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Analysis of Mode Choice among Airplanes, Minibus, and Trains on Muara Teweh – Palangka Raya Route

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Abstract - *The increase in the North Barito district's economy also affects increasing the volume of people and goods transporting into and out of the North Barito district. Providing reliable transportation needs to be done, one of which is by providing alternative transportation services by train. To obtain information on the extent of public interest in trains, it is necessary to choose existing and new transportation modes, namely between airplanes, minibusses, and trains. The route analyzed is from MuaraTeweh-Palangkaraya. The analytical method used is the Multi NomialLogit approach. Based on the results obtained, the attributes include personal characteristics that influence the mode choice, gender, and the traveler's income level. The characteristics of traffic movements that affect the model are travel time, travel cost, and transportation services level. The probability of a balance between the three modes of transportation under study is obtained because the train's cost is IDR. 250,000, -, minibus cost IDR. 200,000, - and an airplane cost IDR. 295,000, -.*

Keywords — *mode choice, sensitivity, travel cost, travel time*

I. INTRODUCTION

MuaraTeweh is the capital of the North Barito district. It is the center for developing the Barito River Basin, which consists of North Barito District, South Barito District, East Barito District, and Murung Raya District. With the increasing development and socio-economic growth in North Barito District and its surroundings, it impacts increasing the volume of people and goods transporting into and out of North Barito District, so that an effective, efficient and sustainable transportation system is needed.

The MuaraTeweh - Palangkaraya route, as far as 380 km, is currently served by two modes of transportation, namely the land transportation mode and the air transportation mode. In the land transportation mode, the operating public transports are buses and minibusses. Meanwhile, the air transportation mode is served by Susi Air with the Cessna C 208B Grand caravan. It is subsidized air transportation that operates only 3 times a week, namely on Tuesdays, Thursdays, and Saturdays. The current travel time for land transportation on the MuaraTeweh-Palangkaraya route is 7 to 9 hours. Meanwhile, using an airplane takes approximately 45 minutes. In terms of cost, currently, inibus rates are around IDR 180,000 - IDR 200,000 for individual transportation and rental IDR 1,000,000.- IDR 1,500,000, while airplane transportation is IDR 455,100, per person (subsidized) up to IDR 1,300,000 (non subsidized).

The existing transportation services are still lacking for the community. Therefore, the Government plans to provide trains on the MuaraTeweh - Palangkaraya route as an alternative transportation mode. For the Government's program to be appropriate and acceptable, it is necessary to study the extent to which the public's interest in the new transportation is compared to existing transportation, especially concerning tariff sensitivity and travel time.

II. THE STUDY THEORY

The model simplifies reality to achieve certain objectives, namely a deeper explanation and understanding and for the benefit of forecasting [1]. The formulation of the mode choice as a choice among alternatives is very much related to individuals or consumer decision-makers' behavior in choosing goods or services. The mode choice model aims to determine the proportion of people who will use each mode [2], defines mode choice as a proportionate share of all people traveling to existing means of transportation, which can be expressed in terms of fractions, ratios, and percentages to total people who use the respective means of transportation such as private vehicles, buses, rental car services, airplanes, trains, and other public transportation.

Mode choice or travel mode choice is the stage of modeling to get the tendency of the perpetrators of the movement using the mode selected as a means of transportation and / or comparison of movements attracted to each available mode. Analysis of mode choice used to compare advantages and disadvantages against the usage of means of transport. Several factors that influence the choice of mode can be classified into three groups, namely the characteristics of the traveler (vehicle ownership, income, household structure, and socio-economic level), the characteristics of the travel (travel destination, travel time, and distance traveled), characteristics of transportation travel (travel time in the vehicle, waiting time, relative availability and parking costs, comfort, trust, and security). A good moode choice model will consider the factors above [3]. The purpose of the analysis is to study the phenomena encountered in the field to allow people to make predictions about the behavior of components in the system being studied. For this reason, the use of the model is suggested to be very useful [4].

Papacostas (1987) states that travelers' behavior in choosing modes of transportation is determined by three factors, namely: The characteristic of the trip-maker, The characteristic of the trip, and The characteristic of the transportation system [5]**.** From research on the use of public transportation in Yogyakarta, the variables that determine the choice of modes of public transportation [6]. These variables are as follow:

1. Public transport factors:
   Ease of achievement, reliability, timeliness, the regularity of service, total travel time, cost level, and information systems.
2. External factors:
   Population income, Activity concentration, Travel distance, Income level, and existing policies such as transportation, environment, parking, and taxes.
3. Personal factors
   Social behavior, ease of use, comfort, social status, and time value.

