Mode Choice Model for Airport Train And Bus Passenger

Mode Choice Model for Inter-City Passenger between Train and Bus

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Abstract: Kuala Namu International Airport started operating on July 25, 2013 to replace Polonia International Airport followed by the operation of airport train and bus as a public transport service mode. The purpose of the study was to define the characteristic of airport train and bus users how they choose both of the transportation modes and to test the sensitivity, if one of the transportation attribute are changes. The data obtained through stated preference method was modelled by using binary logit and probit models. From these two models, the probability of using airport train and bus transportation can be known. The result of analysis showed the equations of the function of utility difference of airport train and bus: $U_{KAB\text{-}BB} = 2{,}606 - 0{,}028X_1 - 0{,}007X_2 - 0{,}014X_3 - 0{,}016X_4 + 0{,}044X_5$, where X_1, (cost attribute), X_2 (time attribute), X_3 (headway attribute), X_4 (access attribute) and X_5 (service attribute).

Keywords: *Stated Preference, Binary Logit, Binary Probit, Attribute, Mode Choice*

1. INTRODUCTION

Since the operation of Kuala Namu International Airport, started on July 25th 2013, this led to the increasing mobility of passengers from Medan to Kuala Namu and vice versa. Public transit system that serves passenger from Medan to Kuala Namu are bus, train and taxi. Rail transport modes known have better service than bus or taxi from the standpoint of travel time, but has the disadvantage problem too since their have higher cost than bus and low accessibility (access from Medan Kota Station only). With regard to sustainable transport, we need a policy to give priority to the use of the train from the bus. This is done because the railway mode is a mode that is more environmentally friendly (have smaller emissions, as explain on Morlok [2]), as well as its movement does not burden the road network of the city of Medan. Policies can be done if it had known the passenger preference in the selection of the public transport.

To get an idea of how the preferences of passengers when choosing a mode of public transport, what the things they consider in selecting public transport modes, and what are the things that significantly influence the modal choice, will be explored in this study.

There are very rarely study regarding of bus and train mode choice competition in Indonesia; Elsa Trimurti [4], in 2001 conducted a study of competition between modes of rail and express bus routes in Bandung and Jakarta. In the study found that the attributes that influence the selection of rail and bus modes are cost, time, headway and service. In that study used a questionnaire with Stated preference techniques binomial logit model, to be able to explain the difference between utility models and also the probability of use of both modes. Also concluded that the passengers on the train prefer the quality of services provided, while the express bus users more concerned with ease of access to and from the bus terminal. In

2005 Harun Rasyid Lubis et all [5], has been conducting research with respect to the selection mode trains, buses and private vehicles for Bandung-Jakarta route. In the study toll road connecting Jakarta-Bandung undeveloped, so the travel time using ground vehicles reach 3-4 hours, while using the train travel time can be achieved 3-3.5 hours. In these studies, there are 5 pieces of attributes used in the design of the SP, namely: rates, travel time, headway, and time delay to reach the train station. In these studies, attribute the most influential is the ticket price, which is then followed by travel time, headway, delay and accessibility to the train station. In 2013 Medis et all. [6] has been make a study for bandung Jakarta passenger characteristic on how they choose the public transport with Random Regret Minimization formula.

In the choose mode of public transport, the passenger more emphasis on a set of attributes offered by the existing modes. Some attributes that accompanies or is owned by a mode called the utility of these modes. Kanafani [1] found that in conducting the assessment or comparison of the mode, the passenger is always considered to act rationally and will choose the mode that has a maximum value. Utility value is a function of several service attributes that can be interpreted differently for each individual, according to the amount of information received and socioeconomic background. In this research, because there are only two modes to be selected, it will be used logit models and probit. The equation of the binary logit models and probit binary is as describes at Tamin [3] as follows:

Binary logit equation form.
Probability to choose Airport Train:

$$P_{KAB} = \frac{\exp^{(U_{KAB-BB})}}{1+\exp^{(U_{KAB-BB})}} \quad (1)$$

Probability to choose Airport Bus:

$$P_{BB} = 1 - P_{KAB} \quad (2)$$

Binary probit equation form.
Probability to choose Airport Train:

$$P_{KAB} = \Phi\left(\frac{U_{KAB-BB}}{\sigma}\right) \quad (3)$$

Probability to choose Airport Bus:

$$P_{BB} = \Phi\left(\frac{U_{BB-KAB}}{\sigma}\right) \quad (4)$$

Where:

P_{KAB} = Probability to choose Airport Train
P_{BB} = Probability to choose Airport Bus.
U_{KAB} = Utility of Airport Train.
U_{BB} = Utility of Airport Bus.
σ = standard of deviation.
Φ = cumulative normal distribution

2. METHOD

The stages of research activity in this study as follows:

1. Identify the condition of modes that will be investigated. In this type of mode of transportation that will be the object of research is a bus service that will be compared with the Airport Railway.
2. Designing survey forms. To design the survey form, the technique used is the stated preference. By using this technique, the question can be posed to the respondents is, changes in both the increase or decrease in the value of similar attributes in both modes, and relevance to the modal choice preferences.
3. The data collection process. Survey forms that have been designed and is disseminated to users of the Airport Bus and Rail service to Medan-Kuala Namu Airport at each station of the transportation modes. Figure 1 bellow describes the object of data.

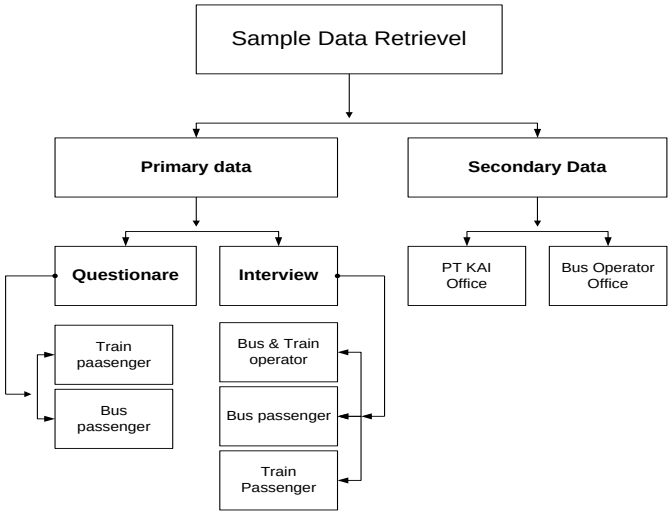

Figure 1. The object of questionnaire and interview

4. Mode Choice Modelling. The data have been collected and processed to obtain a modal choice models. The next step is a test of the model, to determine their validity
5. Sensitivity Analysis Model. Models are declared valid by statistical analysis, and then analysed the sensitivity, to determine the sensitivity of changes in the probability of modal choice, based on the increase or decrease of each attribute.

3. RESULTS AND DISCUSSIONS

The number of valid questionnaires, that processed in this study were 104 questionnaires. As for the distribution of respondents both modes can be seen in Table 1.

Table 1. Distribution of User Respondents Moda Airport Train and Airport Bus service for Travel Medan - Kuala Namu

No.	Moda type	Passenger	Percentage	rounding
1	Airport Train	60	57,69%	58%
2	Airport Bus	44	42,31%	42%

The results of the distribution of questionnaires to passengers, whether they choose a bus or train, showing the reason of the passengers in the selection of the Airport Bus or Train service, as shown in Table 2.

Table 2. Distribution of User Respondents Reason Selection Mode Airport Train and Airport Bus service to Travel Medan - Kuala Namu

No.	Reason	Passenger of Airport Train		Airport Bus	
		quantity	%	quantity	%
1.	Travel Time	36	60	2	4,55
2.	Safety	10	16,67	1	2,27
3.	Comfort	12	20	1	2,27
4.	Accessibility	2	3,33	10	22,73
5.	Fare	0	0	30	68,18
	Total	60	100	44	100

3.1. Correlation Test

This correlation test is used to determine the level of correlation between the independent variables on the dependent variable. Correlation test results against linear equations utility functions can be seen in Table 4.

Table 4. Correlation Matrix

	Y	X_1	X_2	X_3	X_4	X_5
Y	1.000	-0.171	-0.258	-0.191	-0.115	0.283
X_1	-0.171	1.000	0.384	0.000	0.003	0.000
X_2	-0.258	0.384	1.000	0.414	-0.006	-0.114
X_3	-0.191	0.000	0.414	1.000	0.000	0.000
X_4	-0.115	0.003	-0.006	0.000	1.000	0.000
X_5	0.283	0.000	-0.114	0.000	0.000	1.000

From the correlation matrix in table 4 it can be concluded that all independent variables have a fairly low correlation with the dependent variable. While the correlation between independent variables have a low level, so that all the independent variables can be used simultaneously without any possibility multicollinearity problems.

