MODEL OF TRANSPORTATION MODE CHOICE FROM TRANSJAKARTA TO MRT PHASE II (CASE STUDY: TRANSJAKARTA CORRIDOR I BLOK M-KOTA)

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ABSTRACT

Transjakarta Corridor 1 (TJ K1) is the corridor with the highest number of passengers among all Transjakarta corridors, where the total passengers reached 2,686,458 people by December 2019. Increasing of passengers affected decreasing performance of TJ K1, especially in load factor parameter 284.615% with total passengers of 111 people in one trip. Therefore, alternative mode is needed to improve performance of TJ K1. The purpose of this research is to know the modelling choice of mode and the probability of TJ K1 users to the MRT. The variables used are time different (TD) and cost different (CD) between TJ K1 and MRT for Blok M-Kota route. This study uses Stated Preference (SP) technique and analysis of the modal choice model with the Logit Binomial Difference Method. The results analysis the probability of switching users from Transjakarta to MRT will tend to shift when experiencing a change, which costs Rp. 7,500 more expensive than the initial Transjakarta fare with a percentage of displacement of 33.36% with the option of 20 minutes faster, 57.07% with the option of 30 minutes faster, and 77.94% with the option of 40 minutes faster time difference between Transjakarta and MRT with coefficient of determination (R^2) of 0.5025, which mean 50.25% was influenced by variables studied.

INTRODUCTION

Transportation plays a role in moving people or goods from their place of origin to their destination [1], [2]. Currently, Indonesia already has various types of transportation including land, sea, air, and rail-based transportation. Rail-based transportation has a fairly high appeal by the public, because rail-based transportation has the advantage of having a high passenger capacity and will not experience congestion because it has a special line. So that the train becomes a very suitable mode of transportation as urban mass transportation in congested corridors [3].

Transjakarta Corridor 1 (TJ K1) is the corridor with the highest number of passengers among all Transjakarta corridors [4], where the total passengers reached 2,686,458 people by December 2019. Increasing of passengers affected decreasing performance of TJ K1, especially in load factor parameter 284.615% with total passengers of 111 people in one trip. Therefore, alternative mode is needed to improve performance of TJ K1.

Mass Rapid Transit (MRT) become one of the alternatives that can be used by all of people who lives and working in Jakarta. MRT phase I (South North Corridor) along the 15.7 km has started operating since March 1, 2019. The MRT phase I is equipped with 13 stations consist of 7 elevated stations and 6 underground stations. Since MRT phase I started operating, the government plans to carry out the construction of MRT phase II and phase III. MRT phase III (West-East Corridor) of 31.7 km is still in the feasibility study stage. MRT phase III is targeted to start the construction process in 2024-2027. While the MRT phase II (North-South Corridor) along 8.1 km begin the

construction process in February 2020, with a construction period of 58 months and will be completed by the end of 2024.

The interesting thing about the construction of the MRT phase II which consists of 7 stations will intersect with the route of Transjakarta corridor 1. In the Kota-Blok M corridor Transjakarta, users will have the opportunity to move or not to the presence of MRT phase II which is a continuation of MRT phase I. In MRT phase I, there are lines from the direction of Blok M-HI Roundabout, then in MRT phase II it will connect the HI-City Roundabout area starting from Sarinah Station which will pass one of the Halmoni shelters which is a transfer area for Transjakarta corridors 1, 2, 3, 5A, 5C, 5H, 7F, 8, 8A, 9B, 10H, and 12M so that the potential for movement at these stops will be very high. With the MRT, which will operate in the Kota-Blok M area, it can attract people to switch to rail-based transportation modes. This is based on where the level of congestion in Jakarta has not been fully resolved, one way that can be done is the provision of mass transportation, the implementation of odd-even parking, progressive parking rates that can reduce the use of private vehicles. The presence of the MRT is also expected to be able to overcome Jakarta's congestion with the desire of people to move using public transportation. With the hope of the public's desire to change modes from Transjakarta to MRT, data is needed in the form of an analysis of the performance of public transportation, namely Transjakarta corridor 1 to determine the standard of assessment based on the performance of public transportation. So that with an assessment of the performance of public transportation, further research can be carried out, namely the analysis of mode transfer.

After the operation of the Beijing-Guangzhou high-speed train, there was a change in market share between the existing trains, high-speed trains and airplane on the Beijing-Guangzhou route with the attributes of travel costs, tickets, speed, security, comfort, convenience and timeliness being the attributes that were considered [5]. The choice attributes of FSC and LCC business air passengers in South Africa were analysed using eleven variables: degree of seat comfort, schedule/frequency, fare, the authority of seat choice, cancellation charge, airport lounge facility, frequent flyer program, business seat choice, inflight food and drinks, method of payment, and inflight entertainment [6].