The general form of a product's utility is a linear model, which is a combination of various attributes. The model's coefficient represents the relative importance of a product's attributes or known as the weight of preference. Influences that describe the contribution produced by an alternative are expressed in terms of coefficients ($a_{1,}$ ... a_n), namely the estimated calibration results, including the estimated number of parameters of travel time, distance traveled, travel costs, income, age, and gender. The product attribute ($x_{1,}$ ... x_n) is a parameter of choice that influences mode choice in a constant plan (a_o), representing a basic difference *(basic bias)* of a product.

In reality, almost all users of a product always have inconsistent factors in their mode choice behavior, or in other words, there is an error factor that researchers cannot define. Therefore, size is based on random utilities *(random utilities)* that follow them and unobserved variables [7].

When estimating a choice, the value of its utility must be very different from other choices expressed in the form of zero and one probability.

As for the opportunity to choose a mode, a logit model will be used because it is appropriate and easy to find out the probability of mode choice from various mode choices. A mathematical form of transformation is usually called the logit function, specifically for more than two alternative modes called the multinomial logit function.

An approach developed to obtain information on travel behavior is to observe existing behavior, which is often called *the stated preference* technique is a data collection technique that refers to the approach to the opinion of respondents in dealing with various choices. This technique uses an experimental design to make a number of alternative imaginary situations. The step taken to indicate how the respondent responds if the imaginary situation exists, in reality, is to ask the respondent directly. Then the researchers can control all the factors that chose offer. The respondents' opinions can be expressed in rank, rating, or mode choice. Estimates are based on the principle of *maximum likelihood* statistics. This principle will be applied to binary logit with parameters a_1, a_2, or ak from a number of N observation samples taken randomly from the population. The sample *likelihood* is all individual observations (L*), as in equation [7]. The maximum value of L* (a_1, a_2, ...a_k) will be obtained if the partial derivative of a_1,a_2, ... a_k is equal to zero, so that the unknown equation *k*, thus each parameter can be determined.

Analysis of the estimated coefficient parameters using the *logit* method. The data used for analysis are data obtained from field surveys that directly influence the mode choice. Specifically for this study, data analysis will be carried out using *transportation planning software* by *trial and error* will get the best formula.

According to Radam (2010), the requirements to get the best formula are[9]:

1. The *P*-value is close to 0 (<0.05) to illustrate that the attribute being reviewed is valid for use
2. The algebraic sign, especially the *travel time* and *travel cost,* is (-) to illustrate the realistic, if the longer travel time, the smaller the probability of mode choice and the cost.
3. The RSQUARE value should be> 0.21 to illustrate that the utility equation has a strong relationship between independent and independent variables.

Table 1. Guidelines for Interpreting Correlation Coefficients [9]

Pseudo r_2 value	r_2 value	Coefficient interval r	The Level Of The Relationship
< 0,014	< 0,04	0,00 - 0,199	Very low
0,014	0,04	0,20 - 0,399	Low
0,050	0,16	0,40 - 0,699	Medium
0,210	0,49	0,70 - 0,899	Strong
0,403	0,81	0,90 - 1,000	Very Strong

III. RESEARCH METHODS

The research analysis stages are grouped into 2 (two) stages, namely collection and analysis data. In general, these stages can be described as follows:

1. Identification of problems
   Identify problems with the modes of transportation serving the route, i.e., land transportation mode (minibus) and air transportation (airplane).
2. Data Collection.
   Data collection is based on 2 (two) stages, i.e., secondary data collection and primary data collection; secondary data collection is done by requesting data from relevant agencies, and direct observation surveys carry out primary data in the field
3. Carry out a survey form design using the *"experimental design"* approach,
4. Conducting surveys or actual observations in the field (primary data collection),
   Make a mode choice of travel and the composition of choice between land modes (minibus and train transportation) and air transportation modes (airplane).
5. For data analysis using LIMDEP, the logit analysis steps are as follows:
   a. Grouping data according to the choice of mode
   b. *Listing data*
   c. Input the formula $U_i = a_0 + a_1x_1 + a_2x_2 + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + a_nx_n$ for all selected modes.
   d. Run the program and get a table containing parameters, estimates, *standard errors*, *t–statistic*, and *P-values.*
6. If the requirement has not been fulfilled, the data will be re-executed, and so on *trial and error* until a formula is produced according to the conditions above.

