American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-9, Issue-1, pp-25-33
www.ajer.org
Research Paper
Open Access

Preference Moda Choice Of Passenger Between The Highway And The Steel Road By Using Binary Logistic Regression (A Case Study on Surabaya-Yogyakarta Public Transportation)

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ABSTRACT: *Study of passenger mode choicefrom Surabaya to Yogyakartabetween using the highway which is the bus and the steel road that is the train aims to identify the characteristics of the choice of transportation mode as well as knowing the factors that influence passengers in choosing a mode of transportation. This study was conducted using descriptive statistical analysis methods on the characteristics of passenger mode choice between buses and trainsand logistic binomial regression analysis to determine the factors that significantly influenceand the establishment of a binomial logistic regression model.*

Based on research results using logistic binomial regression analysis the best logit regression model is obtained:

$$Logit\ [\boldsymbol{\pi}(\boldsymbol{x})] = log\left(\frac{\boldsymbol{\pi}(\boldsymbol{x})}{1-\boldsymbol{\pi}(\boldsymbol{x})}\right)$$

$$= -2{,}832 + 1{,}254x_{4(1)} + 0{,}920x_{4(2)} - 1{,}999x_{6(1)} + 2{,}020x_{10(3)} + 1{,}976x_{10(4)} + 3{,}674x_{11(1)} - 1{,}674x_{13(1)} + 1{,}949x_{14(1)}$$

Can be seen that the factors that have a significant effectto the choice of passenger transportation mode is monthly income(x_4)*, Trip length*(x_6)*, passenger travel frequency*(x_{10})*, reliability*(x_{11})*, passenger travel costs*(x_{13})*and travel safety*(x_{14})*.*

KEYWORDS*: Modes of transportation, Mode Choice, Regression Analysis, Binary Logit Model*

Date of Submission: 27-12-2019 Date of acceptance: 06-01-2020

I. PRELIMINARY

Over time that has entered the modern era, where transportation is a basic need for all humansin order to make a move or movement. For this to be supported by a mode of transportationwho can provide the services desired by the community. Modes of transportation that can support this including the bus mode and train mode, both types of modes of transportation are included in the category of land transportation different characteristics, where bus modes use highways and trains use steel roads.

Problems in the choice of transportation mode is a problem that is difficult to identify, because in the case of modal choice it concerns satisfaction, comfort and needs of someone different. In this increasingly modernera many road userswho uses his personal transportation, causing traffic jams everywhere. In the end many road users take advantage of public transportation modes including the Surabaya-Yogyakarta bus and train routes. So that public transport managers are competing in facilitating their respective modes.

For inter-city destinations many users choose to use the bus mode because quickly get it, and no less many travelers who use the train modebecause of its convenience. So the authors identify what factors influence the communityin the selection of modes between buses and trains on the Surabaya route to Yogyakarta.

II. LITERATURE REVIEW

Factors that influence the mode choice

There are 4 (four) groups of factors that are considered strong influence towards travel behavior or potential users. Each of these factors is divided into several variables that can be identified. These variables can be

assessed quantitatively and qualitatively. These factors or variables are:
1. Travel characteristics factor group, include variables:
a. Trip purpose
b. Time of trip made)
c. Trip length
2. Traveler characteristics factor group. In this factor group, all variables contribute to influence the behavior of the traveler in choosing the mode of transportation. The variable is:
a. Income
b. Car ownership
c. The condition of private vehicles
d. Density of residential development
e. Socio-economic, such as the structure and size of the family (young couples, have children, retirees or single), age, gender, type of work, location of work, have driving license (SIM) or not.
3. Transportation system characteristics factor group. All variables that influence the behavior of the traveler relate to the performance of the transportation system services like a variable :
a. Relative travel time
b. Relative travel cost
c. Relative level of service
d. The level of access / connecting index / ease of achieving the destination.
e. The level of reliability of public transport in terms of time (on time / reliability), the availability of parking spaces and tariffs.
4. Special characteristics factor, covering :
a. Variable distance of residence with place of activity.
b. VariablePopulation density

Binary Response Regression Model

Binary logistic regression models are used to analyze the relationship between one response variable and several independent variables, with the response variable in the form of dichotomous qualitative data which is worth 1 to state the existence of a characteristic and a value of 0 to express the absence of a characteristic. The logistic regression model:

$$\pi(x_i) = \frac{e^{(\beta_{0i}+\beta_1 x_{1i}+\beta_2 x_{2i}+\cdots+\beta_p x_{pi})}}{1+e^{(\beta_{0i}+\beta_1 x_{1i}+\beta_2 x_{2i}+\cdots+\beta_p x_{pi})}}$$

