LOGIT MODEL FOR TRANSPORTATION MODE CHOICE IN BERAU REGENCY EAST KALIMANTAN

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Abstract. In big cities, thousands of public transportation are very easy to find because they fill the streets and can cause traffic jams. Another case that occurred in Berau District, public transportation was almost non-existent. On the streets private vehicles and transport companies dominate. The number of public transport fleets such as city transportation and buses, is very small in number. Berau Regency has many attractions, but tourists will find it difficult to find public transportation. This study aims to determine the selection of transportation mode choice in Berau Regency using the logit model with the assumed road users choose to use public transport or private transportation. Travel attributes that influence mode choice in Berau district are travel time, transportation costs, space availability, comfort and safety. The cost of private transportation is the same as the cost of public transportation, which is about 79% of people who will still choose to use private transportation. This condition will be achieved if the cost of public transportation is 1.4 times cheaper than the cost of private transportation. Keyword; logit model, mode choice, public and private transportation

1. Introduction

In big cities, thousands of public transportation are very easy to find because they fill the streets and can cause traffic jams. Even today in some cities, there is a lot of confusion between conventional public transportation drivers and online based public transportation drivers. Clashes and vehicle vandalism often occur between conventional transport drivers and online. Many parties were harmed by the incident, both from the economic and physical sectors. Another case that occurred in Berau District, public transportation was almost non-existent. On the streets private vehicles and transport companies dominate. The number of public transport fleets such as city transportation and buses, is very small in number. The fare, for angkot in the city is around 5,000 rupiah. The people of Berau use more private vehicles, even every house has more than one private vehicle. Berau Regency has many attractions, but tourists will find it difficult to find public transportation. Some travel businesses also provide their fleets to take tourists to tourist destinations. Not a few tourists who rent four-wheeled and two-wheeled vehicles. (https://berau.prokal.co/read/news/48717-berau-nyaris-tanpa-transportasi-umum.html)

This research differs from previous research which aims to determine the selection of transportation modes in Berau Regency using the logit model and the decision making to use certain modes is strongly influenced by factors in accordance with the characteristics of road users, namely; the availability or ownership of private vehicles, income and the necessity of using modes to work, the need to take the child to school or social and recreational needs. In addition to the influence of these factors, the selection
is also influenced by other factors, namely travel time, transportation costs, availability of space and the amount of parking fees, comfort and safety, so that the choice of transportation mode is very important in transportation planning. This research assumes that road users choose to move, then they will choose transportation modes and walk, then if they choose to use modes, they are required to choose two choices of using public or private transportation.

2. Research method

2.1. Location Selection
The choice of location in Berau Regency as a study area because most of the land use has changed into a residential area and many tourists visit this area, so that this area has greater trip generation and attraction and as a mode used motorbikes and four wheels for private transportation and public transportation.

2.2. Data collection
The data collected consists of primary data in the form of transportation costs, population income, number of vehicles owned, travel time and distance and age level of respondents. Other data in the form of secondary data include; population data, inflation data, economic growth rate data. The data obtained is recapitulated and processed by the data classification step consisting of editing and coding data. This process is carried out to obtain the processed data which is then entered into the analysis.

2.3. Stages of analysis
Stages of research starts from preliminary studies, problem identification and goal setting, literature study, questionnaire design, preliminary surveys, data collection, data analysis and classification, model calibration, analysis according to the model, and finally conclusions and suggestions are obtained.

2.4. Definition of costs
The basic cost is the amount of sacrifice incurred to produce one unit of transportation service production unit. To make it easier to calculate the basic costs are grouped according to their relationship with the production of services produced, consisting of: direct costs associated with the resulting service products such as fuel use and vice versa indirect costs are costs that are not related to the product services produced. The basic cost for public transportation services, where the main cost is the amount of the cost charged to each passenger of a vehicle traveling once from the origin to the destination point of travel, the time value of a person in public transportation and the value of waiting for the public transport. While the basic cost of private transportation, where the basic cost is the cost of using fuel spent for one trip, the value of time in or using a vehicle for one trip. Mathematically as follows;

- Private vehicle costs; \( C_p \); cost of private vehicle (Rupiah), \( \rho \); vehicle operating cost per unit distance (rupiah), \( D \); distance from movement (km), \( Z \); value of passenger time per unit time (rupiah), \( X_2 \); time in vehicle (minutes), \( C \); parking fees (rupiah).

\[
C_p = \rho D + ZX_2 + C
\]  

(1)

- Public transportation costs; \( X_1 \); vehicle waiting time (minutes), \( X_2 \); time in vehicle (minutes), \( X_3 \); additional costs such as terminal fees (rupiah)

\[
C_u = \rho D + ZX_1 + ZX_2 + X_3
\]