IV. ANALYSIS AND RESULTS

A. EXPERIMENTAL DESIGN

Design selected scenarios for the three competing modes using an experimental design approach. The determination of the attributes of each mode offered is shown in Table 2.

Table 2. The design attributes offered and the initial Orthogonal Code

Alternative Attribut	Airplane	CO	Minibus	CO	Train	CO
Cost Cost Cost	Low - High	(-1) - (1)	Low medium High	(-1) (0) (1)	Low medium High	(-1) (0) (1)
Facilities Facilities Facilities	Every 3 days - Everyday	(-1) - (1)	The fastest Medium Slow	(-1) (0) (1)	The fastest Medium Slow	(-1) (0) (1)

Furthermore, with the orthogonal design method, 16 question combinations were obtained, as shown in Table 3.

Table 3. Format Design Options

SCENARIO	AIRPLANE		MINIBUS			TRAIN		
	Cost IDR (x1,000)	Servece	Cost IDR (x1,000)	Travel Time (Hour)	Servece	Cost IDR (x1,000)	Travel Time (Hour)	Servece
1	300	A	200	7	ECO	375	6	AC
2	295	A	180	7	AC	375	7	ECO
3	295	B	180	9	AC	230	6	AC
4	295	B	200	7	AC	85	9	AC
5	300	B	160	7	AC	85	7	AC
6	300	B	180	7	ECO	85	6	ECO
7	295	A	160	9	ECO	85	7	AC
8	295	B	60	9	ECO	375	9	ECO
9	300	A	80	9	ECO	85	9	AC
10	300	B	60	9	AC	375	6	AC
11	295	A	60	7	ECO	230	6	AC
12	295	A	00	9	AC	85	6	ECO
13	295	B	60	7	ECO	85	6	ECO
14	300	A	160	9	AC	85	6	ECO
15	300	B	200	9	ECO	230	7	ECO
16	300	A	160	7	AC	230	9	ECO

Notes:
Airplane Service (A) = Every Day
Airplane Service (B) = Every 3 Days
Eco = economy class (non AC)
AC = executive class

B. MODELING ANALYSIS

Mode choice modeling was analyzed using a multi nomiallogit approach. The attributes used in the analysis are described in Table 4.

Table 4. Attributes used

No.	Symbol	Variable	Definition
1	A_0	*Konstanta*	Constants in equations
2	X_{1-1}	*Cost*$_{(airplane)}$	travel costs for airplane mode
	X_{1-2}	*Cost*$_{(minibus)}$	travel costs for minibus mode
	X_{1-3}	*Cost*$_{(train)}$	travel costs for train mode
3	X_{2-2}	*Time*	travel time for minibus mode
	X_{2-3}	*Time*	travel time fortrain mode
4	X_3	*Service*	Services for each mode X_{3-1}: airplane service everyday =1 X_{3-1}: airplane service, not everyday =0 X_{3-2} : AC value = 1 ; Non AC = 0 X_{3-3}: AC value = 1 ; Non AC = 0
5	X_4	*Ori*	origin of the trip
6	X_5	*Sex*	Sex type : 1). Male; 2). female

No.	Symbol	Variable	Definition
7	X_6	*Age*	variable age of the respondent : (*1*). 10-20 years.; (*2*). 20-30 years; (*3*) 30-40 years ; (*4*). 40-50 years ; (*5*). >50 years
8	X_7	*Fam*	The number of family members (….)
9	X_8	*Job*	Jobs (1) entrepreneur; (2) private employees; (3) Civil Servant; (4) housewife. ; (4) TNI / Polri members; (5). other
10	X_9	*Status*	Job Position/Status : (1). Employees; (2). Chairman / director
11	X_{10}	*Income*	Total income in a month (1). < 3 million; (2). 3-5 million; (3). 5-7 million; (4). 5-7 million; (5) >7 million
12	X_{11}	*MC*	The ownership of motorcycles
13	X_{12}	*Car*	Car Ownership
14	X_{13}	*Dist.*	Travel distance (muarateweh – Palangka Raya
15	X_{14}	*PuIDR*	Purpose of travel (1) Department/work, (2) business, (3) Education, (4) recreation/vacation, (5) family visits, and (6) others
16	X_{15}	*Reasn*	Reasons to choose the mode (1) because it is more convenient, (2) faster, (3) safer, (4) cheaper, (5) habits, and (6) other factors

Getting the logit equation is best done by trial and error using the LIMDEP program. The results of the experiment using the LIMDEP program are shown in Table 5.

