Probability Analysis of DAMRI Bus Mode Selection on the Operation of Adi Soemarmo International Airport (BIAS) Train

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Abstract. Adi Soemarmo International Airport railway’s construction is an investment in the transportation sector expected to encourage the tourism sector in Joglosemar (Jogja-Solo-Semarang) Area. Adi Soemarmo International Airport (BIAS) train from Solo to the airport with a distance of about 13.5 km is an alternative to public transportation besides the pre-existing DAMRI Bus service. For this reason, this research aims to obtain a probability value for choosing the mode between DAMRI Bus and BIAS Train. The variables used in this research were travel time, tariff, and waiting time using the stated preference technique. The primary data were then processed using logistic regression analysis to obtain the probability values. The results show that the probability value of the fastest travel time in the choice of condition one or scenario 9. The value obtained from comparing airport trains’ use compared to DAMRI buses saves 17 minutes, a reduced waiting time of 22.5 minutes, and cheaper ticket costs around Rp. 10,000. There was a 99.59% increase in passenger displacement from DAMRI buses to BIAS trains from all these comparisons

1. Introduction

The tourism sector is one of the sources of local income that has the potential to be developed. Creating and utilizing local tourism resources and potential is expected to contribute to economic development to increase the locally-generated revenue. The construction of the Adi Soemarmo Airport railway is an investment in the transportation sector. In addition to improving the airport’s accessibility, this airport train process can reduce traffic congestion and provide other options for transportation modes than those that existed before. It is necessary to know how people want the attributes on the airport train to be. Based on this background, research would be carried out on the probability analysis of Adi Soemarmo Airport train mode selection for DAMRI bus passengers.

The previous research conducted [1] and [2] used four variables to obtain the utility values, whereas, in this research, only three variables were used: tariff, travel time, and waiting time. [3] His research also used the stated preference method, but it used the ordered probit model method in the analysis. The difference with this research lay in the analysis method using the binomial logit model. Likewise, [4] used CVM (Contingent Valuation Method) analysis method, whereas this research did not. The study [5] was that the respondents were given yes or no answers in this research.
2. Research Method

This research began with the problem formulation and literature review on the probability of the mode selection in research journals, books, the internet, and other related sources. The stated preference survey interview technique was used for data collection. This technique uses individual respondents’ statements or opinions regarding their choice of a set of options/experimental [6]. In the transportation sector, this technique massively has been used since it can estimate an individual or society’s preferences for transportation (facilities or infrastructure) policy that does not yet exist (still in the form of a hypothesis). The researchers took a total sample of 80 respondents with a maximum error rate (e) of 10%. In this research, the questionnaire design used the respondents’ questions to choose Adi Soemarmo Airport’s transportation mode. Then this choice would present a development scenario to provide a level for each attribute. There were three attributes used in this research: travel fare, travel time, and waiting time. The survey data results for the characteristics of each mode can be seen in Table 1.

From the processed attributes, scenarios that would occur and used in the interview survey were determined. There were 16 scenarios used in the interview survey to the respondents. Then, the questionnaire data results were arranged according to the stated preference method is also used [7], [8], [9], [10]. The data were analyzed to obtain the utility values. The utility concept was used to express an alternative’s attractiveness as something maximized by individuals [11]. The utility was described as a linear combination of several attributes or variables, so it was essential to choose the relevant variable. According to [1] and [12], the utility function depended on the mode service attribute, the individual’s socioeconomic status, and the trip’s characteristics concerning the mode selection model. The difference in utility could be expressed in terms of the difference in the number of relevant attributes between the two modes, formulated as follows:

\[
U_{ka} - U_{moda} = \beta_0 + \beta_1(X_{1ka} - X_{1moda}) + \beta_2(X_{2ka} - X_{2moda}) + \cdots + \beta_n(X_{nka} - X_{nmoda}),
\]

with \(U_{ka} - U_{moda} = \) train utility to the mode, \(\beta_0 = \) constant, \(\beta_1, \beta_2, \beta_3 = \) coefficient, and \(x_1, x_2, x_n = \) forming variables. The probability was then calculated using the binomial logit model to determine the transportation mode based on two methods. In research [13], [14], [15], [16], [17] and [18] also look for the probability of train. The model that the respondent would choose was the model with the highest utility. With the utility values, the probability would be obtained. In this research, the models being compared were the Adi Soemarmo International Airport train with the DAMRI bus. Quoted from [19], deriving the binomial logit model equation to determine the probability is as follows.

\[
P_n(i) = \frac{1}{1 + e^{-\beta(X_i-X_j)}}
\]

with \(\beta = \) Calibration parameters, \(X_i = \) Mode-forming variable value \(i\), \(X_j = \) Mode-forming variable value \(j\), and \(P_n(i) = \) Probability of mode selection \(i\).

