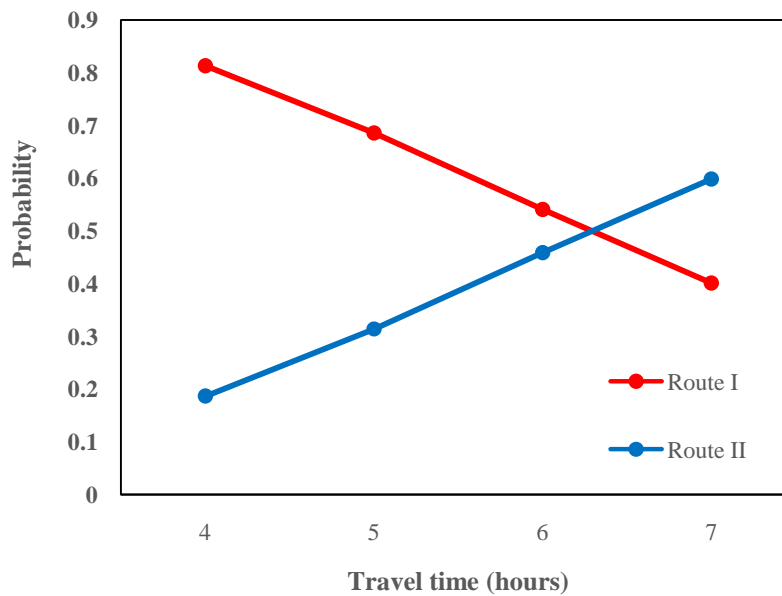


Fig 2: travel time-sensitivity graph

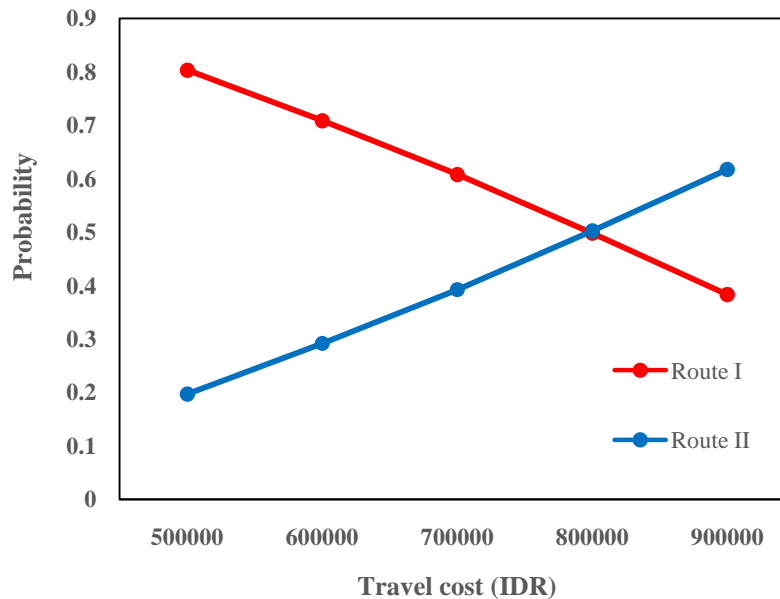


Fig 2: travel cost-sensitivity graph

The graphs in Figure 2 and Figure 3 above show that the probability of choosing Route I will decrease if the travel time and travel costs increase. If the travel time increases by 1 hour, the probability of choosing Route I will decrease by an average of 13.74%. If the cost of travel increases by IDR 100,000.00 then the choice of the route will decrease by an average of 10.5%.

D. Discussion

The resulted model shows that the choice of route for inter-island freight transportation tends to consider two main attributes, namely travel costs and travel time, respectively. This is similar to the research on the selection of goods transportation routes in Mongolia and Bangladesh [8] and Russia [9]. The difference lies in the geographical aspect, where this study raised the issue of selecting inter-island freight transportation routes. This phenomenon was also following the general habit of choosing a mode or route, where the attributes of travel time and travel costs were the main considerations. In addition, this study succeeded in revealing the effect of the variable waiting time and travel frequency in the selection of inter-island freight transportation routes.

