Using confirmatory factor analysis to evaluate the factor determining the bus usage in Surabaya City, Indonesia

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Abstract. Surabaya City is second biggest city in Indonesia which has a vital public transportation called as Suroboyo Bus. The city bus system provides route to connect the northern and southern part of the city with the central business district in the city centre. Policy of developing city bus system in north-south corridor aims to encourage the shifting of automobile to bus use as the traffic congestion is mainly caused by the high dependent of private mobility. The operation of Suroboyo Bus has been a concern because of the attractiveness of the quality with low deck and double-deck bus types, Suroboyo Bus also equipped a priority area, as well as a unique payment system with plastic bottle waste. This study aims to investigate the factors which influence the preference of Suroboyo Bus based on the user’s perceptions. Thus, the city bus system can be evaluated to achieve sustainable city mobility. Using the method of Confirmatory Factor Analysis (CFA), the result shows that there are nine significant factors determining the use of Suroboyo Bus. The city bus usage is mostly influenced by the user characteristic and the service performance of the mode offered.

Keyword: City bus, Factor analysis, CFA, Sustainable transportation

1. Introduction
The need for a transportation system is a derivative requirement needed to fulfill the community movement system [1]. Thus, the provision of a transportation system is crucial with a growing population. Surabaya is the second-largest city in Indonesia. By data from the Central Bureau of Statistics in 2019, the area of the City of Surabaya is 52,087 Ha, with a land area of 33,048 Ha and population growth of 2.07%, this represents that Surabaya has a fast population growth rate and become the most populous city in East Java. Based on the Medium-Term Development Plan (RPJMD) of Surabaya City on 2016-2021, The concentration of primary and secondary activity centers in the North, Central, and South of Surabaya City has created an intense trip attraction and trip production. Based on the 2013 Public Transport System Plan, the stipulation of public transportation in the North-South corridor is the main focus in breaking down traffic density. In April 2018, the city government realized the public transportation development plan through the provision of Suroboyo Bus.

This mass transportation mode serves the movement of people in the city. The Suroboyo Bus has an attractive quality with low deck and double deck bus types, equipped with facilities for disabilities and a space for women. The city bus also has a unique payment system, which uses bottles plastic as a means of payment that can be exchanged for ticket, following the Regulation of the Mayor of Surabaya number 67 in 2018, which refers to the contribution of waste in using city bus service. It is in line with the concept of public transport tariffs with fares that can be reduced as low as possible [2]. Since vehicle
rates are free, the overall cost of the trip is cheaper. However, the non-cash payment system using plastic waste has not been properly socialized by the government which tends to make passengers uncomfortable and inefficient [3].

Based on data from the Surabaya Transportation Department in 2019, there are 3 routes through Surabaya City. They are the north-south corridor, east-west corridor, and MERR (Middle East Ring Road). According to the Surabaya City transportation service report in 2019, the Purabaya-Rajawali (north-south corridor) is the busiest, with a total passenger on average reaching 63,942 people per month serviced by 7 unit of bus vehicles. However, the Suroboyo Bus is still unpopular to be used as the major transportation mode. Based on data from the Surabaya City Transportation Department in 2018, the occupancy of bus only reached 35%, then it had increased to 52% in year 2019, but it was still not satisfactory. Oppositely, data about private vehicle ownership increase by 7.03% with the number of two-wheeled and four-wheeled vehicles reaching 2,159,069 units and 570,571 units respectively [4]. Therefore, the provision of Suroboyo Bus is still unable to reduce the number of private vehicles use in north-south corridor. It is necessary to investigate the factors that determine the use of Suroboyo Bus from user’s perceptions.

Numerous studies have been conducted to explore the preference of city bus in developing countries. Hu, et al. [5] stated that perception-based mode choice analysis provides the comprehensive evaluation to the city bus in China. The measure of passenger’s perception to the transit service quality is essential tool to evaluate the transit performance. Similar to the study in 2018 by Deb and Ahmed [6] which has found that user’s perceptions are important tool to evaluate significant factors affecting people satisfaction to the transit service system in India. Therefore, using bus passenger’s perception to the factors affecting the choice of Surabaya Bus is an approach applied in this study.

2. Research Method

2.1 Method of Collecting Data
Data collection method is divided through primary and secondary data collection. Primary data collection was carried out randomly by distributing 160 questionnaires to Suroboyo Bus users in north-south corridor. Aiming to find out the respondent’s response to the level of influence of the variables to be studied, a Likert scale of 1-10 is used with a value of 1 is interpreted as having no effect and a value of 10 is a very influential interpretation. In addition, the primary survey was carried out by observing through observation, recording descriptively, and documenting as an illustration of the object of observation such as facilities inside and outside of the Suroboyo Bus on the Purabaya-Rajawali route. The secondary data collection method is done by obtaining data through the Surabaya City Transportation Agency and other supporting literatures such as transportation performance reports, previous research, and other published articles.

