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Analysis of transportation mode choice for Electric Rail Train (KRL) and bus for Yogyakarta-Surakarta travel routes

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ABSTRACT

The presence of the electric rail train (KRL) on the Yogyakarta-Surakarta route expands the list of public transportation modes available to residents of Yogyakarta, Surakarta, and surrounding areas. The Yogyakarta-Surakarta route was previously served by one of the road-based transportation, namely Bus, which was widely used but was abandoned by its users due to a variety of factors. The presence of various alternative modes of transportation today, combined with the Covid-19 pandemic, allows users of public transportation services, particularly the Yogyakarta-Surakarta route, to freely make their choices. Data was gathered through direct interviews and online questionnaires distributed using Google forms. Multiple linear regression and binary logit nisbah were used in the data analysis, and the results were obtained using software, specifically Microsoft Excel and Statistical Product and Service Solutions (SPSS). The Study by binary logit results show that lowering the CBUS (Bus fee) by 1,58 times the unit of money from the CKRL (KRL fee) to Rp7.595/trip from the original Rp12.000/trip will increase bus users by 30%. If TBUS (bus time) is accelerated by 1,81 times the unit time from TKRL (KRL time) to 1 hour and 23 minutes/trip from the original 2 hours and 12 minutes, bus users increase by 50%. Bus users will increase by 70% while KRL users will decrease by 30%, so the number of FBUS (bus frequency) must be increased to 16 times/day from the original 10 times/day by 1,69 times FKRL (KRL frequency).

Keywords: mode choice; passenger characteristics; travel characteristics; mode characteristics; binary logit.

INTRODUCTION

The development of an area cannot be separated from all types of supporting facilities such as economic, government, security, and health facilities, among others. These facilities are aided by the expansion of transportation and infrastructure. Passengers/users of transportation facilities are one factor in the development of transportation facilities and infrastructure; the demand for these facilities and infrastructure will serve as the foundation for related parties to follow up. According to Putri et al. (2018), modes of transportation are the various modes of transportation available for travel or the movement of a person from one location to another using transportation facilities. According to Dwiatmoko et al. (2020), good transportation is a relatively quick, safe, and comfortable trip. The transportation system, according to Dodi and Nahdalina (2019), is a collection of fields comprised of facilities and infrastructure supported by management and human resources that form an infrastructure network and service network. One of the shortcomings of public transportation, according to Rahmayana et al. (2021), is that it is less convenient and safe, and the trip is quite long.

Yogyakarta Special Region, a city with cultural, tourist, and educational attractions, appears to be a draw for some Indonesians. Surakarta is a special city that is still part of the territory of the great Kingdom of its time (the Kingdom of Mataram) and is not far away. Because the two cities have a fairly strong and historical relationship, it is not surprising that population mobility is quite high between the two cities. This particular route is served by two modes of transportation: air and land. Due to the accompanying factors, land transportation is one of the modes of choice with a relatively

high possibility of users. Rosyidi (2019) explains that land use is used to explain the type of activity and intensity that occurs on a plot of land, which is simply understood as a function of a land for activity.

The mode of transportation must provide a basic level of service to passengers so that they can feel safe and comfortable while traveling. The Regulation of the Minister of Transportation number 15 of 2019 concerning the Implementation of People Transportation with Public Motorized Vehicles in the Route describes the minimum service standard, which is the minimum size of service that Public Transportation Companies must fulfill in providing services to Service Users that are safe, safe, comfortable, affordable, equal, and regular. Minister of Transportation Regulation 10 of 2012 concerning Minimum Service Standards for Road-Based Mass Transportation and Minister of Transportation Regulation 27 of 2015 concerning Minimum Service Standards for Road-Based Mass Transportation describe several minimum service standards for road-based mass transportation, namely: 1) Security; 2) Safety; and 3) Convenience. According to Regulation of the Minister of Transportation number 63 of 2019 concerning Minimum Service Standards for the Transportation of People by Train, the minimum service standards in rail transportation include at least the following: 1) Safety; 2) Protection; 3) Dependability; 4) Convenience; 5) Convenience; and 6) Equality. The minimum standards of each mode of public transportation must be met, or the public transportation service provider will face sanctions. The Regulation of the Minister of Transportation number 27 of 2015 concerning Minimum Service Standards for Road-Based Mass Transportation describes administrative sanctions as follows: (1) written warning; (2) permit suspension; and/or (3) license revocation for public transportation service provider.