This study was conducted to determine the model of Transjakarta passengers in determining the choice of transportation mode to be used by using the Stated Preference technique, using several variables that are considered influential. The operation of the MRT Phase II will be an alternative mode of choice that competes competitively with Transjakarta mode [7]. In addition, the only variables offered are the difference in fare and travel time to produce a good coefficient of determination.

METHODS

In transportation planning there are quite important to be analysed, namely the mode choice. By analysing the mode choice, it will produce a model that will show the probability that everyone will use that mode. Analysis of mode choice is conducted by estimating the number of passengers who will use this transportation mode [7], [8].

Stated Preference

In the preference survey, two approaches are known. The first approach is Revealed Preference (RP). The revealed preference technique analyses people's choices based on existing reports or current conditions. By using statistical techniques, the factors that influence the selection are identified. The revealed preference technique has drawbacks, among others, in terms of estimating individual responses to a service situation that does not currently exist and may be far different from the current situation.

The drawback in the first approach is tried to be overcome by a second approach called the Stated Preference (SP) technique. SP technique is an approach to respondents to find out their response to different situations. In this technique, the researcher can fully control the factors that exist in the hypothesized situation. Each individual was asked about their response if they were faced with a given situation in the actual situation (what was their preference for the choices offered) [9].

So that respondents in giving answers are still in the shadow because they have never experienced the conditions that exist now. Stated preference technique is a data collection technique that refers to the approach to the opinions of respondents in dealing with various alternative choices. This technique uses experimental design to make several alternative imaginary situations. Stated preference

experimental designs must be structured in such a way that the combination of all the factors included in the study has a correlation with various alternatives [10], [11].

We designed a stated preference survey questionnaire with several sections according to the travel characteristics of each city. The sections were:

- Factors that influence individuals in the choice of mode
- Respondent's personal information such as gender, age, education, income, and occupation
- Travel information includes the purpose of the trip, the base of origin and the destination of the trip
- Choice of individual travel modes (i.e., Transjakarta and MRT services) with alternative service levels with varying travel times and fares.

Travel time is the travel time of the vehicle in minutes or hours, which is the time required to start the journey from the starting point to the destination. Fare are the costs incurred for the payment of the transportation fee in rupiah per person, which is the cost of the Transjakarta/MRT route.

Difference Binary Logit Method

In the binomial logit model, decision making is faced with a pair of discrete alternatives, where the alternative to be chosen is the one that has the greatest utility. Utility in this case is seen as a random variable. Then the binary logit difference method can be used to determine the mode selection. The binary logit method in making decisions is faced with a pair of alternatives that have great utility [12]. For the binary logit method the difference can use a linear regression equation according to equation 1 below [13] :

$$Y = A + B_1X_1 + B_2X_2................. + B_iX_j \qquad (1)$$

with,

$$Xi = Ln\left[\frac{1-P_1^i}{P_1^i}\right] \qquad (2)$$

With the linear equations contained in equation 1 and the assumptions contained in equation 2, it can produce equations 3 and 4 below.

$$B = \frac{N\sum_i(X_iY_i)-\sum_i(X_i)\sum_i(X_i)}{N\sum_i(X_i^2)-[\sum_i(X_i)]^2} \qquad (3)$$

$$A = \bar{Y} - B\bar{X} \qquad (4)$$

Information:

Y = Utility (dependent variable)
X_i, X_j = independent variables; (time different, cost different)
A = regression constant
B_1, B_2 = regression coefficient
Pi = probability of mode selection
$\bar{Y}$ = average Yi
$\bar{X}$ = average Xi

Using the binary logit method, the difference will produce a mode selection model with alternative utilities, namely the probability of travellers using Transjakarta (PTJ) and the probability of travellers using MRT Phase II (P_{MRT}). From equation 1 it is assumed that Yi is a utility, as in equation 5.

$$Y (P_{TJ} – P_{MRT}) = A + B_1X_1 + B_2X_2 \qquad (5)$$

Information:

$Y (P_{TJ} – P_{MRT})$ = utility
P_{TJ} = $\frac{expU(P_{TJ} - P_{MRT})}{1+expU(P_{TJ} - P_{MRT})}$
P_{MRT} = $1 – P_{TJ}$