2.2 Data Analysis Method
Data processing in this study uses quantitative method which provides statistical tests to test a hypothesis using deductive methods that draw facts from general to specific information [7]. This quantitative data processing is supported by Confirmatory Factor Analysis (CFA) methods. This analysis serves to test empirically the measurement model consisting of latent variables and indicator variables [8]. CFA is not intended to produce new models or theories, but rather to test factors and variables developed of the basis of certain theoretical studies so that in the process there will be a reduction in the number of variables and a test of the relationship between variables [9]. In the CFA method, several steps are carried out to obtain the factors that influence the choice of model. First, CFA model based on the literature study of modal choice theories is constructed to determine variables influencing the bus choice. Second, testing the CFA model is carried out using the Maximum Likelihood Estimation (MLE) method. Then, the significant factors are formulated from the model testing.
Constructing CFA model needs to identify the observed and unobserved variables. Observed variables are the respondent’s responses to the questions, while the unobserved variables are referred as latent variables [10]. This study includes 3 latent variables and 15 observed variables. Regarding to these variables, path diagram in CFA model is formed. The research of variables is described in Table 1 below.

| Table 1. Research Variable |
|---------------------------|
| Latent Variable           | Observed Variable | Code |
| User Characteristics Factor| Age               | A1   |
|                          | Gender            | A2   |
|                          | Income            | A3   |
|                          | Household structure | A4 |
|                          | Private vehicle ownership | A5 |
|                          | Driving license ownership | A6 |
| Travel Pattern Factor     | The purpose of travel | B1 |
|                          | Travel distance   | B2   |
|                          | Travel time       | B3   |
|                          | Travel cost       | B4   |
| Mode Services Factor      | Reliability service | C1  |
|                          | Comfortability service | C2 |
|                          | Security service  | C3   |
|                          | Bus stop coverage | C4   |
|                          | Connectivity with other modes | C5 |

3. Result and Discussion

3.1 The Overview of Study Area
The study area focuses on the Suroboyo Bus mode on the Purabaya-Rajawali route as one of the modes that pass through the north-south corridor. In this route, it is served by 45 stopping points. In its operation, Suroboyo Bus has several characteristics in mode service. The following is identification in the characteristics of modal services. The route through several sub-districts and is divided into 14 sub-districts with a round-trip route of 22 Kilometres long. The following is the identification of the characteristics of modal services. This characteristic is important because it includes the value of efficiency, convenience, and the facility maintenance system that must be owned by public transport [11].

A. Reliability Service. Reliability is the availability of adequate in route information throughout the fleet and at stops [12]. From primary data, 16 out of 43 shelters have met the reliability criteria. Also, real-time information on bus arrival schedules is not available at all stops, passengers can only check bus arrivals via barcode scans to find out the real-time location of bus arrivals.

B. Comfortability Service. Convenience indicator with the criteria of the availability of facilities to support passenger comfort [13], such as the lighting in vehicles and at stops, the availability of seats for women, and entertainment and mobile phone charging facilities are readily available in all transportation. However, 22 out of 43 bus stops did not support convenience with no waiting areas and canopies.

C. Security Service. Security service with the criteria for the availability of emergency tools, complaint facilities, emergency exits, identification cards or uniforms of officers, and buttons.
that facilitate passengers to get off have met the safety criteria following applicable public transport service standards.

D. *The Service Coverage.* The service coverage of the stop is determined based on the convenience of passengers from the place of origin to reach the nearest stop as well as the convenience from the destination stop to the destination location. Thus, this variable considers the distance between bus stops and the availability of supporting facilities for stops, such as pedestrian facilities to the location of bus stops in the form of sidewalks, crossings, and traffic signs. These facilities are sufficiently fulfilled with the availability of facilities at 75%.

E. *Connectivity.* Connectivity with other modes of transportation is related to the affordability of the Suroboyo Bus on the Purabaya-Rajawali Route in making transfers between corridors. In this case, it can be assessed based on the criteria for the availability of other modes that support moving and the availability of parking facilities for private vehicles [14]. In this route, there are Joyobojoy Intermodal Terminal and Purabaya Terminal which facilitate passenger transfer and parking. Based on the results of the primary survey, 47% of respondents did not make a mode shift for trips to the departure stop and 68% made a mode shift for trips to the destination location.

### 3.2 Factors Analysis of The Bus Usage

In order to know the influencing factors on the use of the Suroboyo Bus on the Purabaya-Rajawali route, an analysis was carried out using Confirmatory Factor Analysis (CFA) which is useful for reducing as well as providing the level of influence on the factors in the stage mode choice theory as well as an explanation of the results of CFA analysis using AMOS software. The initial stage in developing the CFA model is a path diagram that is formed with standardized values (Figure 1).

