

## Mode Choice Factors of the Bus and Train Route of Malang-Surabaya

Rifky Aisyatul Faroh\*, Sobri Abusini\*\*, Marjono\*\*

\*Mathematics Master Study Program, Brawijaya University, Indonesia

\*\*Mathematics Department, Brawijaya University, Indonesia

Corresponding Author: Rifky Aisyatul Faroh

**ABSTRACT :** Transportation is a tool for moving people or goods from one place to another. A good transportation system will have an impact on the smooth movement of transportation, so that transportation becomes a very important needs in improving the development of the region. The impact of a poor transportation system poses various problems, i.e traffic congestion, accidents, and others. These problems can be solved by the existing transportation planning models. One of the transportation planning models is mode choice. The abundance of public transportation make the traveller must choose one of the available modes. The existence of a difference in cost, security, convenience and other factors cause someone had to pick the best mode in accordance with his wishes. Therefore, this research aims to know the factors that influence someone in selecting mode especially Malang-Surabaya route. The used method to find out the factors by using structural equation model. The result shows that the bus mode choice is affected by age, income, vehicle ownership, distance, safety, accuracy, speed, service, cost, security and convenience. While the train mode choice is affected by age, income, safety, accuracy, service, cost, cleanliness, accessibility, security and convenience.

**KEYWORDS:** Transportation, mode choice, bus, train, structural equation model.

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### I. INTRODUCTION

Transportation is a very important facility in improving the development of an area and the community economy activities. Development improvement and population growth increasing will inflict mobility raising too. A good transportation system will have an impact on the smooth movement of transportation, so that transportation becomes a very important needs in improving the development of the region. The mode choice is one of the transportation planning models that can be used to overcome the problems resulting from the transportation system.

The mode choice has importance role for traveller especially for Malang people who want to go to Surabaya, for example for workers who choose to remain stay in Malang even though working in Surabaya. It also plays an important role for Malang people who will go to Surabaya for vacation purposes or any other purpose. So to be able to get to the destination needed a transportation that simplify the traveller. The number of available public transportation is making the traveller must choose one of the available modes. The existence of a difference in terms of cost, security, convenience, and other factors cause someone had to pick the best mode in accordance with his wishes. Therefore, required an analysis to find out the factors that influence the perpetrators toward Malang journey from Surabaya in taking decisions regarding the mode choice.

In 2008, Shiftan, et al. [1] conducted a study regarding causal relationships between latent variables and measured variables also categorize transportation market based on the latent variable. Deutsch, et al. [2] analyze the relationship between the behavior of the society travel and their perception of the surrounding environment using Structural Equation Models (SEM) based on data from the sample survey of 719 in Sabta Barbara and California, USA. The impact of latent variables can be found in the decision process, for several decades, hybrid choice model (HCM) was developed 1986 Mcfadden [3] using psychometric data explicitly with model attitudes and perceptions as well as their influence against the mode choice.

In 2017, Chen and Li [4] extend the formulation of models to develop model ICLV on public transportation that combines a set of latent variables associated with comfort, personal safety, coziness, service,

and the feeling of waiting for the more sensitive to public transportation users that match data from reasearch in Chengdu, China. The latent variable set is used to describe the behavior of public transportation mode choice to achieve a more precise interpretation of the individual factors that influence the mode choice of public transportation.

In this research was conducted on the passenger public transportation of Surabaya-Malang route and using two modes, namely bus and train. The purpose of this research is to analyze the factors that affect the traveller from Malang to Surabaya in choosing public transportation modes by using the method of Structural Equation Models (SEM).

## II. MATERIALS AND METHODS

### 2.1 Transportation

Transportation is a business of moving, or the movement of people or goods from a location, called the original location, to another location, which is usually called the destination location, for certain purposes using certain tools as well. [5].Transportation problems that have existed since ancient times may still be found in the present, certainly with a much greater quantity and far more severe quality. It is also possible to have other forms that are far more complicated because the more years there are more parties involved so that it is more difficult to overcome. The most popular transportation planning concept is the "Four-Stage Transportation Planning Model", namely trip generation, trip distribution, mode choice, and traffic assignment. [6].

