The Sensitifity and Elastisity Model Approch to The Probality of Wooden Boat Route Selection in Archipelago Area

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Abstract. This study aims to analyze the effect of travel costs Wooden Boat, travel time, delay time and service frequency on the selection of wooden ship routes using the stated preference method. Two variables, dependent and independent variables were analyzed using linear regression analysis, correlation and sensitivity model. From the results of the sensitivity analysis, the travel cost of attribute variable is the most sensitive to the probability of route selection is travel time. The changes of travel time will changes the probability of choosing a route which relatively largerer than changes the other attributes. For the elasticity analysis of the model for each attribute resulted the probability of choosing route 2 is more sensitive than route 1. This is indicated by the cross elasticity value which is greater than the direct elasticity value. The direct elasticity values for the attributes of cost, travel time, delay time, and service level are -0.5248, -0.1667, -0.0845, and 0.1182 respectively. Meanwhile, the cross-elasticity values for the attributes of cost, travel time, delay time, and service level are -0.6477, -0.3979, -0.2016, and 0.2821.

Keywords: Wooden Ship Routes, Sensitifity Model, Elastisity Analysis

1 Introduction

Indonesia is a maritime country. Geographically, Indonesia is located between two oceans, namely the Pacific Ocean and the Indian Ocean. Indonesia also connects two continents, namely Asia and Australia. In addition, Indonesia is an archipelagic country that has more than 17,000 islands with a coastline of more than 99,000 km, making Indonesia the country with the second-longest coastline in the world after Canada. Furthermore, Indonesia has a very wide sea area, in which 2/3 of the country's territory is the sea. Most of Indonesia's territory is in the form of sea, making Indonesia one of the countries that have great potential. In Indonesia, one of the complex problems faced is transportation [1].

In this country, the development of the transportation sector becomes the main priority. However, in fact, it has very complex problems. Ternate is a city that has an influential effect on its surrounding islands, especially Tidore which is closest to Ternate with a distance of 8 minutes by speed boat. This causes conditions in which people between the two islands have to move by using public transportation. The problem of public transportation selection can be considered to be the most important stage in various transportation planning and policies because this concerns the efficiency of movement in urban areas, the space that the government must provide for transportation infrastructure, and the number of modes of transportation that residents can choose [2].

Route selection occurs as a result of fulfillment, which has become needs that normally have to be carried out every day, such as meetings, working, or others. All of these needs are sometimes available around the residence but are usually scattered heterogeneously according to the land use. Therefore, it requires movement either without any mode of transportation (short distance between 1 – 2 km) or with a mode of transportation (medium-to-long distance). Meanwhile, the modes of transportation used by the public are also very diverse, such as private or public vehicles [3].

2 Methods

2.1 Linear Regression Model

This concept is a further development of the description above, especially in cases that have many independent variables and parameters b. This is very necessary, which may indicate that several land-use variables simultaneously affect the trip generation. The equation below presents the general form of the multiple linear analysis.

$$Y = A + B1X1 + B2X2 + \ldots\ldots\ldots + BzXz$$

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Where : Y = dependent variable
X1….Xz = independent variable
A = regression constant
B1…..Bz = coefficient of regression

2.2 Route Selection Model

To calculate the total of samples, the researchers use Slovin's formula (1960), as follows.

$$n = \frac{N}{1+(N.0,1^2)}$$

Where:
N = Total population
n = Total Samples

2.3 Stated Preference Method

Stated preference is an approach by submitting an option statement in the form of a hypothesis to be assessed by the respondents. This stated preference was first developed in the late 1970s. The results of the stated preference are responses or answers from respondents for different situations.

The data analysis approach for the stated preference method uses linear regression analysis. Linear regression analysis is needed to determine the effect of the independent variables on the dependent variable. In using stated preference, respondents' choices are expressed in the scale form, as implemented in the questionnaire for the route selection characteristics, in which the options are 1 = definitely choose route 1, 2 = probably choose route 1, 3 = balanced, 4 = probably choose route 2, and 5 = definitely choose route 2. Data obtained from respondents are transformed into a probability scale form. The probability value is transformed again into the symmetric scale which becomes a utility value that corresponds to the probability scale.