To obtain the Transjakarta passenger mode transfer model for MRT Phase II, several steps were carried out according to **Figure 1.**
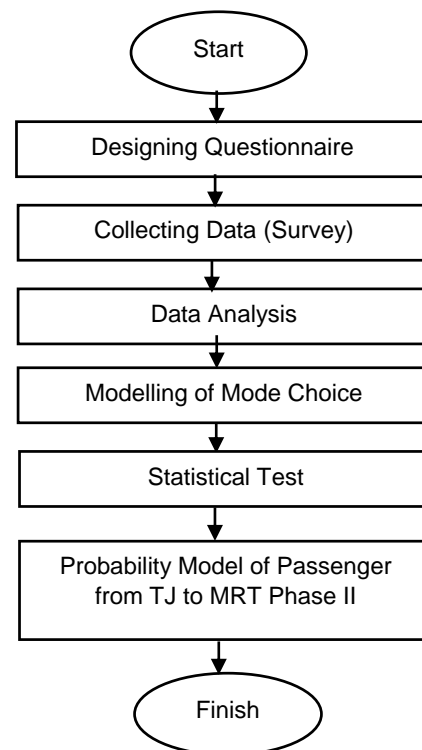

Figure 1. Methodology Research.

Since at the time the research was being conducted there was a Covid-19 pandemic, this research was conducted both offline and online to reduce the risk of being infected with the Covid-19 virus.

RESULTS AND DISCUSSION

Survey

In this study, survey data was conducted online by distributing questionnaires to various social media platforms. The distribution of the questionnaire using Google Form media is carried out until September 2020. However, because it has not reached the required sample. Then direct survey by interviewing the respondents were conducted in November 2020 by implementing the standard of health protocols. From the stated preference survey results obtained 174 respondents with criteria 8 respondents had never used Transjakarta corridor 1 (Blok M - Kota) and 166 respondents had used Transjakarta corridor 1 (Blok M - Kota).

Data Adequacy Test

In this study obtained 48 respondents from 166 respondents which can be said to be valid based on the consistent level of the results of everyone's answer. So to declare this research successful, that is by determining the minimum sample using a sampling technique with the Central Limit Theorem approach. In calculating the minimum sample using the level of confidence or level of significance (a) = 95% and the desired error (g) = 5%. With the number of answers that have been validated as many as 566 from 48 individuals with 12 questions from everyone, the average number of respondents is $47.167 \approx 48$ respondents. So, the value of $Z_{a/2} = 1.964$. The following is a recapitulation of respondents' answers that have been validated as shown in **Table 1**.

Based on the consistent level of answers from each respondent, there were 48 valid answers. Furthermore, an analysis can be carried out for the displacement using the binomial logit method of difference.

Table 1. Recapitulation of respondents' answers.

Scale	Option	Prob (p)	Total Resp. (n)	n x (p - p')^2
1	Absolutely Transjakarta	0.9	100	0
2	Probably Transjakarta	0.7	101	4.04
3	balanced choice	0.5	120	19.2
4	Probably MRT	0.3	135	48.6
5	Absolutely MRT	0.1	110	70.4
			566	142.24
	Total minimum Respondents (people)		48	

Stated Preferences

In this study, the cost different (CD) attribute based on the base price of Transjakarta's ticket is Rp. 3,500 and MRT Phase I is Rp. 3,000 Rp. 14,000 where the cost offered on the MRT refers to every increase in distance of Rp. 1,000/km. So that the projected CD attributes for MRT Phase II are as in the questionnaire sheet. Meanwhile, the time different (TD) attribute refers to the results of the performance survey for the travel time of 40 minutes faster. In MRT Phase II, the assumption of travel time attributes is based on official sources from PT MRT Jakarta, which MRT can travel 45 minutes from Lebak Bulus Station - Kota Station. Based on this data, the travel time from Blok M Station - Kota Station is as follows:
- MRT Phase II (Lebak Bulus - Kota) = 45 minutes for 27.8 km
  27.8 km/45 minutes = 0.6178 km/minute
  So, the MRT Phase II travel time is:
- Blok M - Kota (18 km)
  18 km/0.6178 km/min = 29.158 **≈ 30** minutes.

So that based on **Table 2**, the TD attributes offered to the Phase II MRT mode are 20 minutes, 30 minutes, and 40 minutes faster.

Table 2. Time Different Analysis.