Logit from $\pi(x)$is

$$ln\left(\frac{\pi(x_i)}{1-\pi(x_i)}\right) = \beta_{0i} + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_p x_{pi}$$

If

$$g(x_i) = \beta_{0i} + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_p x_{pi}$$

then

$$\pi(x_i) = \frac{e^{g(x_i)}}{1+e^{g(x_i)}}$$

Parameter Estimation

To determine parameter estimation, Newton-Raphson iteration method is used which requires the first derivative and the second derivative of the likelihood function.
y binomial distribution, then the opportunity density function

$$p(y_i = 1) = \binom{n}{1}\{\pi(x_i)\}^{y_i}\{1-\pi(x_i)\}^{n-y_i},$$

$$= \frac{n!}{1!\,(n-1)!}\{\pi(x_i)\}^{y_i}\{1-\pi(x_i)\}^{n-y_i}$$

for n=1 then

$$p(y_i = 1) = \{\pi(x_i)\}^{y_i}\{1-\pi(x_i)\}^{n-y_i}$$

Because observations are independent, the likelihood function is:

$$l(\beta) = \prod_{i=1}^{n} \{\pi(x_i)\}^{y_i} \{1 - \pi(x_i)\}^{n-y_i}$$

Furthermore, the log likelihood function is:

$$L\,(\beta) = ln\{1\,(\beta)\}$$

$$= ln\left\{\prod_{i=1}^{n} \{\pi(x_i)\}^{y_i} \{1 - \pi(x_i)\}^{n-y_i}\right\}$$

$$= \sum_{i=1}^{n} \left[y_i \pi(x_i) - ln\big(1 + \pi(x_i)\big)\right]$$

with

$$g(x_i) = \beta_{0i} + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_p x_{pi}$$

so it's the first derivative:

$$\frac{\partial L(\beta)}{\partial \beta_0} = \sum_{i=1}^{n} \left[y_i - \frac{e^{g(x_i)}}{1 + e^{g(x_i)}}\right]$$

$$= \sum_{i=1}^{n} [y_i - \pi(x_i)]$$

$$\frac{\partial L(\beta)}{\partial \beta_1} = \sum_{i=1}^{n} \left[y_i x_{1i} - \frac{x_{1i} e^{g(x_i)}}{1 + e^{g(x_i)}}\right]$$

$$= \sum_{i=1}^{n} x_{1i} [y_i - \pi(x_i)]$$

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$$\frac{\partial L(\beta)}{\partial \beta_p} = \sum_{i=1}^{n} \left[y_i x_{pi} - \frac{x_{pi} e^{g(x_i)}}{1 + e^{g(x_i)}}\right]$$

$$= \sum_{i=1}^{n} x_{pi} [y_i - \pi(x_i)]$$

in matrix form
$$\begin{bmatrix} 1 & 1 & \cdot & \cdot & . & 1 \\ x_{11} & x_{12} & . & . & . & x_{1n} \\ . & . & & & & . \\ . & . & & & & . \\ . & . & & & & . \\ x_{p1} & x_{p2} & . & . & . & x_{pn} \end{bmatrix}$$
$$\begin{bmatrix} y_1 - \pi(x_1) \\ y_2 - \pi(x_2) \\ . \\ . \\ . \\ y_n - \pi(x_n) \end{bmatrix} = \boldsymbol{X}'(\boldsymbol{Y} - \boldsymbol{\pi}(\boldsymbol{x}))$$

Furthermore, the second derivative will be sought.

$$\frac{\partial^2 L(\beta)}{(\partial \beta_0)^2} = -\sum_{i=1}^{n} \left[\frac{e^{g(x_i)}\big(1 + e^{g(x_i)}\big) - \big(e^{g(x_i)}\big)^2}{(1 + e^{g(x_i)})^2}\right]$$

$$= -\sum_{i=1}^{n} \pi(x_i)[1 - \pi(x_i)]$$

and

$$\frac{\partial^2 L(\beta)}{\partial \beta_0 \partial \beta_j} = -\sum_{i=1}^{n}\left[\frac{x_{ji}\, e^{g(x_i)}\left(1+e^{g(x_i)}\right) - x_{ji}\left(e^{g(x_i)}\right)^2}{(1+e^{g(x_i)})^2}\right]$$