Land use will have an impact on passenger and cargo mobility, which is directly related to the development of transportation facilities and infrastructure, particularly the Yogyakarta-Surakarta road route. Trains (electric trains) and buses are two popular travel options between Yogyakarta and Surakarta. The addition of a new series of electric trains on the Yogyakarta-Surakarta route provides users with an additional mode of transportation. The author will compare the effects of electric rail trains (KRL) with bus to determine the advantages and disadvantages of each mode. According to Ramadianti and Widyaningsih (2020), one of the differences between bus and electric rail trains (KRL) is that trains have their own crossing.

Mode Choice

According to Supit et al. (2019), mode selection is a stage of the transportation planning process that determines the process of loading trips or knowing the number (in terms of proportions) of people and goods that will use or select various modes of transportation that serve a specific point of origin for specific travel purposes also. The mode/vehicle selection model is a stage in transportation planning that predicts the type and number of vehicles (modes) used in the traffic/travel flow from one point of origin to another (Rosyidi, 2019). The goal of mode choice modeling is to determine the proportion of travel expenses based on the travel subject (person/goods) who will choose or use the available vehicle types (Rosyidi, 2019). According to Rosyidi (2019), the following factors can influence mode choice: (1) travel characteristics; (2) traveler behavior; (3) transportation system factors; and (4) land use and zone characteristics. Dwiatmoko et al. (2020) a good transportation system/means will provide maximum customer satisfaction, resulting in good infrastructure for the larger community.

Binary Logit

Tamin (2000) defines the binary logit model as a model that can describe the distribution of trips with mode selection. According to Rosyidi (2019), the binary logit model is a travel distribution approach model that involves two modes of transportation. Model logit biner is divided into two types: model logit biner-selisih and model logit biner-nisbah. Tamin (2000) explains that the model logit biner-selisih is used when the change factor is not variable, whereas the model logit biner-nisbah is used when the change factor is variable.

According to Sugiono (2019), a research variable is an attribute/nature/value of a person, object, or activity with a specific variation determined by the researcher to be studied and from which conclusions will be drawn later. This study investigates what factors influence a person's choice of

mode of transportation (bus and KRL). Figure 1. depicts the dependent (variable Y) and independent factors (variables X) that influence the choice of transportation modes in this study. Table 1. will explain the study's provisional hypothesis.

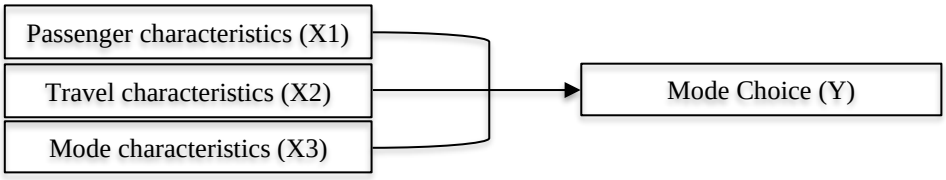

Figure 1. The effect of passenger characteristics, travel characteristics, and mode characteristics on mode choice

Table 1. Hypothesis Path

Hypothesis		Path	
H_1	Passenger characteristics (X1)	→	Mode Choice
H_2	Travel characteristics (X2)	→	Mode Choice
H_3	Mode characteristics (X3)	→	Mode Choice

Table 1 shows the relationship of independent variables passenger characteristics (X1), travel characteristics (X2), and transportation mode characteristics (X3) on mode choice (Y).

RESEARCH METHOD

Place and time of research

Rosyidi (2019) defines the study area as a space/spatial (object) that is carried out through planning and modeling to predict the transportation needs that exist within/from/to the area. The study areas in this research are Yogyakarta, Surakarta, and the area between the two cities. The study location is a location that, according to the author, can represent the study area. The study locations in this research are Yogyakarta Tugu Station, Yogyakarta Giwangan Terminal, Solo Balapan Station, and Tirtonadi Terminal. The research time is September 2021 – November 2021.

Method of collecting data

Data collection methods are techniques or methods for obtaining materials, information, facts, and reliable information needed in research. These methods include questionnaires, observations, interviews, tests, document analysis, and others (Sudaryono, 2019). A questionnaire is used in this study. The questionnaire method is used because the author will still guide the respondents when providing answers on a Likert scale. Table 2. will explain the indicator of independent variable X in this study:

Table 2. Measurement Items

Variable X	Indicator
Passenger characteristics (X1)	[1] Gender (X1.1)
	[2] Age (X1.2)
	[3] Level of education (X1.3)
	[4] Occupation (X1.4)
	[5] Income per month in rupiah (X1.5)
	[6] Private vehicle ownership (X1.6)
Travel characteristics (X2)	[1] Travel costs (X2.1)