	Travel Time of Transjakarta (minutes)	*Time Different*
Transjakarta	50	*Time different:* 1. Fast: 70-30 = 40 minutes 2. Medium: 60-30 = 30 minutes 3. Slow: 50-30 = 20 minutes
	60	
	70	
MRT Phase II	30	

Model of Mode Choice

MRT Phase II will be connected to MRT Phase I which has started operating since 2019. MRT Phase I - Phase II will pass along the Lebak Bulus - Kota corridor. Where there are some intersections between MRT line Blok M - Kota corridor and Transjakarta corridor. With these two alternative modes, a binomial difference logit model will be available which is used for the mode selection model approach. These two things are difference that is more expensive in terms of cost (cost different) and the difference is faster in terms of time (time different). The probability of choosing a mode between Transjakarta and MRT based on the utility difference function between the two modes is as shown in the equation below [14]:

$$Y = A + B_1X_1 + B_2X_2 \qquad (6)$$

with,

$$Xi = Ln\left[\frac{1-P_{tj}^i}{P_{tj}^i}\right] \qquad (7)$$

And

$$Xi = Ln\left[\frac{1-P_{mrt}^i}{P_{mrt}^i}\right] \qquad (8)$$

where:
i   = integer (0, 1, 2, 3, …)
Xi   = independent variable (in this case, X1 = Dtime different and X2 = Dcost different)
B and C= regression coefficient
A   = regression constant
Ptj   = Probability of choosing Transjakarta
Pmrt   = Probability of selecting MRT

To determine the response from respondents of Transjakarta corridor 1 (Blok M - Kota), rating techniques with 5 (five) semantic scales are used as shown in **Table 3**.

Table 3. Semantic Scale.

Rating	Information
1	Choose Transjakarta
2	Probably Transjakarta
3	Balanced choice
4	Probably MRT
5	Choose MRT

The results of the respondent's choice based on the rating are considered as a representation of the utility ratio assessment that will be carried out by respondents and passengers of Transjakarta corridor 1 (Blok M - Kota). Then this semantic scale is transformed into a numerical scale which will become the dependent variable in the regression analysis. The transformation process from a semantic scale to a numerical scale is shown as follows:

The value of the probability scale is represented by rating values of 1, 2, 3, 4, and 5 with a standard score of $1 = 0.9$; $2 = 0.7$; $3 = 0.5$; $4 = 0.3$; $5 = 0.1$.

By using the linear transformation of the binary logit model, the numerical values for each choice probability are obtained as shown in **Table 4**.

Table 4. Transformation Value.

Rating	Transformation value	
	Probability Scale (P)	Difference logit numeric scale Ln[P/(1-P)]
1	0.9	-2.19722
2	0.7	-0.84730
3	0.5	0.00000
4	0.3	0.84730
5	0.1	2.19722

Correlation Test

The correlation test is used to test the relationship of two or more independent variables (X) with one dependent variable (Y) simultaneously. The correlation coefficient is the size or strength of the weakness between two

variables expressed in numbers. The multiple correlation coefficient can be symbolized by the letter R. The results of the correlation test in this study are as shown in **Table 5**. The magnitude of the correlation coefficient is as follows [3], [15], [16]:

1. R = -1, completely negative shown a relationship between two variables or more but the direction is reversed.

2. R = +1, completely positive (very strong), shown a very strong relationship between two or more variables.

3. R = 0, there is no relationship between two or more variables being tested

Table 5. Result of Correlation Test.

	Time Different (X1)	Cost Different (X2)	Probability (Y)
Time Different (X1)	1		
Cost Different (X2)	-0.5913	1	
Probability (Y)	0.0349	0.5531	1

The correlation value between travel time and fares in the **Table 5**, a correlation value close to -1 or +1 indicates a strong relationship between the two variables and an r value close to 0 indicates a weak relationship between the two variables. While the + (positive) and - (negative) signs provide information about the direction of the relationship between the two variables. If the value is + (positive) then the two variables have a unidirectional relationship. In other words, an increase in travel time will coincide with an increase in the demand for MRT travel and vice versa. If the value is – (negative) it means that the correlation between the two variables is opposite. The increase in the value of the fee or fare will be accompanied by a decrease in the demand for MRT travel.

Selected Model Equation

Based on the results of the utility mode choice analysis using equations 1-8 and the statistical tests carried out resulted in a binomial logit difference model with a value of R^2 = 0.50258, having 2 independent variables, namely time different (TD) and cost different (CD). The results of the binomial difference logit model that have been validated by statistical analysis are shown in **Table 6 - 8** and interpreted as follows:

1. The selected model has a coefficient of determination (R^2) of 0.5025. Where this value has an influence on all attributes of utility changes in the model by 50.25% and the remaining 49.75% is influenced by other attributes that are not considered in this model.

2. All travel attributes in the selected model have a negative value (-), because it is in line with expectations to meet the parameters required.

Table 6. Result of Correlation Test.

Regression Statistics	
Multiple R	0.70893
R Square	**0.50258**
Adjusted R Square	0.50081
Standard Error	1.02151
Observations	566

Table 7. Anova.