The purpose of the node choice model is to know the proportion of people who will be using every mode. Process has the meaning to calibrate the model selection mode in the basic free variables by knowing that affect the selection of the mode. Model selection mode is one of the most important model in transportation planning. There are four factors that can influence mode choice, including [6]:

- a. Characteristics of road users
- b. Characteristics of movement
- c. Characteristics of transportation mode facilities
- d. Characteristics of the city or zone

### 2.2 Structural Equation Model (SEM)

SEM is a statistical method that is formed from a combination of two methods, namely (1) factor analysis developed in psychology / psychometry or sociology and (2) simultaneous equation models developed in econometrics [7]. According to Hox and Bechger in 1998 SEM is defined as a multivariate analysis technique developed to cover the limitations possessed by previous analysis models that were widely used in statistical research. These models include regression analysis, path analysis, and confirmatory factor analysis[8].

According to Wijanto (2008) SEM characteristics described into the SEM model components consisting of [9]:

1. two types of Variables, namely the Latent Variable and the Observed or Measured or Manifest Variables.
2. two types of Model, namely the Structural models and Measurement Model.
3. two types of Errors, namely the Structural Error and Measurement Error.

The model in SEM is divided into two, there are [9]:

#### a. Structural Model

Structural models are models that describe relationships which occur between latent variables. The general form of the structural model is as follows [10]:

$$\eta_{m \times 1} = B_{m \times m} * \eta_{m \times 1} + \Gamma_{m \times n} * \xi_{n \times 1} + \zeta_{m \times 1} \quad (1)$$

where  $\eta$  is endogen latent variable,  $\xi$  is exogen latent variable, B is path coefficient matrix for relationships between endogenous latent variables,  $\Gamma$  is path coefficient matrix for the relationship of endogenous latent variables and variables latent exogenous and  $\zeta$  is structural error.

#### b. Measurement Model

Measurement models are models that describe relationship which occur between latent variable and their indicators (observed variable) [8].Measurement equation model for Y and X are [10]:

$$Y_{p \times 1} = \Lambda_{y_{p \times m}} * \eta_{m \times 1} + \varepsilon_{p \times 1} \quad (2)$$

$$X_{q \times 1} = \Lambda_{x_{q \times n}} * \xi_{n \times 1} + \delta_{q \times 1} \quad (3)$$

where Y is manifest variable for variable latent endogeneous, X is manifest variable for variable latent exogeneous,  $\Lambda_y$  is coefficient variable latent endogeneous,  $\Lambda_x$  is coefficient variable latent exogeneous,  $\varepsilon$  is error measurement that connect to Y, and  $\delta$  is error measurement that connect to X.

Bollen and Long in 1993 explained that the procedure of SEM generally will contain the stages as follow [9]:

- 1). Model Specification: The model specification stage is related to the formation of the initial model of structural equations, before estimation is carried out. This initial model is formulated based on a theory or previous research.

2). Identification: This stage relates to the study of the possibility of obtaining unique values for each parameter in the model and the possibility of simultaneous equations there is no solution. Broadly speaking, there are three categories of identification in simultaneous equations, namely: a. The Under-identified Model, b. The Just-identified Model, and c. The Over-identified Model. In the SEM, sought to acquire models that over-identified and to avoid under-identified models.

3). Estimation: This stage is related to estimation of the model to produce parameter values using one of the available estimation methods. The choice of estimation method used is often determined based on the characteristics of the variables analyzed. The available estimation methods, among others [8], Two Stage Least Square (TSLS), Unweighted Least Square (ULS), Generalized Least Square (GLS), Maximum Likelihood Estimation (MLE), Robust Maximum Likelihood (RML), Generally Weighted Least Square (WLS), Diagonally Weighted Least Squares (DWLS).

4). Goodness of Fit: This stage is related to test the compatibility between the model and the data. According to Hair, et al (1998), evaluation of the level of data compatibility with the model was carried out through several stages, namely overall model fit, measurement model fit, and compatibility of structural models model fit [9]. Goodness of Fit that can be used is Root Mean Square Error of Approximation (RMSEA), Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI), and Comparative Fit Index (CFI).

5). Respecification: This stage is related to the respecification of the model based on the results of the previous stage match test.

### 2.3 Survey and Data

The location of the research was held in Malang, East Java. Data collection is done by filling out questionnaires distributed to users of public transportation (Bus and Train). There are 210 data respondents who are users of public transportation analyzed. The data analyzed consisted of 15 indicators, namely age, income, family size, vehicle ownership, distance, safety, accuracy, speed, service, cost, cleanliness, accessibility, security, convenience, and frequency of travel. Each indicator is obtained from the answer to the questionnaire to respondents using public transportation. Data obtained from survey results are then processed and analyzed. The indicators obtained are then analyzed using the Structural Equation Model (SEM) method to find out which factors are most influential in choosing the Bus and Railway modes.