3.2. Alternative of the utility function equation

Some alternative equations can be formed from the existing five independent variables. Equations are considered the best by the criteria for having a small constant value, as well as having the greatest value to the components of the F-stat and R^2.

$U_{KAB-BB} = 2{,}606 - 0{,}028X_1 - 0{,}007X_2 - 0{,}014X_3 - 0{,}016X_4 + 0{,}044X_5$.
Where:
KAB= KA=Airport Train

BB=Airport Bus
X_1 = the difference in the cost attribute (cost).
X_2 = the difference in attributes (time).
X_3 = difference attribute departure time (headway).
X_4 = the difference in the time it takes from their address to the bus/train station (access time).
X_5 = difference service attributes (service).

3.3. The t-test and test F

The t-test was conducted to ascertain the influence of each attribute of the dependent variable. The independent variable is said to have an influence on the dependent variable when the value t count> t-table. By looking at Table 5 it can be concluded all the attributes in the utility function (utility binomial logit) affect modal choice, as shown by the results of testing hypotheses H_0 reject or accept H_1.

F test (simultaneous hypothesis testing) was used to test the effect of independent variables on the dependent variable simultaneously. In Table 5 shows that the utility functions binomial logit has simultaneously independent variables that significantly influence the dependent variable. This is because the value of the F-count> F-table.
hypothesis:

H_o = No influence between independent variables and the dependent variable.
H_1 = There is influence between independent variables and the dependent variable.

Table 5. T test and F test result

variables	Test-t			Test- F		
	T-Count	T-table	Decision	F-Count	F-table	Decision
X_1	6,370	1,666	H_0 Reject	109,231	2,46	H_0 Reject
X_2	5,678	1,666	H_0 Reject	109,231	2,46	H_0 Reject
X_3	7,147	1,666	H_0 Reject	109,231	2,46	H_0 Reject
X_4	6,568	1,666	H_0 Reject	109,231	2,46	H_0 Reject
X_5	15,117	1,666	H_0 Reject	109,231	2,46	H_0 Reject

3.4. Graph modal choice

Graph modal choice is a graph showing the relationship between the probability of modal choice, with the difference in value of the utility of the airport railway and bus service. When the difference in value between the utility and the Airport Railway Bus service increases, the probability of choosing the train service will increase. Conversely if the difference between the value of the utility Airport Train and Bus service to decline, then the probability of choosing the train service will decrease. And if the utility value of both are the same, so that the utility value of the difference is 0, then the probability of train and bus service Bus service will be balanced (Pr KA service = Pr Bus service = 0.5).

The amount of utility and probability modal choice on logit models can be seen in Table 6. While the graph showing the relationship between: the differences of the utility with a probability of modal choice on logit model, can be seen in Figure 2.

Table 6. Probability of Mode Choice with Binary Logit Model

No	Option	Cost (000) Rp	Time (min)	Headway (min)	Access Time (min)	Service (%)	$U_{(KAB-BB)}$	$Pr_{(KAB)}$	$Pr_{(BB)}$
	a	65	-43	75	15	0	-0.203	0.4494	0.5506
	b	55	-43	75	15	0	0.077	0.5192	0.4808
1	c	40	-43	75	15	0	0.497	0.6218	0.3782
	d	45	-43	75	15	0	0.357	0.5883	0.4117
	e	85	43	75	15	0	-1.365	0.2034	0.7966
	a	65	-43	75	15	0	-0.203	0.4494	0.5506
	b	65	-28	75	15	0	-0.308	0.4236	0.5764
2	c	65	-63	75	15	0	-0.063	0.4843	0.5157
	d	65	-35	75	15	0	-0.259	0.4356	0.5644
	e	65	-20	75	15	0	-0.364	0.4100	0.5900
	a	65	-43	75	15	0	-0.203	0.4494	0.5506
	b	65	-43	90	15	0	-0.413	0.3982	0.6018
3	c	65	-43	60	15	0	0.007	0.5017	0.4983
	d	65	-43	15	15	0	0.637	0.6541	0.3459
	e	65	43	135	15	0	-1.645	0.1618	0.8382
	a	65	-43	75	0	0	0.037	0.5092	0.4908
	b	65	-43	75	15	0	-0.203	0.4494	0.5506
4	c	65	-43	75	-15	0	0.277	0.5688	0.4312
	d	65	-43	75	-15	0	0.277	0.5688	0.4312
	e	65	-43	75	15	0	-0.203	0.4494	0.5506
	a	65	43	75	15	-10	-1.245	0.2236	0.7764
	b	65	-43	75	15	-20	-1.083	0.2529	0.7471
5	c	65	-43	75	15	-30	-1.523	0.1790	0.8210
	d	65	-43	75	15	10	0.237	0.5590	0.4410
	e	65	-43	75	15	20	0.677	0.6631	0.3369
	f	65	-43	75	15	30	1.117	0.7534	0.2466