The waiting time and frequency of trips in this study were related to the level of infrastructure availability and the operational pattern of ferry transportation. Existing conditions indicate that Route I had a greater probability of choice because it had a sailing frequency of 10 round trips/day. That is why, distribution actors have flexibility in choosing the time to travel, even though the impact was a relatively long waiting time on Route I.

These findings were input for stakeholders to develop infrastructure and operational patterns

of ferry transportation so that they can support the smooth distribution of goods between islands.

IV. CONCLUSION

This study had described the preferences of inter-island goods distribution actors when faced with alternative route choices that have different characteristics. Through a case study on the Ambon Island-Seram Island corridor, this study had analyzed several main variables from the two available routes, namely Route I which passes through the Hunimua-Waipirit crossing, and Route II which passes through the Hunimua-Amahai crossing. Through the application of a related preference survey (RP) and conditional logit model (CLM), it was found that the route choice by distribution actors was significantly influenced by travel time, travel costs, waiting time, and travel frequency. With these preferences, Route I was still the favorite choice of distribution actors. The results of this study can be used as a basis for estimating the level of infrastructure needs and the operational pattern of ferry transportation to ensure the smooth distribution of goods between islands.

REFERENCES

- [1] SonnyM, HadiwardoyoSP, SusantonoB, BenabdelhafidA (2015) The development of a freight distribution model for connecting inter-island freight transport, *International Journal of Technology* 5:743-750.
- [2] Salim A (2006) *Manajemen Transportasi*, Jakarta-Indonesia, PT. RajaGrafindo Persada.
- [3] Sjafruddin A, Lubis HAS, Frazila RB, Dharmowijoyo DB (2010) Policy evaluation of multimodal transportation network: the case of inter-island freight transportation in Indonesia, *Asian Transport Studies*, Volume 1 Issue 1:18-32.
- [4] Mappangara ASC, et. al. (2012) *Kajian jaringan trayek angkutan laut nasional untuk muatan petikemas dalam menunjang konektivitas nasional*, Prossiding Seminar Nasional Teknik Sipil UMS (2012).
- [5] Siahaan LD, Jinca MY, Wunas S and Pallu MS (2013) Transportasi laut kontainer dalam pengembangan master plan percepatan dan perluasan ekonomi Indonesia di Indonesia bagian timur, *Jurnal Transportasi*. Vol. 13 No. 3:193-200.
- [6] Hope K (2008) The inter-island transport system, 40th Annual Monetary Studies Conference Eastern Caribbean Central Bank.
- [7] Hossain M and Ahsan HM (2020) Efficiency of rail freight transport in Bangladesh, *Proceeding 5th International Conference on Advances in Civil Engineering (ICACE)* Cuet, Chattogram, Bangladesh.
- [8] Poltavskaya JO and Lebedeva OA (2020) Model for selecting transportation option based on analysis characteristics of the freight system, *IOP Conference Series: Materials Science and Engineering* 971: 052071.
- [9] Ganbat E and Hwan-Seong Ki (2017) Empirical study of multimodal transport route choice model in freight transport between Mongolia and Korea, *Open Science Journal*.
- [10] Vidana-Bencomo JO, Balal E, Anderson JC and Hernandez S (2018) Modelling route choice criteria from home to major streets: a discrete choice approach, *International Journal of*