$$= -\sum_{i=1}^{n} x_{ji}\, \pi(x_i)[1-\pi(x_i)]$$

For example, the first partial derivative of $L(\beta)$ to β_j ,j≤pis:

$$\frac{\partial L(\beta)}{\partial \beta_j} = \sum_{i=1}^{n}\left[y_i - \frac{x_{ji}\, e^{g(x_i)}}{1+e^{g(x_i)}}\right]$$

$$= \sum_{i=1}^{n} x_{ji}\,[y_i - \pi(x_i)]$$

then the second partial derivative with respectto β_u , $u \le p$is:

$$\frac{\partial^2 L(\beta)}{\partial \beta_u \partial \beta_j} = -\sum_{i=1}^{n}\left[\frac{x_{ui}\, x_{ji}\, e^{g(x_i)}\left(1+e^{g(x_i)}\right) - x_{ui}\, x_{ji}\left(e^{g(x_i)}\right)^2}{(1+e^{g(x_i)})^2}\right]$$

$$= -\sum_{i=1}^{n} x_{ui}\, x_{ji}\, \pi(x_i)[1-\pi(x_i)]$$

foru,j = 1,2,…,p

and

$$\frac{\partial^2 L(\beta)}{\left(\partial \beta_j\right)^2} = -\sum_{i=1}^{n}\left[\frac{x_{ji}\, x_{ji}\, e^{g(x_i)}\left(1+e^{g(x_i)}\right) - x_{ji}\, x_{ji}\left(e^{g(x_i)}\right)^2}{(1+e^{g(x_i)})^2}\right]$$

$$= -\sum_{i=1}^{n} \left(x_{ji}\right)^2 \pi(x_i)[1-\pi(x_i)]$$

If stated in the form of a matrix is as follows:

$$= -\begin{bmatrix} 1 & 1 & . & . & . & 1 \\ x_{11} & x_{21} & . & . & . & x_{n1} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ . & . & . & . & . & . \\ x_{1p} & x_{2p} & . & . & . & x_{np} \end{bmatrix}$$

$$\begin{bmatrix} \pi(x_1)[1-\pi(x_i)] & 0 & . & . & . & 0 \\ 0 & \pi(x_2)[1-\pi(x_i)] & . & . & . & 0 \\ . & . & & & & . \\ . & & & & & . \\ . & & & & & . \\ \ldots\ldots\ldots 0 \ldots\ldots & \ldots\ldots\ldots\ldots 0 & . & . & . & \pi(x_n)[1-\pi(x_i)] \end{bmatrix}$$

$$\begin{bmatrix} 1 & x_{11} & . & . & . & x_{1p} \\ 1 & x_{21} & . & . & . & x_{2p} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ . & . & . & . & . & . \\ 1 & x_{np} & . & . & . & x_{np} \end{bmatrix}$$

$$= \boldsymbol{X'VX}$$

Estimation of parameters $\beta$by Newton-Raphson iteration method :

1. Initial estimates are selected for β, example$\hat{\beta} = \mathbf{0}$
2. Calculated **X'(Y-** $\boldsymbol{\pi(x)}$) and**X'VX,**then the inverse is calculated from **X'VX**
3. At each i+1 new estimated calculations is $\hat{\beta}_{\boldsymbol{i+1}} = \hat{\beta}_{\boldsymbol{i}} + \{\boldsymbol{X'VX}\}^{-\mathbf{1}}\{\boldsymbol{X'}^{(\boldsymbol{Y}-\boldsymbol{\pi}(\boldsymbol{x}))}\}$
4. Iteration ends if obtained $\hat{\beta}_{\boldsymbol{i+1}} \cong \hat{\beta}_{\boldsymbol{i}}$

PARAMETER TEST

1. Test the likelihood ratio

Hypothesis testing and test statistics are as follows:

$H_0: \beta_1 = \beta_2 = \cdots = \beta_j$,the predictor variable has no effect on the response variable.

H_1: there is at least one$\beta_j \neq 0$,at least one predictor variable influences the response variable.

$$G = -2ln\left(\frac{L_0(\beta)}{L_1(\beta)}\right),$$
$$= -2[ln\, L_0(\beta) - ln\, L_1(\beta)],$$
$$= -2(L_0 - L_1)$$

L_0 =Likelihoodwithout predictor variables,

L_1 =Likelihood with predictor variables.