(2)

2.5. Estimated time value
The value of one's time is very dependent on the purpose of the trip (business/work and non-business goals) the amount of which can describe the time services of consumers provided by the road to road users. The value of business / work trips is quantified as the value of hourly time, assuming the same as the hourly value of income per capita. To calculate the time value the results of the study were used in several provinces with an average value of 1999 in three zones as shown in table 1. The values in table 1 are used to find the future value; \( i \); 13.44% (annual average rate), \( n \); 10 years, \( P \); 235 Rupiah/day
(medium zone); With this analysis the average time value in 2019 is obtained as in table 1, while the number of passengers for each type of study vehicle is presented in table 1.

\[ F = P (1 + i)^n \]  

(3)

### Table 1. Average time values

| Zona  | Passenger time value | Passenger time value in 2019 | The number of passengers for each type of vehicle* |
|-------|----------------------|-----------------------------|---------------------------------------------------|
| High  | 300 rupiah/day       | 1,900.00 rupiah/day         | Passenger pick-up: 7                              |
| Medium| 235 rupiah/day       | 1,500.00 rupiah/day         | Bus: 19                                           |
| Low   | 170 rupiah/day       | 1,100.00 rupiah/day         | Car: 4                                            |
|       |                      |                             | Motorcycle: 2                                     |

*Concurrent technologies corporation (CTC), 1999

3. Analysis

This stage is carried out an analysis of costs based on staffing factors; income level; and simulation equations for regression. The next stage is to calibrate the logit model with analysis using the binomial-logit-difference model and the binomial-logit-ratio model.

3.1. Analysis of public transport costs

Generalized cost for public transportation that is the cost to be paid or the cost of waiting time for a vehicle or the value of passenger time. The calculation of the time value to the value of inflation in Berau Regency is considered a medium zone, so the passenger time value (Z) is as follows;

\[ \text{Time value} = \text{Time zone value of passenger zone medium} \times \text{average inflation} \]

Then time value = 1500 x (5.97% + 11.31% + 4.30% + 5.91% + 9.62%) / 5

= 11,133 rupiah/day or 463.87 rupiah/hours atau 7.73 rupiah/minute.

Thus obtained:

Passenger time value (Z) = Number of passenger vehicles sampled x time value

(5)

Passenger time value = 7 x 7.73 (rupiah) = 54.11 ~ 55 rupiah/minute. So based on formula (2), the general cost for public transportation for a distance of 9 kilometers, the waiting time for a vehicle is 10 minutes and the trip time is 30 minutes regardless of additional costs can be calculated as; \( C_u = (300 \times 9) + (55 \times 10) + (55 \times 30) + 0 = 4,900 \) rupiah.

3.2. General public transport costs

Generalized cost for private transportation, namely costs to be paid including parking fees. Berau Regency is considered a medium zone, so the value of passenger time (Z) is as follows;

| Group          | Cp (Rupiah) | Cu (Rupiah) |
|----------------|-------------|-------------|
| K1: Salary for civil servants ≤ 5,000,000 (Rupiah) | 1,694 | 4,716 |
| K2: Salary for civil servants 5,000,000 – 7,500,000 000 (Rupiah) | 1,685 | 4,667 |
| K3: Salary for civil servants ≥ 7,500,000 (Rupiah) | 1,658 | 4,479 |
| K4: Private employee salary ≤ 5,000,000 (Rupiah) | 1,712 | 4,819 |
| K5: Private employee salary 5,000,000 – 7,500,000 (Rupiah) | 1,715 | 4,825 |
| K6: Private employee salary ≥ 7,500,000 (Rupiah) | 1,702 | 4,755 |

Passenger time value = 1.5 x 7.73 (rupiah) = 11,595 ~ 12 rupiah/minute.

Meanwhile vehicle operating costs for private vehicles; \( v \); average speed of 40 km/hr, \( a \); constant of 24, \( b \); coefficient with a value of 596, \( c \); coefficient with a value of 0.00370, then; vehicle operating costs
= 24 + (596/40) + (0.00370 x 402) = 44.82 rupiah/km. Based on the formula (1), the general cost for private transportation for a distance of 9 km, and a 30 minute trip length with a parking fee of 1,000 rupiah can be calculated as follows: $C_p = (44.82 \times 9) + (12 \times 30) + 1000 = 1,763.38$ rupiah

vehicle operating costs = $a + b/V + c V^2$

### 3.3. Analysis based on staffing factors and income levels

Workers in this study are distinguished based on employment status, namely private and public employees, income level and age. Based on the calculation of public costs both the use of private transport and public transportation (public transportation or Microbus) and based on employment status and income levels obtained average analysis results.