- Transportation Science and Technology:74-88.
- [11] Díez-Gutiérrez and Babri S (2020) Explanatory variables underlying the route choice decisions of tourists: the case of Geiranger Fjord in Norway, *Transportation Research Part A* 141:398-409.
 - [12] Diaz CED (2011) Mode choice of inter-island travelers: analyzing the willingness of ferry passengers to shift to air transportation, *Journal of the Eastern Asia Society for Transportation Studies*, Vol. 9.
 - [13] Hermawati P, Adisasmita SA, Ramli MI, and Aly SH (2019) Choice models of trip chain and transportation mode for international tourist in tourism destination island, *International Journal of GEOMATE*. Vol.16 Issue 55:195-203.
 - [14] Anderson MK, Nielsen OA, Prato CG (2017) Multimodal route choice models of public transport passengers in the greater Copenhagen area, *EURO J Transp Logist*:221-245.
 - [15] Rusdiansyah (2018) Travel mode choice preferences of urban commuters in Kuching City, Malaysia based on stated preferences data.
 - [16] Tsukai M and Okumura M (2003) Analysis of inter-city passenger's route choice behavior on non-shortest-time routes, *Journal of the Eastern Asia Society for Transportation Studies*, Vol. 5:1463-1475.
 - [17] Uchiyama N and Taniguchi E (2012) A study of dispatcher's route choice model based on evolutionary game theory, *The Seventh International Conference on City Logistics, Procedia - Social and Behavioral Sciences* 39:495 – 509.
 - [18] Ramli MI, Yatmar H, Dharmowijoyo DBE, Adisasmita SA, Pasra M, Arif A, Dwiatmoko H and Irawan MZ (2020) Passenger's choice in responding to inter-city railway operation for Makassar – Parepare line: a conditional logit model based on stated preference method, *Proceeding The 2nd Aceh International Symposium on Civil Engineering (AISCE)*. IOP Conf. Series: Materials Science and Engineering:1-9.
 - [19] Román C, Espino R, Martín JC (2009) Analyzing competition between the high-speed train and alternative modes: the case of the Madrid-Zaragoza-Barcelona corridor, *Journal of Choice Modelling*, 3(1):84-108.
 - [20] Fischer SM, Beck M, Herborg LM and Lewis MA (2020) A hybrid gravity and route choice model to assess vector traffic in large-scale road networks, royalsocietypublishing.org/journal/rsos:1-20.
 - [21] BPS Provinsi Maluku (2020) Maluku Dalam Angka 2019.
 - [22] Gurning ROS (2006) Analisa konsep Trans-Maluku sebagai pola jaringan transportasi laut di Propinsi Maluku, *Academia Accelerating the World Research*:1-8.
 - [23] Mandaku H (2020) Evaluasi kinerja angkutan penyeberangan dalam menunjang distribusi barang antar-pulau saat pandemi Covid-19 di Provinsi Maluku, *Jurnal Arika*. Vol 14 No. 2:102 – 110.
 - [24] Guillbault M (2008) Enquete ECHO – Ernois-Chargeurs-perations de transport, *Resultants de Reference*.
 - [25] Tamin OZ (2000) *Perencanaan dan Pemodelan Transportasi – Edisi Kedua*, Penerbit ITB, Bandung – Indonesia.
 - [26] Ramli MI, Oeda Y and Sumi T (2010) Study on mode choice model of a trip for daily household logistic based on binomial logit model *Proceeding The 3rd International Conference of Transportation and Logistic (T-LOG)*.

- [27] Puan OC et al. (2019) Transportation mode choice binary logit model: a case study for Johor Bahru City, GEOTROPIKA IOP Conference Series: Material Science and Engineering 527:1-9.
- [28] Siradol S, Paonoi W, Meeyai S, Ratanavahora V (2019) Container transport mode choice analysis with a binary logit model case study: Northeastern Thailand, Engineering and Applied Science Research July – September 46(3):256-266.
- [29] Jourquin B and Beuthe M (2019) Cost, transit time and speed elasticity calculations for the European continental freight transport, Transport Policy 83:1–12.
- [30] Becker H, Ciari F, Axhausen KW (2017) Modeling free-floating car-sharing use in Switzerland: A spatial regression and conditional logit approach, 17th Swiss Transport Research Conference Monte Verità/Ascona.
- [31] Senk P and Biler S (2012) Estimation of the value of travel time savings using conditional logit model, Proceedings of 30th International Conference Mathematical Methods in Economics:860-863.
- [32] Moreno MB (2006) Airline choice for a domestic flight in Sao Paulo Metropolitan area: an application of the conditional logit model, Journal of Air Transportation Vol 11 No. 02:22-42.