## III. RESULTS AND DISCUSSION

### 3.1 DataAnalisis

#### 3.1.1 Normality Test

Normality assumption can be tested with the help of LISREL 9.30 and SPSS software by looking at the skewness and kurtosis of z statistics values. If the value of  $z_{hitung} \leq 0.05$  then it can be said that the data distribution is not normal. Conversely, if the value of  $z_{hitung} > 0.05$  then it can be said that the data distribution is normal. Univariate normality test and multivariate normality of Bus passenger data used in this analysis can be tested the normality, as presented in Figure 1 below.

Test of Univariate Normality for Continuous Variables							
Variable	Skewness		Kurtosis		Skewness and Kurtosis		
	Z-Score	P-Value	Z-Score	P-Value	Chi-Square	P-Value	
US	0.056	0.955	-0.687	0.492	0.475	0.789	
PD	0.369	0.712	-1.840	0.066	3.523	0.172	
JK	-0.011	0.991	-0.241	0.810	0.058	0.971	
KK	0.365	0.715	-0.313	0.754	0.231	0.891	
JR	-0.382	0.702	-0.314	0.754	0.245	0.885	
KS	-0.155	0.877	-0.742	0.458	0.575	0.750	
KT	-0.069	0.945	-0.654	0.513	0.432	0.806	
KC	0.010	0.992	-0.392	0.695	0.154	0.926	
PL	-0.169	0.866	-0.467	0.641	0.246	0.884	
BE	-0.219	0.827	-0.994	0.320	1.036	0.596	
KB	-0.176	0.860	-0.760	0.447	0.609	0.738	
AK	-0.166	0.869	-0.646	0.519	0.444	0.801	
KA	-0.068	0.946	-0.862	0.389	0.747	0.688	
KY	-0.087	0.931	-0.699	0.484	0.497	0.780	
FR	-0.039	0.969	-0.935	0.350	0.876	0.645	

Fig 1 Univariate Normality Test of Bus Passenger Data

From the results above, the univariate normality test shows the test results for each variable normality since the p-value Skewness and Kurtosis each indicator is greater than 0.05.

Relative Multivariate Kurtosis = 1.034  
Test of Multivariate Normality for Continuous Variables

Skewness			Kurtosis			Skewness and Kurtosis	
Value	Z-Score	P-Value	Value	Z-Score	P-Value	Chi-Square	P-Value
22.242	2.569	0.010	263.682	3.121	0.002	16.339	0.000

**Fig 2 Multivariate Normality Test of Bus Passenger Data**

Based on the results of the output in Figure 2 above, it can be seen that the multivariate normality is not normal because p-value for the Skewness and Kurtosis is  $0.000 < 0.05$ .

While the univariate normality test and multivariate normality Train passenger data used in this analysis can be tested the normality, as presented in Figure 3 below.

Test of Univariate Normality for Continuous Variables

Variable	Skewness		Kurtosis		Skewness and Kurtosis	
	Z-Score	P-Value	Z-Score	P-Value	Chi-Square	P-Value
US	0.209	0.834	-1.445	0.148	2.133	0.344
PD	0.071	0.943	-1.960	0.050	3.847	0.146
JK	-0.201	0.841	-0.485	0.628	0.276	0.871
KK	1.279	0.201	0.648	0.517	2.056	0.358
JR	-0.025	0.980	-2.181	0.029	4.758	0.093
KS	-1.331	0.183	-0.473	0.636	1.997	0.368
KT	-0.631	0.528	-1.506	0.132	2.666	0.264
KC	-0.359	0.720	-1.593	0.111	2.666	0.264
PL	-1.298	0.194	0.226	0.821	1.735	0.420
BE	-1.206	0.228	-1.337	0.181	3.241	0.198
KB	-1.443	0.149	-0.535	0.593	2.368	0.306
AK	-1.497	0.134	-1.202	0.229	3.686	0.158
KA	-1.090	0.276	-1.784	0.074	4.371	0.112
KY	-0.304	0.761	-1.290	0.197	1.756	0.416
FR	0.142	0.887	-1.734	0.083	3.027	0.220

**Fig 3 Univariate Normality Test of Train Passenger Data**

From the results in Figure 3, it can be seen that all variables is normality, i.e. variables age, income, family size, vehicle ownership, distance, safety, accuracy, security, convenience, speed, service, cost, cleanliness, frequency of travel, and accessibility since the p-value Skewness and Kurtosis greater than 0.05.