Table 5. Experiment results to get the modal choice utility equation

Independent Variable			Model in the program	OUTPUT PROGRAM
Airplane	Minibus	Train		
- Cost - Service - Sex - Income	-Cost -Time	-Cost -Time	U(airplane)= cost*X1+ service*X3+ sex*X5+ Inc*X10 / $U_{(bus)}$ =a_bus+cost*X1+ time*X2/ $U_{(train)}$=a_train+cost*X1 +time*X2	RsqAdj = 0,21793 P-value : COST = 0,0000 SERVICE =0,0000 SEX = 0,0150 INCOME = 0,0000 A_BUS=0,0000 TIME=0,0000 A_TRAIN = 0,0000

Note :

- Nilai*RsqAd*= **0,21793** greater than (>0,21), Plane constant (A) marked (+) valid.
- P –Value all<0,05 (qualify)
- The algebraic sign is a cost and time attribute (-) = qualify
- Nilai*RsqAdj* = **0,21793 (Strong Relationship)** danconstant marked (+) = acceptable.

Furthermore, based on these experiments' results, the utility equation of each mode of transportation can be written. In the utility mode choice transportation airplane, minibus, and train, the attributes that can be combined to produce the best utility are *cost*, *service*, *gender*, *and income.*

The utility equation is:

$$U_{(airplane)} = -0,00000881.X_1 + 2,41258675.X_3 + 0,30575811.X_5 + 0,29778234.X_{10}$$

$$U_{(minibus)} = 4,6251817 - 0,00000881.X_{1\text{-}2} - 0,3891718X_2$$

$$U_{(train)} = 4,651867 - 0,00000881.X_{1\text{-}2} - 0,3891718X_2$$

Which :

$X_{1\text{-}(i)}$ = the value of the cost of each mode of travel (Rp). (airplane=1, minibus=2 dan train=3)

$X_{3(i)}$ = service attribute value, (minibus AC=1, non AC=0; train AC=1; non AC = 0, Airplane everyday=1, not every day =0)

$X_{5(i)}$ = value of gender attribute, (male=1, female=0)

$X_{4(i)}$ = value of income attribute, (<3 million=1, 3-5 million=2, 5-7 million=3, and> 7 million =4)

C. SENSITIVITY OF TRAVEL COST

Based on the condition of the respondent's characteristics and the dominant movements occur as follows:

1. Cost attribute ($X_{1\text{-}1}$) for airplane = IDR 300,000, - minibus cost ($X_{1\text{-}2}$) = IDR 200,000. while the most expensive cost for trains is IDR375,000.
2. For the travel time attribute (X_2)) for the minibus mode, we take the fastest time of 7 hours (420 minutes) $X_{2\text{-}2}$ = 420, while for the train, we take the fastest time of 6 hours (360 minutes) $X_{2\text{-}3}$ = 360.
3. For service X_3 attributes for airplane$X_{3\text{-}1}$ every day (1), not every day (0).
4. The dominant gender attributes (X_5) are female (52.7%) with ordinal value (0) and male (47.3%) with ordinal value (1).
5. The dominant income attribute (X_{10}) is income below 3 million (52.7 percent) with an ordinal value (1).

From the data approach's assumptions and using the developed equation, the sensitivity of the cost attribute can be described as shown in Figure 1.

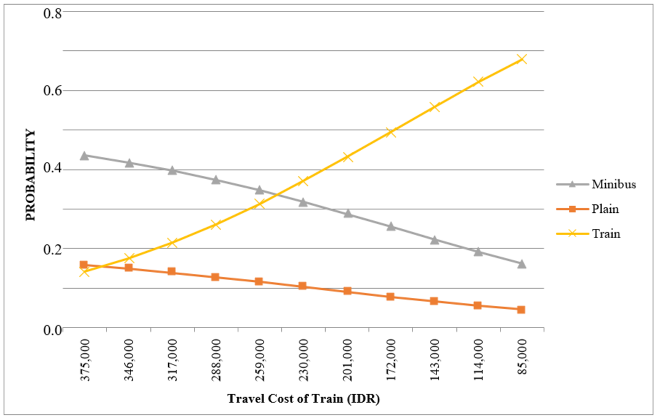

Figure 1. The graph of the sensitivity of the travel cost against the probability of mode choice modes