Test Criteria :H_0rejected if $G \geq \chi^2{}_{(a,v).}$

2. Wald Test

The hypothesis used is:

$H_0: \beta_j = 0$,predictor variable the j-th does not affect the response variable,

H_1:there is at least one$\beta_j \neq 0$,the j-th predictor variable influences the response variable.

Test Statistics :

$$W^2 = \frac{\hat{\beta}_k}{SE(\hat{\beta}_k)}$$

RejectH_0, if value $W^2 > Z_{a/2}$.

III. RESEARCH METHODS

The population in this study is the number of passengers per day of patas buses and economy trains on the Surabaya route to Yogyakarta.

- Train

The average number of fast bus passengers per day, according to data sources at Purabaya terminal is:

Table 1. The average number of passengers per day in rail passenger transportation modes

No.	**Train Operator**	**Passenger x Many passes**	**Average (people)/day**
1.	Sancaka	560 x 1	560
2.	Logawa	480 x 1	480
3.	Sri Tanjung	320 x 1	320
amount			1.360

- Bus

The average number of fast bus passengers per day, according to data sources at Purabaya terminal is:

Table 2. Average number of passengers per bus passenger transportation mode

No.	**Bus Operator**	**Passenger x Many passes**	**Average (people)/day**
1.	SugengRahayu (Eksekutif AC) C	48 x 4 x 2 pp	384
2.	Eka (Eksekutif AC)	48 x 4 x 2 pp	384
amount			768

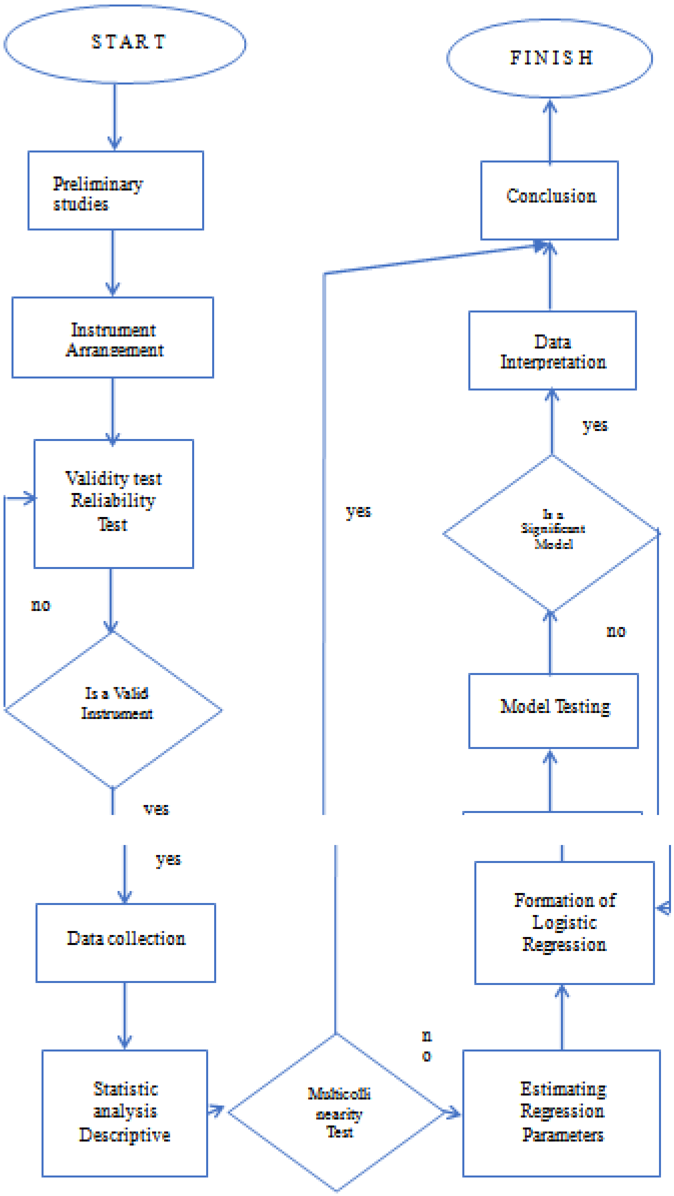

Figure 1. Research Flow Chart

IV. RESULTS AND DISCUSSION

Early Models of Binary Logistic Regression

Data were obtained secondary from public bus transportation and Surabaya-Yogyakarta route railroad public transportation. The results of data processing obtained the estimated parameter values for the binary logistic regression model as follows:

Table 3. Variables in the equation

Variable	Parameter β
X4(1)(Income Rp.1.500.001,00-Rp.2.500.000,00)	1.707
X4(2)(income Rp.2.500.001,00-Rp.3.500.000,00)	0.995
X6(1)(Shorter Travel Length)	-2.352
X11(1)(Can count on)	3.942
X13(1)(Travel expense Rp.100.001,00-Rp.130.000,00)	-1.800
X14(1)(Safety on duty)	1.697
Constant	-3.798

The initial binary logistic regression model formed is:

$$\text{Logit}[\boldsymbol{\pi}(\boldsymbol{x})] = log\left(\frac{\pi(x)}{1-\pi(x)}\right)$$

$$= -3,798 - 0,955x_{1(1)} - 0,666x_{1(2)} + 0,720x_{1(3)} + 0,240x_{1(4)} - 0,294x_{2(1)} - 2,704x_{3(1)} + 0,318x_{3(2)} - 0,035x_{3(3)} - 0,338x_{3(4)} + 1,707x_{4(1)} + 0,995x_{4(2)} - 2,352x_{6(1)} + 2,032x_{7(1)} + 0,733x_{7(2)} + 0,535x_{7(3)} + 0,313x_{9(1)} - 0,908x_{9(2)} + 0,282x_{9(3)} - 1,382x_{10(1)} - 1,708x_{10(2)} + 0,870x_{10(3)} + 1,148x_{10(4)} + 3,942x_{11(1)} - 1,755x_{12(1)} + 0,848x_{12(2)} - 1,800x_{13(1)} - 0,094x_{13(2)} + 1,697x_{14(1)} + 0,974x_{15(1)} + 0,827x_{15(2)}$$

Model Match Test

Model compatibility test used the Likelihood Ratio test.

1. Hypothesis :

$H_0 : \beta_1 = \beta_2 = . . . = \beta_p = 0$ (the model is not suitable)

H_1 :one of $\beta_{jk} \neq 0$ with j= 1,2,. . .,p (suitable model)

2. Significance level α=0.05

3. Test statistics:

To determine the statistical value of the G test, then the value of -2LogLikelihood is determined, Estimated output values are obtained through iteration with the following results:

Table 4. Block iteration 0

Iteration		-2 Log likelihood
Step 0	1	252.218
	2	252.218

Table 5. Block iteration 1

Iteration		-2 Log likelihood
Step 0	1	141.371
	2	124.893
	3	121.438
	4	121.127
	5	121.122
	6	121.122
	7	121.122

The statistical value of the G test is as follows:

$$\text{G} = -2\ \ln\left(\frac{\text{likelihood without predictor variables}}{\text{likelihood with predictor variables}}\right)$$

= (-2 In likelihood without predictor variables) – (-2 likelihood with predictor variables)

= 252,218 – 121,122

= 131,096

This G value can be seen from the Chi Square value in table 6 as follows :

Table 6. Chi-Square Value

		Chi-square
Step 1	Step	131.096
	Block	131.096
	Model	131.096

4. Test criteria

H_0 rejected if rated $G > \chi^2_{(0.05,30)}$ with $\chi^2_{(0.05,30)} = 43,773$.

5. Conclution

H_0 rejected because $G > \chi^2_{(0.05,30)}$ that is 131,096 > 43,773.

So it is concluded that the model is suitable, meaning that the coefficient of simultaneity has a real influence on the model.

Wald Test

1. Hypothesis :

$H_0 : \beta_j = 0$

$H_1 : \beta_j \neq 0$ for j = 1,2,…,30.

2. Significance level α = 0.05.
3. Test statistics:

Parameter estimate value β, Wald value and significance value can be seen in table 7.