Relative Multivariate Kurtosis = 1.022  
Test of Multivariate Normality for Continuous Variables

Skewness			Kurtosis			Skewness and Kurtosis	
Value	Z-Score	P-Value	Value	Z-Score	P-Value	Chi-Square	P-Value
27.387	6.725	0.000	260.575	2.349	0.019	50.741	0.000

**Fig 4 Multivariate Normality Test of Train Passenger Data**

Based on the results in Figure 4 above, it can be seen that the multivariate normality is not normal because p-value for the Skewness and Kurtosis is  $0.000 < 0.05$ . According to Ghazali and Fuad in 2008, there are two assumptions abnormality data. In this research, used the second assumption, namely model estimation using the method of Maximum Likelihood, but must also correct standard errors and some goodness of fit indices due to abnormality of distribution data [11].

### 3.1.2 Multicollinearity Test

The aim of the Multicollinearity test is to check whether the regression model is found the existence of a correlation between the dependent variables [12]. The lack of correlation between the dependent variables shows that the regression model is good. Method of calculating this test is performed by calculating Pearson

correlation between observed variables. The requirement that must be met in order for a variable is said to have no multicollinearity or don't have high correlation between the variables is look the correlation value, if correlation value between  $-0.7 < r < 0.7$  then it said did not have the high multicollinearity or correlation. Multicollinearity test calculation based on each charge indicators, data Bus and Train passengers fill terms because the correlation value is at  $-0.7 < r < 0.7$ .

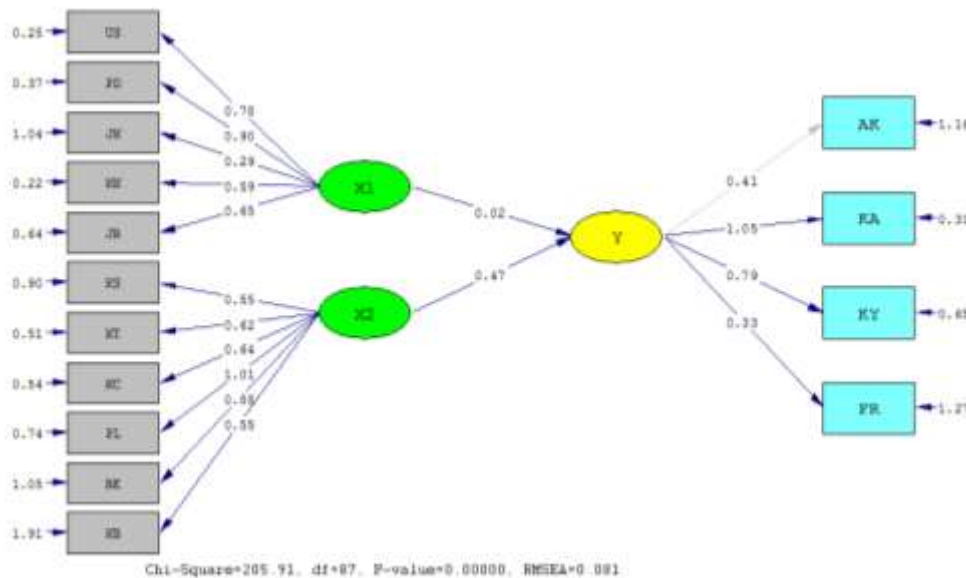
**3.2 SEM Analisis**

The approach of using SEM of the relationship of structural behavior of passenger, performance satisfaction and mode choice used to analyze causal relationships or linkages between variables.

**3.2.1 SEM Analisis of Bus 1**

a. Model Specification

Step of specifications model or early structural model on the data Bus passengers can be seen in Figure 5 below.