	[2] Travel time (X2.2)
	[3] The number of transit points (X2.3)
	[4] On time departure (X2.4)
	[5] Travel Regulations for Covid-19 (X2.5)
Mode characteristics (X3)	[1] Transportation mode cleanliness (X3.1)
	[2] Transportation mode safety (X3.2)
	[3] Transportation mode of convenience (X3.3)
	[4] Accessibility to modes of transportation (X3.4)

Data processing

This study is quantitative. This study investigates the factors that influence a person's decision to use a mode of transportation (bus and KRL). The survey method (questionnaire) is used in this study, which is distributed at the study sites. The survey results will be tested, analyzed, and analyzed using a quantitative approach. Figure 1 depicts independent variables, while table 2 depicts indicators (measurement items) that are awaiting statistical analysis.

Data analysis

The distribution of trips using transportation modes is analyzed using a binary/binomial logit method/model in this study. The author selected the binary logit / binomial logit method / model because only two modes of transportation were compared in this study. This research mode was chosen using software assistance, specifically Microsoft Excel and/or Statistical Product and Service Solutions (SPSS).

RESULTS AND DISCUSSION

Respondent Characteristics

The distribution of modal user characteristics includes age, gender, level of education, occupation, monthly income, and private vehicle ownership from 200 questionnaires distributed. Table 3. will describe the characteristics of passengers.

Table 3. Characteristics of Passengers

Characteristics	Observer	Frequency (n=200)	Percentage (%)
Gender	Man	77	38,5%
	Woman	123	61,5%
Age	< 20 years old	15	7,5%
	20 – 30 years old	117	58,5%
	31 – 40 years old	18	9%
	41 – 50 years old	39	19,5%
	51 – 60 years old	10	5%
	> 60 years old	1	0,5%
Level of education	Primary school	2	1%
	Junior high school	1	0,5%
	Senior high school	94	47%
	Diploma	9	4,5%
	Bachelor’s degree	94	47%
Occupation	Entrepreneur	26	13%
	Collage student/student	82	41%

	Government employees/military/Police	15	7,5%
	Private sector employee	77	38,5%
Income per month (Rupiah)	< 2.000.000	72	36%
	≥ 1.000.000	128	64%
Private vehicle ownership	Motorcycle	152	76%
	Car	4	2%
	Motorcycle and car	44	22%

Validity test results

Sujarweni (2021) explains that the validity test has a function to determine the appropriateness of a question on the questionnaire in describing a variable; if r table > r count, the question is valid. Researchers used the Statistical Package for the Social Sciences (SPSS) application to validate the data. Table 4. shows the results of the validity test.

Table 4. Validity Test Results

Variable	Indicator	R_{count}	R_{table}	Description
Passenger characteristics (X1)	X1.1	0,449	0,138	Valid
	X1.2	0,540	0,138	Valid
	X1.3	0,672	0,138	Valid
	X1.4	0,596	0,138	Valid
	X1.5	0,639	0,138	Valid
	X1.6	0,671	0,138	Valid
Travel characteristics (X2)	X2.1	0,845	0,138	Valid
	X2.2	0,874	0,138	Valid
	X2.3	0,838	0,138	Valid
	X2.4	0,858	0,138	Valid
	X2.5	0,812	0,138	Valid
Mode characteristics (X3)	X3.1	0,925	0,138	Valid
	X3.2	0,935	0,138	Valid
	X3.3	0,938	0,138	Valid
	X3.4	0,925	0,138	Valid

Table 4. shows that all of the independent variable (X) indicators obtained have R Counts greater than R Table, indicating that all indicators are declared valid and can be used.

Reliability test results

The reliability test, according to Ismanto and February (2021), is related to the accuracy of the questionnaire, which is an indicator of the variable; a questionnaire question is said to be reliable if the respondent's answers are stable and consistent. The researchers used the Statistical Package for the Social Sciences (SPSS) application to test the data's reliability. Table 5. shows the reliability test results.

Table 5. Reliability Test Results

Variable	Cronbach's Alpha coefficient	Value Scale	Description
Passenger characteristics (X1)	0,729	> 0,60 – 0,80	High
Travel characteristics (X2)	0,816	> 0,80 – 1,00	Very high
Mode characteristics (X3)	0,829	> 0,80 – 1,00	Very high

Table 5. shows that all independent variables (X) obtained have high and very high Cronbach's alpha values, indicating that the data obtained is reliable.

Normality test results

The researchers used the Statistical Package for the Social Sciences (SPSS) application to test the data's normality. Table 6. shows the normality test results.

