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

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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 ANDMETHODOLOGY

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.

ISSN: 0011-9342 | Year 2021
Issue: 8 | Pages: 13090 - 13101

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.

Design Engineering

ISSN: 0011-9342 | Year 2021
Issue: 8 | Pages: 13090 - 13101

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:

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

ISSN: 0011-9342 | Year 2021
Issue: 8 | Pages: 13090 - 13101

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}/Uwere obtained then these values can be entered into the Binomial Logit Model [25].The general form of this model was

$$P_{(i)} = \frac{e^{\beta xin}}{e^{\beta xin} + e^{\beta xjn}} = \frac{1}{1+e^{-\beta(xin - xjn)}} \quad (4)$$

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. DATAANALYSIS 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 IIIillustrate 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.

ISSN: 0011-9342 | Year 2021
Issue: 8 | Pages: 13090 - 13101

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 (Prob.>Chi2 <α). 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| <α). 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

ISSN: 0011-9342 | Year 2021
Issue: 8 | Pages: 13090 - 13101

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

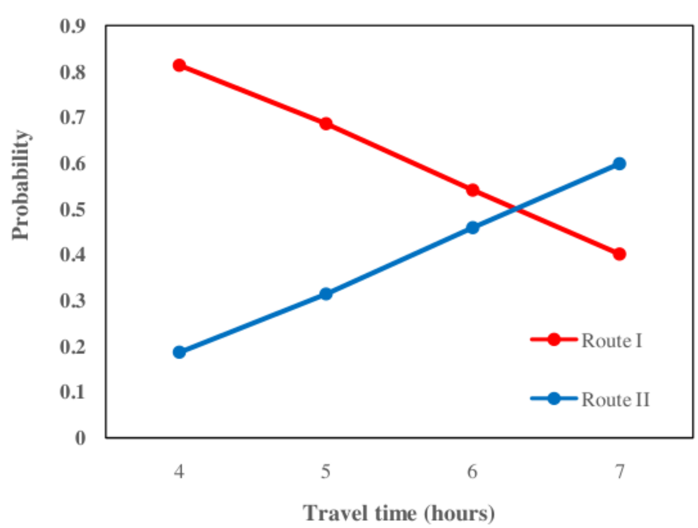

Fig 2: travel time-sensitivity graph

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Issue: 8 | Pages: 13090 - 13101

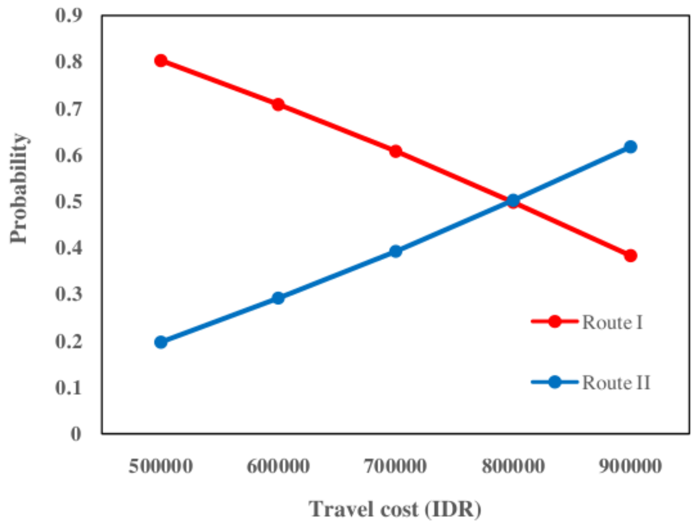

Fig 2: travel cost-sensitivity graph

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 routewill 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

ISSN: 0011-9342 | Year 2021
Issue: 8 | Pages: 13090 - 13101

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.

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