**Fig 5 Result of Structural Model Estimation 1 (Bus)**

b. Identification

Identification of the model on the parameter prediction of Bus passenger data is over identified model because the number of parameters that are known to be larger than the number of parameters being estimated. With the highest degree of freedom is 87 ( $df > 0$ ) means that already meet the standards.

c. Estimation

The estimation method used in this research is the Maximum Likelihood method with the help of LISREL 9.3 software. Analysis is performed with 21 maximum iterations.

d. Goodness of Fit

The next step is goodness of fit, i.e. measurement model fit (validity and reliability), compatibility of structural models model fit (the value of  $R^2$ ), and overall model fit (Goodness of Fit).<sup>a)</sup>Based on the results of the measurement model fit analysis explains that the measurement model of the 15 indicators that fill the standards of validation only 11 indicators, namely, age, income, vehicle ownership, distance, speed, accuracy, safety, service, cost, security, and convenience. The result is a validation test can be viewed from the value of loading factors, that should be more than equal to 0.4 and the t-value analysis should be more than equal to 1.96. Then to test the reliability of the latent variables, 3 variables have a good reliability i.e. variable passenger behavior, performance satisfaction, and the mode choice because the constructs reliability value is more than equal to 0.7. b) analysis results of structural models fit compatibility explain that  $R^2 = 0,223$  it means that the model can explain the circumstances on the field of 22.3%. c) Further analysis based on the results of the overall model fit means from the 4 criterias for Goodness of Fit (GOF) namely RMSEA, GFI, AGFI, CFI and all of them did not fill the standard. The results can be seen in Table 1.

**Table 1 Goodness of Fit Result Model 1 (Bus)**

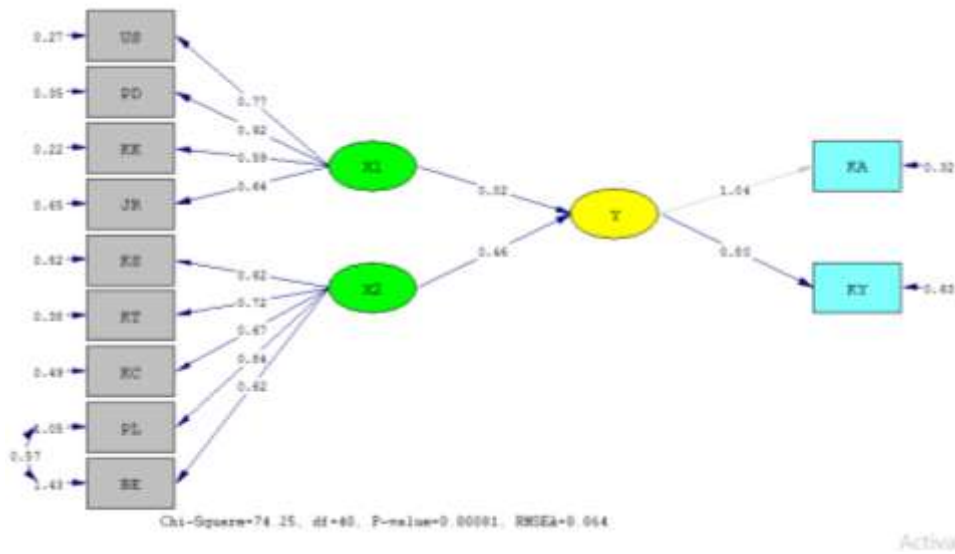
Goodness of Fit	Cut off Value	Analisis Result	Model Evaluation
RMSEA	≤0,08	0,081	Bad
GFI	≥0,90	0,887	Bad
AGFI	≥0,90	0,844	Bad
CFI	≥0,95	0,874	Bad

e. Respecification

The results of the above analysis explains that the results of the prediction of structural model parameter 1 does not yet have sufficient ability so it needs to the respecification models.

**3.2.2 SEM Analisis of Bus 2**

The result of the model respecification shows that the degree of freedom values is 40 (df > 0) which means including over identified model, with 10 maximum iterations. The results of the 2nd structural model parameter prediction can be seen in Figure 6.



**Fig 6 Result of Structural Model Estimation 2 (Bus)**

The goodness of fit result for 2nd structural model is as follows: a) Based on the results of the measurement model fit analysis explains that the measurement model of the 11 indicators that fill the standards of validation is the 11 indicators, i.e. age, income, vehicle ownership, distance, speed, accuracy, safety, service, cost, security, and convenience. The result is a validation test can be viewed from loading factor value, that should be more than equal to 0.4 and the t-value analysis should be more than equal to 1.96. Then to reliability test, 3 latent variables have a good reliability, i.e. variables of passenger behavior, performance satisfaction, and mode choice the constructs reliability value is more than equal to 0.7. b) ) analysis results of structural models fit compatibility explain that  $R^2 = 0,213$  it means that the model can explain the circumstances on the field of 21.3%. c) Further analysis based on the results of the overall model fit means from the 4 criterias for Goodness of Fit (GOF), all variables fill the criteria, so it was concluded that the proposed model is declared fit with data. It can be seen in Table 2.