Table 6. Kolmogorov-Smirnov Test Results

		Unstandardized Residual
N		200
Normal Parameters[a,b]	Mean	0,0000000
	Std. Deviation	0,94006852
Most Extreme Differences	Absolute	0,057
	Positive	0,057
	Negative	-0,053
Test Statistic		0,057
Asymp. Sig. (2-tailed)		0,200[c,d]

Table 6. shows that the value of Asymp.Sig = 0.2 is greater than 0.05, implying that the data is normally distributed.

Autocorrelation test results

The researchers used the Statistical Package for the Social Sciences (SPSS) application to test the data's autocorrelation. Table 7. shows the autocorrelation test results.

Table 7. Runs Test Results

	Unstandardized Residual
Test Value[a]	0,00000
Cases < Test Value	2
Cases >= Test Value	198
Total Cases	200
Number of Runs	5
Z	0,165
Asymp. Sig. (2-tailed)	0,869

Table 7. shows that the value of Asymp.Sig = 0.869 is greater than 0.05, indicating that the data does not show autocorrelation.

Multicollinearity test results

The researchers used the Statistical Package for the Social Sciences (SPSS) application to test the data's multicollinearity. Table 8. shows the multicollinearity test results.

Table 8. Multicollinearity Test Results

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-2,020	0,447		-4,519	0,000		
	X1.1	-0,143	0,151	-0,031	-0,943	0,347	0,731	1,368
	X1.2	0,021	0,083	0,008	0,255	0,799	0,710	1,409

X1.3	1,164	0,067	0,661	17,278	0,000	0,525	1,906
X1.4	0,009	0,070	0,004	0,122	0,903	0,712	1,404
X1.5	0,251	0,165	0,056	1,519	0,130	0,561	1,784
X1.6	0,172	0,091	0,068	1,888	0,061	0,592	1,690
X2.1	0,272	0,124	0,104	2,189	0,030	0,338	2,957
X2.2	-0,124	0,134	-0,045	-0,926	0,356	0,320	3,127
X2.3	0,329	0,133	0,115	2,481	0,014	0,356	2,805
X2.4	0,117	0,146	0,041	0,799	0,425	0,288	3,472
X2.5	-0,136	0,119	-0,047	-1,138	0,257	0,451	2,218
X3.1	0,166	0,154	0,077	1,079	0,282	0,151	6,614
X3.2	0,324	0,155	0,149	2,092	0,038	0,152	6,577
X3.3	0,036	0,156	0,016	0,229	0,819	0,151	6,604
X3.4	-0,457	0,145	-0,212	-3,152	0,002	0,170	5,874
X3.5	0,407	0,118	0,183	3,462	0,001	0,276	3,624

Table 8. shows that the VIF value of all independent variables is between 1 and 10, indicating that the data does not indicate multicollinearity.

Heteroscedasticity test results

The researchers used the Statistical Package for the Social Sciences (SPSS) application to test the data's heteroscedasticity. Table 9. shows the heteroscedasticity test results.

Table 9. Heteroscedasticity Test Results

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-2,020	0,447		4,413	0,000
	X1.1	-0,143	0,151	-0,031	-0,508	0,612
	X1.2	0,021	0,083	0,008	-1,521	0,130
	X1.3	1,164	0,067	0,661	-4,255	0,000
	X1.4	0,009	0,070	0,004	-1,554	0,122
	X1.5	0,251	0,165	0,056	1,434	0,153
	X1.6	0,172	0,091	0,068	1,571	0,118
	X2.1	0,272	0,124	0,104	3,951	0,000
	X2.2	-0,124	0,134	-0,045	1,241	0,216
	X2.3	0,329	0,133	0,115	-3,254	0,001
	X2.4	0,117	0,146	0,041	1,825	0,070
	X2.5	-0,136	0,119	-0,047	-2.763	.006
	X3.1	0,166	0,154	0,077	-2,125	0,035
	X3.2	0,324	0,155	0,149	-0,958	0,339
	X3.3	0,036	0,156	0,016	1,852	0,066

X3.4	-0,457	0,145	-0,212	-0,078	0,938
X3.5	0,407	0,118	0,183	2,117	0,036

Table 9. shows that the t-statistic value of all independent variables is not statistically significant, implying that the data does not show heteroscedasticity.

Multiple linear regression analysis

The data was analyzed using the Statistical Package for the Social Sciences (SPSS) application and Microsoft Excel by the researchers. The following discussion describes the results of multiple linear regression:

Table 10. R^2 Value

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0,927[a]	0,860	0,847	0,980

Table 10. shows that the correlation between the independent variable (X) and the dependent variable is 0.927. (Y). The value of $R^2 = 0.860$ indicates that the independent variable (X) influences the dependent variable (Y) by 86% and the rest is influenced by other variables. Adjusted R is a more stable version of R^2.