After that, a regression analysis is conducted to obtain the utility model. By using linear regression, constants 0 to *n* are obtained as model parameters.

$$U\,(route_1 - route_2) = a_0 + a_1 X_1 + a2\, X_2$$

$$P_{route1} = \frac{exp^{(route1-route2)}}{1+ exp^{(route1-route2)}}$$

$$P_{route2} = 1 - P_{route1}$$

$$P_{route2} = \frac{1}{1+ exp^{exp^{(route1-route2)}}}$$

Where:
U (R1 - R2) = Difference in utility value of route 1 and route 2
a_0……..an = Model parameters
X_1…….Xn = Value of the attribute

3 Results And Discussion

Respondents in this survey are residents of the cities of Ternate and Tidore who use wooden motorboats to travel from Ternate to Tidore or vice versa. In addition, the characteristics of respondents are explained further in the following section.

1. Income Level

Table 1. Distribution of Respondents by Monthly Income

No	Monthly Income	Total	Percentage %
1	≤ 1,500,000 IDR	20	20
2	1,500,000 – 3,500,000 IDR	22	22
3	3,000,000 – 5,000,000 IDR	21	21
4	≥ 5,000,000 IDR	17	17
5	No income	20	20
Total		100	100

2. Main Reason for Route Selection

Table 2. Distribution of Respondents by Reason for Route Selection

No	Reason for Route Selection	Total	Percentage %
1	Punctuality (Departure/Arrival)	13	13
2	Shorter travel time	33	33
3	Cheaper travel costs	6	6
4	Availability of transportation (frequent departure frequency)	48	48
Total		100	100

3. Travel Purposes

Table 3. Distribution of Respondents by Travel Purposes

No	Travel Purposes	Total	Percentage %
1	Work	27	27
2	Business	28	28
3	School	8	8
4	Others	37	37
Total		100	100

4. Most Frequently Passed Routes

Table 4. Distribution of Respondents by Most Frequently Passed Routes

No	Uraian	Jumlah	Presentase %
1	Ternate (Bastiong) – Tidore (Rum) or vice versa	60	60
2	Tidore (Tokici) – Ternate or vice versa	40	40
Total		100	100

3.1 Model Formulation

The model formulation is based on the comparison of the results obtained from the approach using a regression program. Based on the results of the regression calculations performed, the selection is carried out based on the gained model parameters and other statistical values, as shown in Table 5 below.

Table 5. Modeling Results

Variables	Estimation			
	Coefficient	t-stat		
Constant	1.4598			
Travel cost (X1)	-3.13568E-05	15.997		
Travel time (X2)	-0.0618	9.540		
Delay time (X3)	-0.0762	9.334		
Service frequency (X4)	0.0762	2.284		
Statistical Rating				
Observations	2400			
Rho-square	0.7943			
F-test	470.217	2309.220	413.881	2057.513

Based on the information presented in table 5, the model formulation for this study is as follows.

$(U_{(route1-route2)}) = 1.4598 - 3.13568E\text{-}05X_1 - 0.0618\ X_2 - 0.0762\ X_3 - 0.0762\ X_4$

$$Proute_1 = \frac{exp^{(1.4598 - 3.13568E-05X1 - 0.0618X2 - 0.0762X3 - 0.0762X4)}}{1 + exp^{(1.4598 - 3.13568E-05X - 0.0618X2 - 0.0762X3 - 0.0762X4)}}$$

$Proute_2 = 1 - Proute_1$

$$Proute_2 = \frac{1}{1 + exp^{(1.4598 - 3.13568E-05X - 0.0618X2 - 0.0762X3 - 0.0762X4)}}$$

Where:

X_1 = Travel costs including those using motorbike

X_2 = Travel time

X_3 = Delay time

X_4 = Service Frequency

Y = Numerical Scale Value

3.2 Correlation Analysis

Correlation analysis aims to determine the degree of the linear relationship of a variable with other variables. Concerning regression analysis, this analysis can measure the accuracy of the regression line for explaining the dependent variable. The correlation value ranges from 1 to -1. The closer the value to 1 or -1 is, the stronger the relationship between the two variables will be. Conversely, if the value is close to 0, it means that the relationship between the two variables is getting weaker. A positive value indicates a unidirectional relationship (if X goes up, then Y goes up), while a negative value shows an inverse relationship (if X goes up, then Y goes down). The results of the calculation of the correlation coefficient between the attributes of the travel route choice and the respondents' utility are shown in the following table.