**Table 2 Goodness of Fit Result Model 2 (Bus)**

Goodness of Fit	Cut off Value	Analisis Result	Model Evaluation
RMSEA	≤0,08	0,064	Good
GFI	≥0,90	0,940	Good
AGFI	≥0,90	0,901	Good
CFI	≥0,95	0,958	Good

**3.2.3 SEM Analisis of Train 1**

a. Spesifikasi Model

Step of specifications model or early structural model on the data Train passengers can be seen in Figure 7 below.

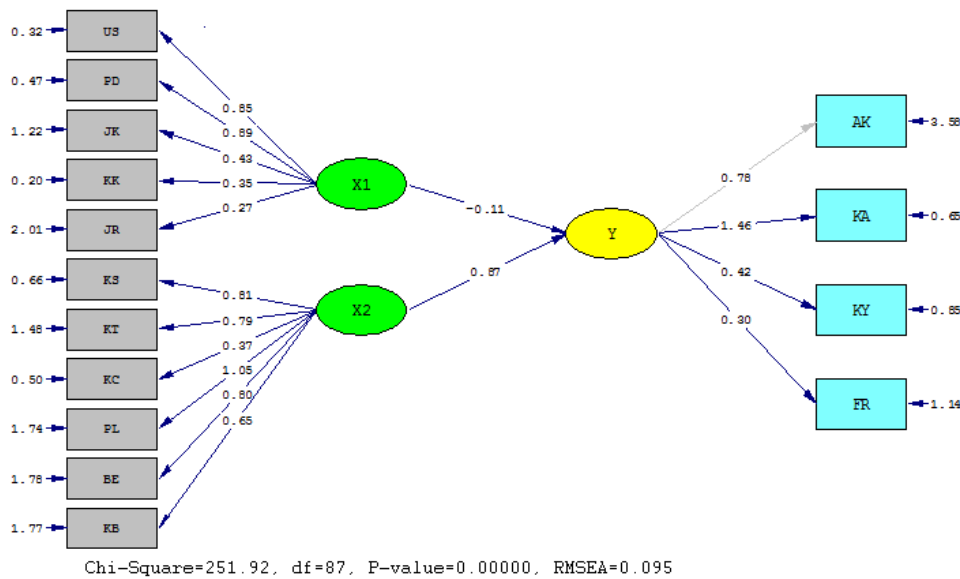


Fig 7 Result of Structural Model Estimation 1 (Train)

b. Identification

Identification of the model on the parameter prediction of Train passenger data is over identified model because the number of parameters that are known to be larger than the number of parameters being estimated. With the highest degree of freedom is 87 ( $df > 0$ ) means that already meet the standards.

c. Estimation

The estimation method used in this research is the Maximum Likelihood method with the help of LISREL 9.3 software. Analysis is performed with 16 maximum iterations.

d. Goodness of Fit

The next step is goodness of fit, i.e. measurement model fit (validity and reliability), compatibility of structural models model fit (the value of  $R^2$ ), and overall model fit (Goodness of Fit). a) Based on the results of the measurement model fit analysis explains that the measurement model of the 15 indicators that fill the standards of validation only 11 indicators, namely, age, income, number of family, safety, accuracy, service, cost, cleanliness, accesblility, security, and convenience. The result is a validation test can be viewed from the value of loading factors, that should be more than equal to 0.4 and the t-value analysis should be more than equal to 1.96. Then to test the reliability of the latent variables, 3 variables have a good reliability i.e. variable passenger behavior, performance satisfaction, and the mode choice because the constructs reliabilty value is more than equal to 0.7. b) analysis results of structural models fit compatibility explain that  $R^2 = 0,822$  it means that the model can explain the circumstances on the field of 82.2%. c) Further analysis based on the results of the overall model fit means from the 4 criterias for Goodness of Fit (GOF) namely RMSEA, GFI, AGFI, CFI and all of them did not fill the standard. The results can be seen in Table 3.