Table 7. Parameter Estimation Value, Wald Value and Significance

	B	Wald	Sig.
X1		1.160	0.889
X1(1)	-0.955	0.111	0.739
X1(2)	0.666	0.374	0.541
X1(3)	0.720	0.457	0.499
X1(4)	0.240	0.066	0.798
X2(1)	-0.294	0.110	0.740
X3		1.140	0.888
X3(1)	-2.704	0.672	0.413
X3(2)	0.318	0.103	0.748
X3(3)	-0.035	0.003	0.957
X3(4)	-0.338	0.230	0.631
X4		4.579	0.101
X4(1)	1.707	3.065	**0.040**
X4(2)	0.995	2.775	**0.046**
X6(1)	-2.352	9.918	**0.002**
X7		2.065	0.559
X7(1)	2.032	1.883	0.170
X7(2)	0.733	0.555	0.456
X7(3)	0.535	0.252	0.616
X9		1.069	0.784
X9(1)	0.313	0.156	0.693
X9(2)	-0.908	0.549	0.459
X9(3)	0.282	0.245	0.621
X10		8.906	**0.034**
X10(1)	-1.382	0.340	0.560
X10(2)	-1.708	1.403	0.236
X10(3)	0.870	0.606	0.436
X10(4)	1.148	1.059	0.304
X11(1)	3.942	26.514	**0.000**
X12		3.604	0.165
X12(1)	-1.755	0.899	0.343
X12(2)	0.848	2.420	0.120
X13		4.918	**0.046**
X13(1)	-1.800	4.101	**0.043**
X13(2)	-0.094	0.023	0.880
X14(1)	1.697	5.410	**0.020**
X15		2.117	0.347
X15(1)	0.974	1.992	0.158
X15(2)	0.827	1.362	0.243
Constant	-3.798	5.628	0.018

Based on the Sig. in table 7 withα = 5% it can be concluded that the factors that have a significant effect on the choice of mode between bus and train areincome, trip length, reliability, travel costs and travel security. While age, gender, occupation, travel destination, travel time, travel frequency, comfort level, travel costs and departure distance have no significant effect.

The Binary Response Regression Final Model

Based on the Wald test, the variables used in the final model are the variables that have a significant effect. The estimated value of the parameter can be seen on table 8.

Table 8. Parameter Estimation Value, Wald Value and Significance for the Final Model

	B	Wald	Sig.	Exp(B)
X4	-	4.797	0.091	
X4(1)	1.254	2.864	0.041	3.506
X4(2)	0.920	3.345	0.037	2.510
X6(1)	-1.999	10.155	0.001	0.136
X10	-	11.929	0.018	
X10(1)	0.431	0.050	0.823	1.538

X10(2)	-0.707	0.307	0.579	0.493
X10(3)	2.020	4.071	0.044	7.537
X10(4)	1.976	3.862	0.049	7.211
X11(1)	3.674	29.471	0.000	39.407
X13		8.118	0.017	
X13(1)	-1.674	4.756	0.029	0.188
X13(2)	0.358	0.506	0.477	1.431
X14(1)	1.949	8.846	0.003	7.025
Constant	-2.832	7.835	0.005	0.059

The final model is

$$\text{Logit}\ [\boldsymbol{\pi}(\mathbf{x})] = \log\left(\frac{\boldsymbol{\pi}(\mathbf{x})}{1-\boldsymbol{\pi}(\mathbf{x})}\right)$$

$$= -2{,}832 + 1{,}254x_{4(1)} + 0{,}920x_{4(2)} - 1{,}999x_{6(1)} + 2{,}020x_{10(3)} + 1{,}976x_{10(4)} + 3{,}674x_{11(1)} - 1{,}674x_{13(1)} + 1{,}949x_{14(1)}$$

V. CONCLUSION

Based on the results of the analysis and discussion it can be concluded:

1. From the thirteen independent variables examined in this study, six variables were significantly affected, namely income, travel length, trip frequency, reliability, travel costs and trip safety. And the seven independent variables that have insignificant influence are age, sex, occupation, travel destination, travel time, travel comfort and distance of departure.
2. The binomial logit regression model that is formed is:

$$\text{Logit}[\boldsymbol{\pi}(\mathbf{x})] = \log\left(\frac{\boldsymbol{\pi}(\mathbf{x})}{1-\boldsymbol{\pi}(\mathbf{x})}\right)$$

$$= -2{,}832 + 1{,}254x_{4(1)} + 0{,}920x_{4(2)} - 1{,}999x_{6(1)} + 2{,}020x_{10(3)} + 1{,}976x_{10(4)} + 3{,}674x_{11(1)} - 1{,}674x_{13(1)} + 1{,}949x_{14(1)}$$

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Ma’rifah, Kharisatul. "Preference Moda Choice Of Passenger Between The Highway And The Steel Road By Using Binary Logistic Regression (A Case Study on Surabaya-Yogyakarta Public Transportation)" *American Journal of Engineering Research (AJER)*, vol. 9(01), 2020, pp 25-33