Table 6. Correlation between Utilities and Attributes of Choice of Travel Routes

No	X1	X2	X3	X4	Y
Y	1				
X1	0.68586	1			
X2	-0.3115	-0.4064	1		
X3	-0.2734	-0.3929	-0.3935	1	
X4	-0.6837	-0.9783	0.38514	0.39509	1

From the results of the calculation above, the correlation value between variable Y and variable X1 is 0.68586, meaning that the variable is quite influential on route selection. In addition, the correlation value between variable Y to variable X2 is -0.4064, indicating that the variable has little effect. Furthermore, the correlation value between variable Y and variable X3 is -0.3935, showing that the variable also has little impact. Apart from that, the correlation value between variable Y to variable X4 is 0.39509, meaning that the variable also only has little influence.

3.3 Model Elasticity

The model elasticity is needed to evaluate the sensitivity of the response by measuring the percentage change in the probability of choosing a route as a result of a change in the percentage of a certain attribute in the utility function of each model.

By using the average value and based on the existing model formulation, the utility value and probability of selecting route 1 for each model can be seen in Table 9 below.

Table 8. Utility Value and Probability Model

Average Value of Attribute Difference				U (Route 1 - Route 2)	P (Route 1 - Route 2)
Cost	Travel Time	Delay	Service		
23750	9.125	3.75	5.25	0.870	0.705

By obtaining the probability value of route 1, the gained elasticity values of various attributes, both direct elasticity and cross elasticity, on the average attribute values are shown in Tables 10 and 11.

Table 9. Direct Elasticity (Direct Elasticity)

Direct Elasticity to Attributes			
Δ Cost	Δ Travel Time	Δ Delay	Δ Service
-0.5248	-0.1667	-0.0845	0.1182

Table 10. Cross Elasticity (Cross Elasticity)

Cross Elasticity to Attributes			
Δ Cost	Δ Travel Time	Δ Delay	Δ Service
-0.6477	-0.3979	-0.2016	0.2821

Based on the results of the calculation of direct elasticity and cross elasticity above, it can be interpreted as follows.

a. The cost of travel including for those using motorbikes is the most sensitive attribute in influencing route selection. This can be seen from its elasticity value which is greater than the elasticity value of other attributes.
b. In general, all the attributes considered in the model are more sensitive in influencing the selection of route 1 compared to that of route 2. This is indicated by the value of cross elasticity for all attributes, which is greater than the value of the direct elasticity in all its attributes.
c. For the attribute of service level on the direct elasticity, the sign is positive, meaning that if there is an increase in travel time (faster travel time) and service level (better service level) on route 1, there will be an increase in the probability of choosing route 1. The opposite thing will occur to the attributes of travel costs, travel time, and delay time, in which a negative sign indicates that if there is an increase in travel costs (becomes more expensive) or departure schedules (becomes longer) on route 1, it will result in a decrease in the probability of choosing route 1.

3.4 Model Equation

Based on statistical tests on each alternative equation, the utility difference function equation chosen is alternative 1 with the largest R^2 value. The route selection model between route 1 and route 2 obtained in this study is a binary logit model with the utility function between route 1 and route 2 in the form of a linear equation.

The equations of the route selection model as a result of the analysis are presented in the following.

The probability of choosing route 1:

$$P_{route1} = \frac{exp^{(1.4598 - 3.13568E-05X \ - 0.0618X2 - 0.0762X3 - 0.0762X4)}}{1 + exp^{(1.4598 - 3.13568E-05X \ - 0.0618X2 - 0.0762X3 - 0.0762X4)}}$$

The probability of choosing route 2:

$$P_{route2} = \frac{1}{1 + exp^{(1.4598 - 3.13568E-05X \ - 0.0618X2 - 0.0762X3 - 0.0762X4)}}$$

Where:

X_1 = Δ Cost (Travel cost including for those using motorbike)
X_2 = Δ Travel Time
X_3 = Δ Time delay
X_4 = Δ Service Frequency

Table 11. The average value of attribute difference

The average value of attribute difference			
Δ Cost	Δ Travel Time	Δ Delay	Δ Servic
23750	9.125	3.75	5.25

3.5 Sensitivity to the Attribute of Travel Cost

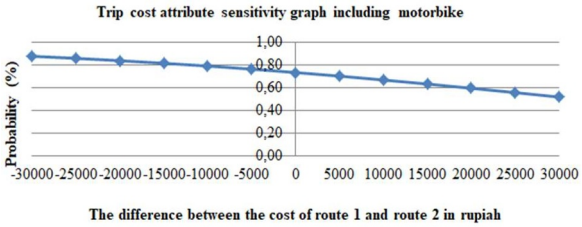

Fig. 1. Sensitivity to the Attribute of Travel Cost

Results of the sensitivity analysis to changes in the attribute of travel costs as shown in Figure 1 indicate several things, namely as follows.