![Figure 1. First CFA Model in Path Diagram](image)

The mode selection factor testing uses the Maximum Likelihood (MLE) method. This method is appropriate because this study uses a sample size of 100-200 assuming normality is met [15]. This test is used to see to what extent the latent variables can explain the observed variables based on the model suitability criteria in the following Cut-Off in Table 2.
Table 2. Model Evaluation in First CFA Model

| Criteria        | Cut-off Model | Model Result | Model Evaluation |
|-----------------|---------------|--------------|------------------|
| Chi-Square (df=87; 0.05) | ≤ 109.77 | 229,024 | Deficient |
| CMIN/df         | ≤ 2          | 2,632       | Deficient |
| P Value         | ≥ 0.05       | 0.000       | Deficient |
| RMSEA           | ≤ 0.08       | 0.101       | Deficient |
| GFI             | ≥ 0.90       | 0.834       | Deficient |
| CFI             | ≥ 0.90       | 0.687       | Deficient |
| TLI             | ≥ =0.90      | 0.623       | Deficient |

In table 2, it is explained that the CFA criterion value by testing the suitability model using RMSEA, GFI, CFI, and TLI has not met the model criteria. From the due diligence criteria, it is necessary to reconstruct variables. Based on the identification of the value of Construct Reliability (CR) at least >1.96 to state the variable relationship is correct, while the *** sign states that the P-value is significant or is <0.05 [16]. Then the variables that must be eliminated to achieve a fit CFA model are the variables of Gender (A2), Income (A3), Household Structure (A4), Travel Distance (B2), Reliability (C1), and Service Coverage of Shelters (C4). The reduced variables are determined based on the estimated value of CR and P-value based on the measurement value of the Maximum Likelihood Estimate (MLE) with each Standard Error (S.E.) value in Table 3.

Table 3. Maximum Likelihood Estimate in First CFA Model

| Estimate        | S.E. | C.R. | P   |
|-----------------|------|------|-----|
| A1              | ---  | 1.000|     |
| A2              | ---  | .576 | .450| .129| .201|
| A3              | ---  | .220 | .385| .571| .568|
| A4              | ---  | 1.418| .711| 1.995| .046|
| A5              | ---  | 4.146| 1.829| 2.267| .023|
| A6              | ---  | 3.604| 1.565| 2.302| .021|
| B1              | ---  | 1.000|     |
| B2              | ---  | .976 | .235| 4.156| ***|
| B3              | ---  | .686 | .199| 3.451| ***|
| B4              | ---  | 1.191| .272| 4.370| ***|
| C1              | ---  | 1.000|     |
| C2              | ---  | .850 | .168| 5.046| ***|
| C3              | ---  | .721 | .142| 5.082| ***|
| C4              | ---  | .749 | .216| 3.464| ***|
| C5              | ---  | .565 | .189| 2.991| .003|

The six variables indicated insignificance based on the results of the MLE test and MI (Modification Indices) score. The six variables were declared with the following considerations.

- In the latent variables of user characteristic, observed variables of gender (A2), income (A3), and household structure (A4), each of which has a P weight of 0.201, 0.568, and 0.046 indicating that these characteristics are invalid and the majority are not considered for choosing the Suroboyo Bus mode based on community perceptions.
- In the latent variable of travel pattern, the distance travelled (B2) is a valid and reliable factor with P <0.05. However, this variable is considered to be reduced in the MI (Modification
Indices) value which show the low score for considering the travel distance variable in the model.

- In the latent variables of mode service, the variable of reliability (C1), and coverage of the services of the bus stop (C4) is valid and reliable with a value of P <0.05. However, based on the results of MI score, it shows that the effect value generated by these two variables is small with a low level of influence so that it has the potential to be reduced. This is also supported based on the results of the primary survey through respondents showing the level of reliability of the Suroboyo Bus which is still low and pedestrian support facilities on the variable coverage of the Services at the Suroboyo Bus stop which is not evenly distributed.

Based on the result of reducing variables, the path diagram is formed in final CFA model by the AMOS software in Figure 2.