Table 3 Goodness of Fit Result Model 1 (Train)

Goodness of Fit	Cut off Value	Analisis Result	Model Evaluation
RMSEA	$\leq 0,08$	0,095	Bad
GFI	$\geq 0,90$	0,862	Bad
AGFI	$\geq 0,90$	0,809	Bad
CFI	$\geq 0,95$	0,791	Bad

e. Respecification

The results of the above analysis explains that the results of the prediction of structural model parameter 1 does not yet have sufficient ability so it needs to the respecification models.

3.2.4 SEM Analysis of Train 2

The result of the model respecification shows that the degree of freedom values is 31 ( $df > 0$ ) which means including over identified model, with 19 maximum iterations. The results of the 2<sup>nd</sup> structural model parameter prediction can be seen in Figure 8.

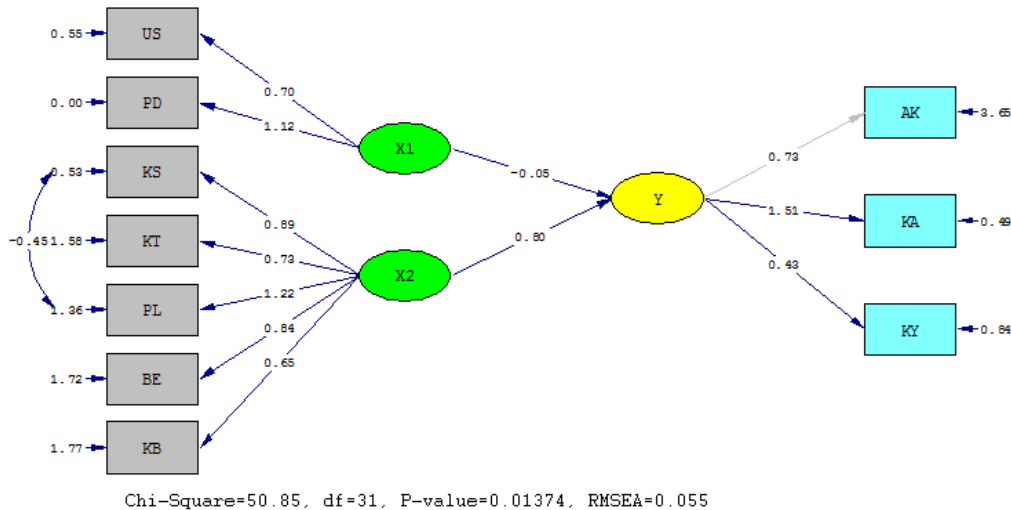


Fig 8 Result of Structural Model Estimation 2 (Train)

The goodness of fit result for 2<sup>nd</sup> structural model is as follows: a) Based on the results of the measurement model fit analysis explains that the measurement model of the 11 indicators that fill the standards of validation is 10 indicators, i.e. age, income, safety, accuracy, service, cost, cleanliness, accessibility, security, and convenience. The result is a validation test can be viewed from loading factor value, that should be more than equal to 0.4 and the t-value analysis should be more than equal to 1.96. Then to reliability test, 3 latent variables have a good reliability, i.e. variables of passenger behavior, performance satisfaction, and mode choice the constructs reliability value is more than equal to 0.7. b) ) analysis results of structural models fit compatibility explain that  $R^2 = 0,660$  it means that the model can explain the circumstances on the field of 66,0%. c) Further analysis based on the results of the overall model fit means from the 4 criterias for Goodness of Fit (GOF), all variables fill the criteria, so it was concluded that the proposed model is declared fit with data. It can be seen in Table 4.

Table 4 Goodness of Fit Result Model (Train)

Goodness of Fit	Cut off Value	Analisis Result	Model Evaluation
RMSEA	≤0,08	0,055	Good
GFI	≥0,90	0,954	Good
AGFI	≥0,90	0,919	Good
CFI	≥0,95	0,961	Good

IV. CONCLUSION

Based on analysis result, the conclusion is the factors that influence someone in mode choice i.e. age, income, vehicle ownership, distance, speed, accuracy, safety, service, cost, cleanliness, accessibility, security, and convenience. Each mode choice between bus and train has different factors. These differences are outlined as follows.

- a. Factors that influence the mode choice of Bus: age, income, vehicle ownership, distance, Speed, accuracy, Safety, service, cost, security, and convenience.
- b. Factors that influence the mode choice of Train: age, income, safety, accuracy, cost, service, cleanliness, accessibility, security, and convenience.



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