ANOVA	df	SS	MS	F	Significance F
Regression	2	595.67	297.8	285.42	2.1E-86
Residual	565	589.57	1.043		
Total	567	1185.2			

Table 8. Result of Regression Analysis.

	Coefficients	Standard Error	t Stat	P-value
Intercept	0.3539	0.164	2.16	0.0314
TD	0.0977	0.006	15.04	0.0000
CD	0.0004	0.000	23.86	0.0000

From the model results, the probability value (P-Value) of 0.0314 can be interpreted as the magnitude of the observed probability (probability) of the test statistic. The value of (alpha) is the maximum error determined by the researcher, while the p-value or significance is the error value obtained by the researcher from the results of statistical calculations (Statistical Test Results) where the value of (alpha) of 0.1 means that the P-value of the model < (alpha) means that the model has an error of about 3.14%.

Then the difference equation for the utility of the Transjakarta mode and the MRT mode is:

$U(P_{tj} - P_{mrt}) = 0.3539 + 0.0977X_1 + 0.0004X_2$

Where:

X_1 = time difference between Transjakarta and MRT

X_2 = cost difference between Transjakarta and MRT

From the analysis results, the probability of passengers who will move from Transjakarta to MRT Phase II is shown in **Figure 2**.
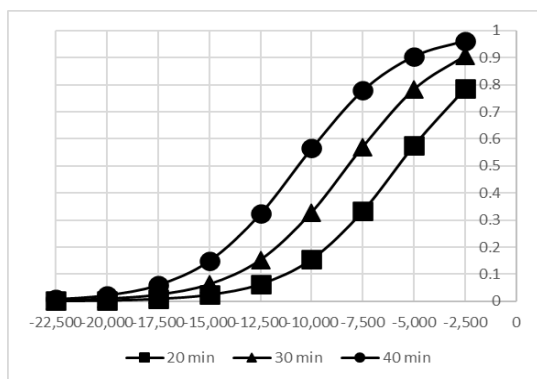

Figure 2. Graph of the Probability of Transjakarta passenger movement to MRT Phase II.

Based on the results of the data tabulation for the probability of MRT moving, it can be seen in the MRT probability graph as shown in **Figure 2**. Where there are 78.72%; 90.76%; 96.31% in a row with a difference of 20 minutes, 30 minutes, and 40 minutes faster will move from Transjakarta to MRT by spending an additional Rp. 2,500 more expensive. As can be seen in the tabulation results, the probability of switching users from Transjakarta to the MRT will tend to shift when experiencing a change, which costs Rp. 7,500 more expensive than the initial Transjakarta fare with a transfer percentage of 33.36%; 57.07%; 77.94% in a row with a difference of 20 minutes, 30 minutes, and 40 minutes faster. From the results of the model and graph obtained, that an increase in the fare difference to become more expensive will reduce the demand for MRT travel and the difference in travel time will increase the demand for MRT travel. The existence of this passenger transfer model due to the operation of the MRT will cause demand for travel using Transjakarta to decrease, so the anticipation is needed by relevant stakeholders to minimize the negative impact on demand for Transjakarta travel.

CONCLUSION

The expected mode selection model in this study are two independent variables to be tested, there are: time different variable (TD) and the cost different variable (CD). So that the expected dependent variable is the probability of the mode transfer of Transjakarta users to the MRT for Blok M - Kota route using the binomial difference logit method. Based on the results of the study of 48 respondents with a coefficient of determination (R^2) of 0.5025. This value has an influence on all attributes of utility changes in the model by 50.25% and the remaining 49.75% is influenced by other attributes that are not considered in this model. Furthermore, all travel attributes in the selected model have a negative value (-) because it is in line with expectations to meet the parameters of the reasonableness condition.

The expected probabilities with the option of 20 minutes, 30 minutes, and 40 minutes faster time difference between Transjakarta and MRT travel times are 78.72%; 90.76%; 96.31% in a row will move from Transjakarta to MRT by incurring additional costs more expensive Rp. 2,500. Meanwhile, the probability of switching users from Transjakarta to MRT will tend to shift when experiencing a change, which costs Rp. 7,500 more expensive than the initial Transjakarta fare with a percentage of displacement of 33.36%; 57.07%; 77.94% in a row. Then Transjakarta users who will switch to MRT with a percentage of less than 60%, when the additional cost is more expensive than Rp. 10,000.

For future research, it is necessary to add other independent variables, including frequency, headway, travel time to the bus stop/station, comfort, travel time from the bus stop/station to the destination which is expected to increase the coefficient of determination (R^2) and the resulting model is more representative.

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