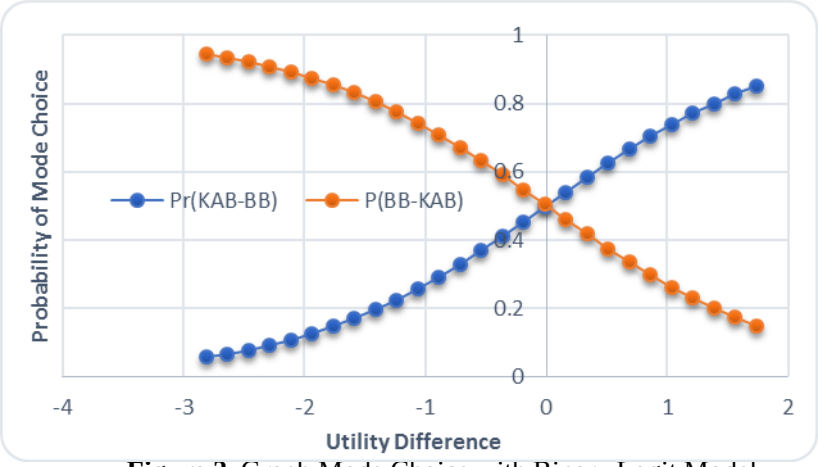

Figure 2. Graph Mode Choice with Binary Logit Model

3.5. Sensitivity Model

An assessment of the sensitivity of the model is meant to understand the rate of change of the probability modal choice value for airport train service when we made of changes to the attribute value gradually.

Some types of the sensitivity of the model either using logit or probit are shown in Figure 3 through Figure 6.

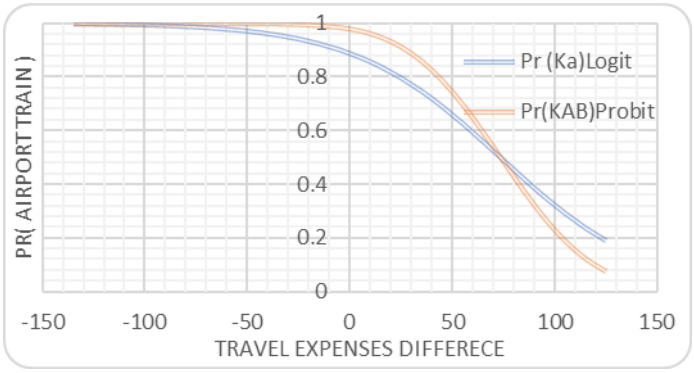

Figure 3. Comparison of Sensitivity of Probit and Logit Binary Model for Travel Expenses

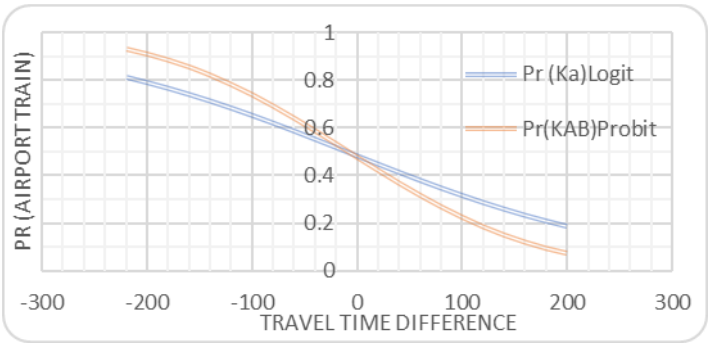

Figure 4. Comparison of sensitivity between Logit Binary and Binary Probit Model for Travel Time Attribute