### Table 1. Airport Train and DAMRI Bus Attributes

| Tariff     | Travel time (minute) | Waiting time (minute) |
|------------|----------------------|-----------------------|
| Airport Train | DAMRI Bus | Airport Train | DAMRI Bus | Airport Train | DAMRI Bus |
| 15000      | 25000       | 13         | 30        | 40         | 45        |
| 37200      | 25000       | 18         | 30        | 22.5       | 15        |
3. Results and Discussion

3.1. Airport train utility analysis

The analysis was carried out by finding the difference in each variable between the airport train and the DAMRI bus. The results can be seen in Table 2.

| Scenario | $S(T_{KA} - T_{BD})$ | $Rp(C_{KA} - C_{BD})$ | $T(H_{KA} - H_{BD})$ |
|----------|----------------------|-----------------------|----------------------|
| 1        | -12                  | -10                   | -12.5                |
| 2        | -12                  | -10                   | -5                   |
| 3        | -12                  | -10                   | 7.5                  |
| 4        | -12                  | -10                   | 25                   |
| 5        | -12                  | 12.7                  | -22.5                |
| 6        | -12                  | 12.7                  | -5                   |
| 7        | -12                  | 7.5                   |
| 8        | -12                  | 7.5                   |
| 9        | -17                  | -10                   | -22.5                |
| 10       | -17                  | -10                   | -5                   |
| 11       | -17                  | -10                   | 7.5                  |
| 12       | -17                  | -10                   | 25                   |
| 13       | -17                  | 12.7                  | -22.5                |
| 14       | -17                  | 7.5                   |
| 15       | -17                  | 7.5                   |
| 16       | -17                  | 25                   |

With $S = \text{Travel Time Difference in minute}$, $Rp = \text{Tariff Difference in rupiah}$, $T = \text{Waiting Time Difference in minute}$, $T_{KA} = \text{Travel time airport train}$, $T_{BD} = \text{Travel time DAMRI bus}$, $C_{KA} = \text{Cost/Tariff airport train}$, $U_{KA} = \text{Utility airport train}$, $C_{BD} = \text{Cost/Tariff DAMRI bus}$, $H_{KA} = \text{Waiting time airport train}$, $H_{BD} = \text{Waiting time DAMRI bus}$, $U_{BD} = \text{Utility DAMRI bus}$.

Then the data in Table 2 were combined with the answers from each scenario. Furthermore, the data were entered into the statistical software to determine the utility equation’s constant and coefficient. The utility model obtained was as follows:

$$U_{KA} - U_{BD} = -9.348 - 4.471(T_{KA} - T_{BD}) - 0.381(C_{KA} - C_{BD}) - 0.134(H_{KA} - H_{BD})$$  \hspace{1cm} (3)

The utility analysis results can be seen in Table 3.

3.2. Coefficient of determination statistical test

It was used to determine the independent variables (travel time, tariff, and waiting time) explaining the dependent variable. The results can be seen in Table 4. From Table 4, the Nagelkerke R Square value or Pseudo-R2 ($\hat{R}^2$) the value was 0.811. Then, by using the mapping graph of $\hat{R}^2$ and R2 values, the R2 the value was 1. It could be concluded that the independent variables’ ability to explain the dependent variable was 100%, so the model was declared the goodness of fit.

3.3. Hosmer and Lemeshow test

The Hosmer and Lemeshow test [20] results can be seen in Table 5.

From the Hosmer and Lemeshow test results above, it was found that the probability values of sig 0.585 and 0.153 were more significant than the 5% (0.05) significance level, so the null hypothesis (H0) could be rejected. It meant that the model could predict its observation value, or it could be said that the model could be accepted.
Table 3. The utility analysis results