The effect of passenger characteristics, travel characteristics, and mode characteristics on mode choice.

According to the findings of the analysis, the multiple linear regression model from the processed data is as follows:

$$Y = -2,020 - 0,143X1.1 + 0,021X1.2 + 1,164X1.3 + 0,009X1.4 + 0,251X1.5$$
$$+0,172X1.6 + 0,272X2.1 - 0,124X2.2 + 0,329X2.3 + 0,117X2.4 - 0,136X2.5$$
$$+0,166X3.1 + 0,324X3.2 + 0,036X3.3 - 0,457X3.4 + 0,407X3.5$$

According to the equation above, each addition of 1% X1.5 will increase Y by 0.251%, while other variables will have a unidirectional impact.

Binary logit results

The data obtained by the researchers is analyzed using the Microsoft Excel application. The following discussion explains the binary logit results:

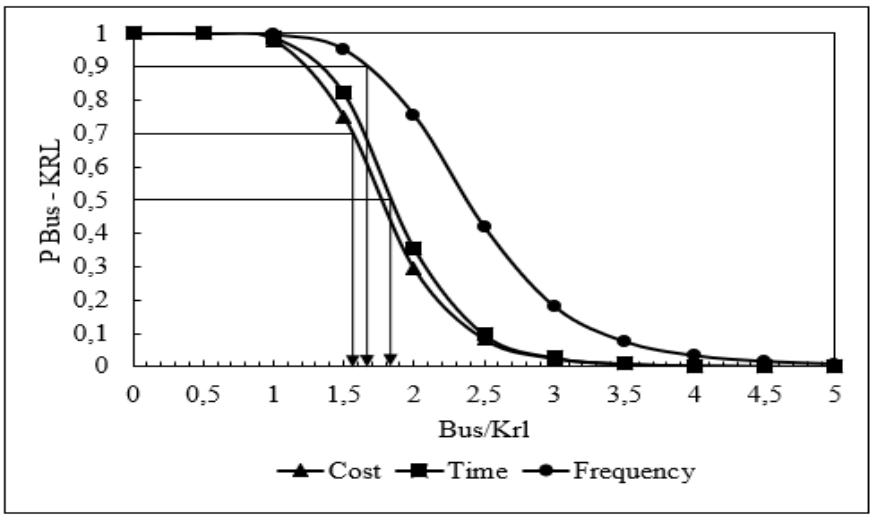

Figure 2. Binary Logit Nisbah KRL and Bus Mode Graph Model

Figure 2. shows that reducing the CBUS (bus fee) by 1.58 times the unit of money from the CKRL (KRL fee) to Rp7,595/trip from the original Rp12,000/trip increases the probability of bus users by 30%. If TBUS (bus time) is reduced by 1.81 times the unit time from TKRL (KRL time) to 1 hour and 23 minutes/trip from the original 2 hours and 12 minutes, bus users increase by 50%. Because bus users will increase by 70% while KRL users will decrease by 30%, the number of FBUS (bus frequency) must be increased to 16 times/day from the original 10 times/day.

Hypothesis test

The researcher employs the Statistical Product and Service Solutions (SPSS) application to test the correlation of the obtained data. The results of the correlation test can be found in Tables 10. Based on Table 11.

Table 11. Hypothesis Test Results

Hypothesis		Path	Pearson Correlation Value	Value Scale	Description	Sig	Results
H_1	Passenger characteristics (X1)	→	0,485	>0,40 – 0,70	Strong Relationship	0,000	Accepted
H_2	Travel characteristics (X2)	→	0,550	>0,40 – 0,70	Strong Relationship	0,000	Accepted
H_3	Mode characteristics (X3)	→	0,581	>0,40 – 0,70	Strong Relationship	0,000	Accepted

Table 11. shows that all independent variables (X) obtained have a Pearson Correlation value that indicates a strong relationship. The three hypotheses (H_1, H_2, and H_3) presented above can be accepted because they influence the mode choice of KRL and bus.

CONCLUSION

This study found that several factors, including passenger characteristics, travel characteristics, and transportation mode characteristics, influence respondents' choice of mode of transportation between KRL and bus. This study also explains that the cost, time, and frequency of the fleet in a day are the most important factors that influence the choice of transportation modes. The study's findings are expected to serve as a reference for parties involved in improving transportation modes, particularly KRL and bus.

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