1. It indicates the negative line slope, meaning that the greater the difference in travel costs is, the lower the probability of choosing route 1 will be.
2. By only paying attention to changes in the cost difference, for the competition of selecting route 1 and route 2, it can be illustrated that the probability of choosing route 1 will be greater than the probability of choosing route 2 if the cost difference between route 1 and route 2 is less than 30,000 IDR.

3.6 Sensitivity to the Attribute of Travel Time

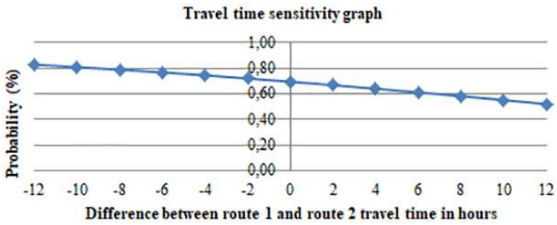

Fig. 2. Sensitivity to the Attribute of Travel Time

Results of the sensitivity analysis to changes in the attribute of travel time as shown in Figure 2 indicate several things, namely as follows.

1. It indicates the negative line slope, meaning that the greater the difference in travel time is, the lower the probability of choosing route 1 will be.
2. By only paying attention to changes in the travel time difference, it can be illustrated that the probability of choosing route 1 will be greater than the probability of choosing route 2 if the difference in travel time is less than -0.8 hours or the travel time in route 1 is 0.8 hours or faster than the travel time in route 2.

3.7 Sensitivity to the Attribute of Time Delay

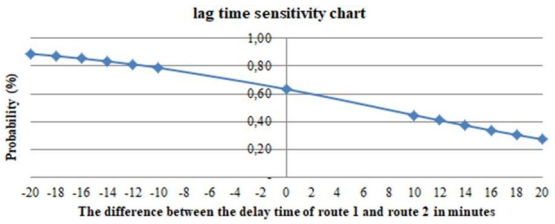

Fig. 3. Sensitivity to the Attribute of Time Delay

Results of the sensitivity analysis to changes in the attribute of time delay as shown in Figure 3 indicate several things, namely as follows.

1. It indicates the negative line slope, meaning that the greater the difference in delay time is, the lower the probability of choosing route 1 will be.
2. By only paying attention to changes in the delay time difference, it can be illustrated that the probability of choosing route 1 will be greater than the probability of choosing route 2 if the difference in delay time between route 1 and route 2 is less than 23 minutes.

3.8 Sensitivity to the Attributes of Service Level

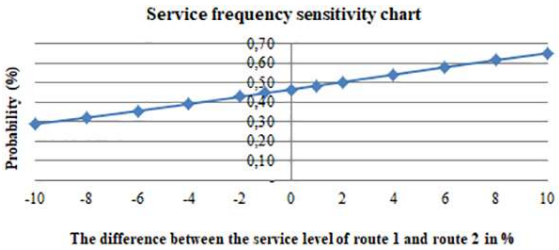

Fig. 4. Sensitivity to the Attribute of Service Level

Results of the sensitivity analysis to changes in the attribute of service level as shown in Figure 4 indicate several things, namely as follows.

1. It indicates the positive line direction, meaning that the greater the difference in service level is, the greater the probability of choosing route 1 will be.
2. By only paying attention to changes in the service level difference, it can be illustrated that the probability of choosing route 1 will be greater than the probability of choosing route 2 if the difference in service level is greater than 8% or the service level of route 1 is 8% or more than the service level of route 2.

4 Conclusion

1. The direct elasticity values for the attributes of cost, travel time, delay time, and service level are -0.5248, -0.1667, -0.0845, and 0.1182 respectively. Meanwhile, the cross-elasticity values for the attributes of cost, travel time, delay time, and service level are -0.6477, -0.3979, -0.2016, and 0.2821.
2. From the results of the sensitivity analysis, it can be seen that the attribute which is the most sensitive to the probability of route selection is travel time. In other words, changes in travel time will result in changes in the probability of choosing a route, in which these changes are relatively larger when compared to changes that occur due to other attributes.

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