| Scenario | $S(T_{KA} - T_{BD})$ | $R_p(C_{KA} - C_{BD})$ | $T(H_{KA} - H_{BD})$ | Utility |
|----------|----------------------|------------------------|----------------------|---------|
| 1        | -12                  | -10                    | -22.5                | 3.129   |
| 2        | -12                  | -10                    | -5                   | 0.784   |
| 3        | -12                  | -10                    | 7.5                  | -0.891  |
| 4        | -12                  | -10                    | 25                   | -3.236  |
| 5        | -12                  | 12.7                   | -22.5                | -5.5197 |
| 6        | -12                  | 12.7                   | -5                   | -7.8647 |
| 7        | -12                  | 12.7                   | 7.5                  | -9.5397 |
| 8        | -12                  | 12.7                   | 25                   | -11.8847|
| 9        | -17                  | -10                    | -22.5                | 5.484   |
| 10       | -17                  | -10                    | -5                   | 3.139   |
| 11       | -17                  | -10                    | 7.5                  | 1.464   |
| 12       | -17                  | -10                    | 25                   | -0.881  |
| 13       | -17                  | 12.7                   | -22.5                | -3.1647 |
| 14       | -17                  | 12.7                   | -5                   | -5.5097 |
| 15       | -17                  | 12.7                   | 7.5                  | -7.1847 |
| 16       | -17                  | 12.7                   | 25                   | -9.5297 |

Table 4. Coefficient of Determination Test Results with Statistical Software for Airport Train and DAMRI Bus

| Step | -2 Log likelihood | Cox & Snell R Square | Nagelkerke R Square |
|------|-------------------|----------------------|---------------------|
| 1    | 492.466a          | 0.579                | 0.811               |

Table 5. Hosmer and Lemeshow Test Results with Statistical Software for Airport Train and DAMRI

| Step | Chi-square | df | Sig. |
|------|------------|----|------|
| 1    | 4.686      | 6  | 0.585|

3.4. Overall percentage test

Overall percentage test is a test used to find out the predictive power of the regression model obtained. Table 6 shows the statistical software results.

Table 6. Overall Percentage Test Results with Statistical Software for Airport Train and DAMRI Bus

| Observed                | $\mu_1$ | $\mu_2$ | $\xi$ |
|-------------------------|---------|---------|-------|
| Step 1 Y                |         |         |       |
| Unwilling to Use Airport Train | 825     | 49      | 94.4  |
| Willing to Use Airport Train     | 55      | 351     | 86.5  |
| Overall Percentage         |         |         | 91.9  |

with $\mu = \text{Unwilling to Use Airport Train}$, $\mu_2 = \text{Willing to Use Airport Train}$, and $\xi = \text{Percentage Correct}$. Based on the logistic regression results above, it could be concluded that the predictive power or model accuracy in classifying the observations was 91.9%.
3.5. Airport train probability analysis

The calculation results for the probability values of each scenario can be seen in Table 7. with

| Scenario | $\Delta T$ | $R_p$ | $\Delta t$ | Utility | $P$ (%) |
|----------|-----------|-------|------------|---------|---------|
| 1        | -12       | -10   | -22.5      | 3.129   | 95.81   |
| 2        | -12       | -10   | -5         | 0.784   | 68.65   |
| 3        | -12       | -10   | 7.5        | -0.891  | 29.09   |
| 4        | -12       | -10   | 25         | -3.236  | 3.78    |
| 5        | -12       | 12.7  | -22.5      | -5.5197 | 0.40    |
| 6        | -12       | 12.7  | -5         | -7.8647 | 0.04    |
| 7        | -12       | 12.7  | 7.5        | -9.5397 | 0.01    |
| 8        | -12       | 12.7  | 25         | -11.8847| 0.00    |
| 9        | -17       | -10   | -22.5      | 5.484   | 99.59   |
| 10       | -17       | -10   | -5         | 3.139   | 95.85   |
| 11       | -17       | -10   | 7.5        | 1.464   | 81.21   |
| 12       | -17       | -10   | 25         | -0.881  | 29.30   |
| 13       | -17       | 12.7  | -22.5      | -3.1647 | 4.05    |
| 14       | -17       | 12.7  | -5         | -5.5097 | 0.40    |
| 15       | -17       | 12.7  | 7.5        | -7.1847 | 0.08    |
| 16       | -17       | 12.7  | 25         | -9.5297 | 0.01    |

$\Delta T =$ travel time difference, $R_p =$ Tariff difference, $\Delta t =$ waiting time difference, and $P =$ probability

4. Conclusions

From the previous analysis results, it could be concluded that the probability of selecting the airport train depended on the offered conditions. Picking this transportation could be seen in every situation that occurred. The more favorable the Airport Train variable, the greater the probability value was. The results show that the probability value of the fastest travel time in the choice of condition one or scenario 9. The value obtained from comparing airport trains’ use compared to DAMRI buses saves 17 minutes, a reduced waiting time of 22.5 minutes, and cheaper ticket costs around Rp. 10,000. There was a 99.59% increase in passenger displacement from DAMRI buses to BIAS trains from all these comparisons.

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