From Figure1 illustrates that in the condition of airplane transport cost in standard conditions (IDR 295,000) and minibus transportation cost is at normal cost (IDR 200,000,) it can be seen that the probability of mode choice modes of train and transportation is low (14%) on the highest cost conditions applied are IDR 375,000, - In these conditions the probability of land transportation (minibus) reached the highest number (44%), followed by air transport modes (airplane) which have a high enough probability (42%). Furthermore, in the mode of train transportation, to achieve conditions that can compete with existing modes of transportation, a trial for the use of cost is carried out by constantly reducing cost (IDR 375,000) to reach the lowest cost (IDR85,000). On the condition of air transport cost of IDR 295,000, - public minibus IDR 200,000 and train transportation IDR 250,000, - there is a balanced probability that the airplane = 33%, minibus = 34% and train = 33%. This illustrates that the ideal cost applied to the training land transportation mode is IDR 250,000,-with a 6 hours travel time that can compete with existing modes of transportation.

D. SENSITIVITY OF TRAVEL TIME

The mode of train transportation as a new mode of transportation in Central Kalimantan is unknown with certainty the travel time required for the Muara Teweh-Palangkaraya route. Therefore, the calculation of time sensitivity is carried out on train transportation mode. While the mode of transportation of planes and minibusses is not calculated considering that the transportation mode has a definite travel time. The time sensitivity calculation is done by entering the existing attributes and combining travel time in train transport mode.

The calculation of travel time sensitivity uses the following attributes:

- $(X_{1\text{-}1})$ = IDR 295, 000.- (cost of the airplane)
- $(X_{1\text{-}2})$ = IDR 200, 000.- (cost of the minibus)
- $(X_{1\text{-}3})$ = IDR 250, 000.- (cost of thetrain)
- $(X_{2\text{-}2})$ = 7 hours (fastest minibus travel time)
- $(X_{2\text{-}2})$ = *searched (e.g. = 9 hours, 8.5 hours 8 hours etc.)*
- $X_{3\text{-}1}$ = 1 (Everyday)
- $X_{5\text{-}1}$ = 0 (Female)
- $X_{10\text{-}1}$ = 1 (Below 3 million)

A travel time-sensitivity graph can be made by entering the utility equality for the three modes of transportation, as shown in Figure 2.

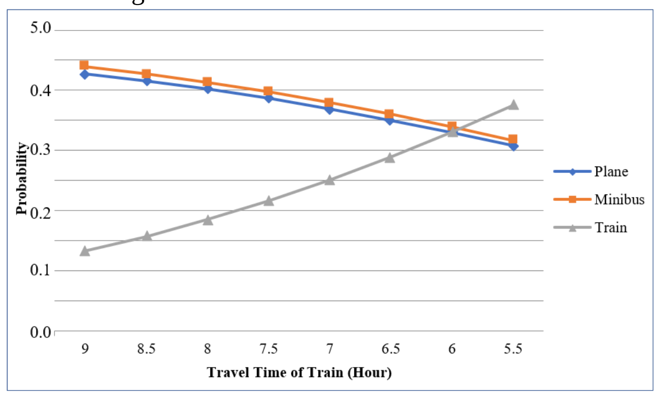

Figure 2. The graph of the sensitivity of the travel time against the probability of mode choice modes

Figure 2 shows that the greater the train travel time, the less the probability value (, the less likely it is to be chosen by the traveler). This sensitivity calculation obtained a balance of probability between airplane transportation mode and minibus mode and train mode, which is at 6 hours of train travel time and 7 hours of minibus travel time.

V. CONCLUSION

From the description above it can be concluded several things at once to answer the problem formulation that has been determined. The transportation mode choice utility model obtained is as follows:

$$U_{(airplane)} = -0{,}00000881.X_1 + 2{,}41258675.X_3 + 0{,}30575811.X_5 + 0{,}29778234.X_{10}$$

$$U_{(minibus)} = 4{,}6251817 - 0{,}00000881.X_{1\text{-}2} - 0{,}3891718X_{2\text{-}2}$$

$$U_{(train)} = 4{,}651867 - 0{,}00000881.X_{1\text{-}3} - 0{,}3891718X_{2\text{-}3}$$

The dominant influential attributes in the modeling mode choice of the airplane, minibus, and train transportation modes on the Muara Teweh-Palangkaraya route are travel cost attributes, minibus and train travel time attributes, service attributes, gender attributes, and income attribute of the traveler.

The effect of cost sensitivity on the mode choice of transportation modes of airplanes, minibusses, and trains on the Muara Teweh-Palangkaraya route is that the higher the cost applied to the mode of transportation, the smaller the probability of the mode to be selected, and the lower the cost on the mode the higher the probability of the mode of transportation to be selected.

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