![Figure 2. Final CFA model in Path Diagram](image)

In the following step, MLE test is carried out to determine the level of significance of observed variables. There are nine observed variables which are found significant at P value less than 0.05. It can be described in Table 4 below.

|   | Estimate | S.E.  | C.R.   | P     |
|---|----------|-------|--------|-------|
| A1 | UserCharacteristic | 1.000 |        |       |
| A5 | UserCharacteristic | 4.893 | 2.582  | 1.895 | .058 |
| A6 | UserCharacteristic | 4.136 | 2.074  | 1.995 | .046 |
| B1 | TravelPattern | 1.000 |        |       |
| B3 | TravelPattern | .568  | .2410  | 2.706 | .007 |
| B4 | TravelPattern | 1.188 | .323  | 3.676 | *** |
Based on MLE table and path diagram construction, the final CFA model has been declared significant. Then, the level of influence of observed variables can be explained by interpreting the value of each loading factor. The higher value of loading factor means the higher contribution of observed variables to explain the latent variables. In contrast, observed variables with low loading factor have a weak contribution to explain the latent construct. The standardized loading factor values for each variable in are described in Table 5.

| Latent Variable | Observed Variable | Code | Loading Factor (Standarized) |
|-----------------|-------------------|------|-------------------------------|
| User Characteristics | Age | A1 | 0.171 |
| | Private vehicle ownership | A5 | 0.909 |
| | Driving license ownership | A6 | 0.772 |
| Travel Pattern | The purpose of travel | B1 | 0.526 |
| | Travel time | B3 | 0.318 |
| | Travel cost | B4 | 0.569 |
| Mode Services | Comfortability service | C2 | 0.806 |
| | Security service | C3 | 0.739 |
| | Connectivity with other modes | C5 | 0.252 |

The variables which are considered strong have a factor weighting value of 0.50 or more [17]. Some explained that the acceptable minimum is 0.40 [18]. Based on the loading factor table, the nine significant variables can be obtained an interpretation in the study of the use of the Suroboyo Bus mode on the Purabaya-Rajawali route as follows.

- The variable of private vehicle (A5) and driving license ownership (A6) have the highest effect that reach the value of 0.909 and 0.772 respectively on the user characteristic. This is supported by the data which shows about 50% of the respondents do not own a private vehicle in the form of a motorbike and 87.5% in the form of a car. In addition, it is found that 54% of the respondents who use Suroboyo Bus did not have a driving license. This means that the demand of Suroboyo Bus is mostly the captive users of public transportation. Meanwhile, the age variable is less considered as factor influencing the use of city bus based on the weight of loading factor is very low at 0.171.

- The variables of travel cost (B3) and travel purpose (B4) have sufficient weight to influence the bus usage, the factor weight at 0.546 and 0.526 respectively. This value aligns with the result of the respondent description which state that the majority of Suroboyo users pay the overall trip cost which is relatively cheap, with an average of Rp. 7,000.00. In addition, the consideration of using Suroboyo Bus is mostly for recreational purpose and visiting relatives which have high proportion at 39% and 25% respectively. Meanwhile, the variable of travel time (B1) is less considered with an indication that the waiting time for the mode is quite long with an average of 16.3 minutes.

- In the characteristic of mode service, the comfort (C2) and safety (C3) variable obtain the high factor weight which reach at 0.806 and 0.739 respectively. Based on this loading factor, the users of Suroboyo Bus express their satisfaction with the attributes service in term of comfort and safety. However, the intermodal connectivity variable (C5) has very low weight at 0.252
that means the factor less influence the users to choose Suroboyo Bus. This indicates that the Purabaya-Rajawali route has inadequate transfer facilities and less integration with other kind of public modes.

4. Conclusion

Suroboyo Bus is city bus which has operated more than two years in Surabaya City. The provision of city bus system aims to provide alternative mode for private users, then the urban congestion can be solved in north-south corridor. Nevertheless, the city bus still unable to attract the demand effectively. This study finds some variables which significant influence the use of city bus based on user’s perception. Using CFA model, there are nine observed variables which drive users to use the city bus, such as age, vehicle ownership, holding driving license, travel purpose, travel time, travel cost, comfortability service, security service, and intermodal connectivity. Based on personal characteristic, the ownership of vehicle and driving license have significant influence to users to choose the Suroboyo Bus as their main mobility mode. This means that Suroboyo Bus mostly attract the captive user rather than the choice group. It is essential to develop the policy of Suroboyo Bus which allow to compete with automobile, thus the private users shift their choice to the city bus. In addition, the bus attribute services of comfortability and security have significant influence to the use of city bus. The finding is that the preference of passengers to city bus is led by a high perception of bus service comfort and secure. These attributes are important to be maintained as the vital factors to attract bus ridership. In contrast, the variable of intermodal connectivity plays less significant effect to the bus usage. This indicates that the connection between Suroboyo Bus with other public modes still less to support the mode transfer. Furthermore, the variable of travel cost and purpose are moderate correlated with the factors influencing the use of city bus. The free charge of bus usage and the payment system are needed to be evaluated the effectiveness to support the people’s mobility.

Based on the study result, factors determining the use of city bus in Surabaya City are useful to be considered in developing the policy of Suroboyo Bus provision. Future studies considering the perceived perception of local government, operator and other parties to the Suroboyo Bus are still needed to improve the bus city system. In addition, the study conducting to the expected or desired service quality of city bus is also essential to be investigated.

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9

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