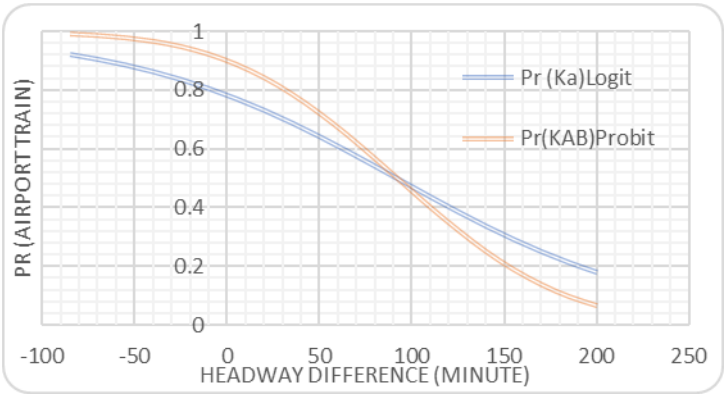

Figure 5. Comparison of Sensitivity for Probit and Logit Binary Models for Headway Attribute

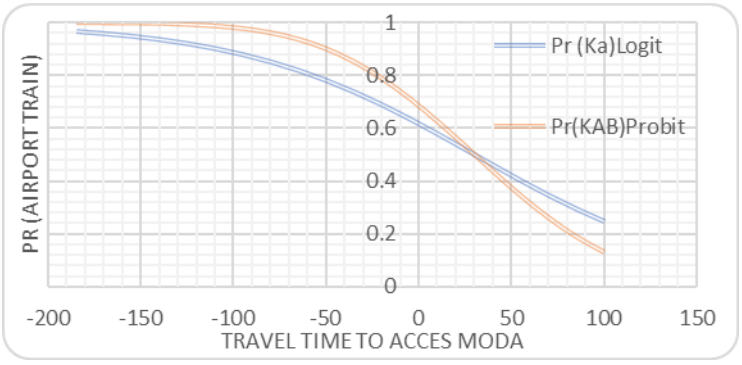

Figure 6. Comparison of sensitivity for Logit and Probit binary model for Travel Time into Station attribute

Figure 3 to 6 shows that travel expenses are the most sensitive attribute. About 50% of passenger will change their mode if travel expenses of Train decreases about Rp.50.000, -.

For travel time attribute, either logit or probit model shows that the differences travel time of the mode is not significant a motivation for the passenger to change their mode. Headway attribute is not an issue for the passenger to switch their mode for existing condition, but there will be a different situation when the difference has reach 20 to 150 minute for probit model and 10 to 150 minute for logit model. In that situation probability passenger who choose airport train from 70% or 80% to will decrease to 35% or 80% from the existing airport train passenger. Travel time into station attribute shows that we can switch existing passenger to choose airport train if we can decrease their access time (travel time to the airport train station from their home) into 50 minute lesser to 50 longer. In that situation probability of passenger can be decrease into 40%.

4. CONCLUSIONS

1. Travel expenses are the biggest factors that most influence on a passenger bus in modal choice behavior.
2. The utility model modal choice between airport train and airport bus service Medan - Kuala Namu route that reviewed in this study: $U_{KAB\text{-}BB} = 2{,}606 - 0{,}028X_1 - 0{,}007X_2 - 0{,}014X_3 - 0{,}016X_4 + 0{,}044X_5$.
   From this model we can conclude that increasing cost, time, headway, access and time will be decrease airport train value utility. It means that passenger will chose airport bus rather than airport train.
3. From sensitivity analysis we can make conclude that travel expenses are the most sensitive attribute.
4. Government policy for sustainable issue can be support when passenger change their mode from bus to train. In this study it can be held with decreasing airport train travel expenses. It can be solved by make a subsidy to all of airport train passenger.
5. Another way to increase probability of passenger to choose the airport train is to make several airport train station, so it will decrease their travel time to access the airport train station.

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