### 3.4. Linear regression analysis and logit model

With analysis using linear regression analysis methods for the binomial logit difference model and the binomial logit ratio model, obtained results such as table 3 and table 4

#### Table 3. Linear regression for binomial-logit-difference models

| No. | $C_p$ (Rupiah) | $C_u$ (Rupiah) | $(C_p-C_u)$ (Rupiah) | $P_p$ (Y) | Log $[P(1-P_p)/P_p]$ | $Y_i$ | $X_i$ | $X_i^2$ | exp$(A+BX_i)$ | $P=1/[1+exp(A+BX_i)]$ |
|-----|----------------|----------------|----------------------|-----------|------------------------|------|------|--------|----------------|------------------|
| 1   | 1.694          | 4.716          | 3.022                | 0.888     | -0.903                 | -2729.285 | 9132484 | 0.204 | 0.830 |
| 2   | 1.685          | 4.667          | 2.982                | 0.983     | 0.016                  | -1.786 | 5326225 | 0.214 | 0.823 |
| 3   | 1.658          | 4.479          | 2.821                | 0.833     | 0.166                  | -0.699 | 1971500 | 0.263 | 0.791 |
| 4   | 1.712          | 4.819          | 3.107                | 0.933     | 0.066                  | -1.146 | 3560297 | 0.183 | 0.845 |
| 5   | 1.715          | 4.825          | 3.110                | 0.972     | 0.027                  | -1.552 | 4826148 | 0.182 | 0.845 |
| 6   | 1.702          | 4.755          | 3.053                | 0.700     | 0.300                  | -0.368 | 1123433 | 0.196 | 0.835 |

$\sum = 18095$ ; $-6.454 = -19536.89$ ; $54629207$  

$B = \{N \sum XY - (\sum X \sum Y)\}/\{N \sum X^2 - (\sum X)^2\} = -0.001$  

$A = Y - B.X$ ; $Y$ (Y average) and $X$ (X average)  

2.248

From table 3 the equation for the binomial-logit-difference model is obtained and then entered into the simultaneous equation with the aim of getting results, where $\alpha$ and $\beta$ are the model parameters of the regression equation:

$$Y = \alpha + \beta X; Y = 2.248 - 0.001 X$$

$$Log \{(1-P_p)/P_p\} = \alpha + \beta (C_p - C_u) = 2.248 - 0.001(C_p-C_u)$$

#### Table 4. Calculation of the coefficient of determination

| Group | $Y_i$ | $\bar{Y}$ | $i$ | $\bar{Y}_i - \bar{Y}$ | $(\bar{Y}_i - \bar{Y})^2$ | $Y_i$ | $\bar{Y}_i$ | $Y_i - \bar{Y}_i$ | $Y_i - \bar{Y}_i)^2$ | $\bar{Y}$ |
|-------|-------|-----------|-----|------------------------|--------------------------|------|---------|------------------|---------------------|--------|
| 1     | -0.903| -0.336    | -0.903| -0.567                 | 0.321                    | 0.172| 0.029   | -0.903           | 0.000               | -0.903 |
| 2     | -1.786| -0.319    | -1.786| -1.467                 | 2.153                    | -0.710| 0.504   | -1.786           | 0.000               | -1.786 |
| 3     | -0.699| -0.249    | -0.699| -0.450                 | 0.202                    | 0.377| 0.141   | -0.699           | 0.000               | -0.699 |
| 4     | -1.146| -0.373    | -1.146| -0.773                 | 0.597                    | -0.070| 0.004   | -1.146           | 0.000               | -1.146 |
| 5     | -1.552| -0.374    | -1.552| -1.177                 | 1.386                    | -0.476| 0.226   | -1.552           | 0.000               | -1.552 |
| 6     | -0.368| -0.350    | -0.368| -0.018                 | 0.000                    | 0.708| 0.500   | -0.368           | 0.000               | -0.368 |
| $\sum$| -6.454| 4.661     | 1.408| -6.454                 | 1.408                    | 4.661| 1.408   | -6.454           | 1.408               | 4.661 |
| average| -1.076|           |       |                        |                          |      |         |                  |                    |        |

To get the coefficient of determination the equation is used:

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(Y - \bar{Y})^2}{\sum_{i=1}^{n}(Y - \bar{Y})^2}$$

Value ; $R^2 = 1 - 0.302 = 0.698$
### Table 5. Calculation of linear regression analysis method for the binomial-logit-ratio model

| No. | CJR (Rupiah) | CJB (Rupiah) | CJR / CJB (%) | PP (%) | CU (%) | Log[(1 - Pi)/Pi] | Xi Yi | Wi | Log ( Wi ) | P = 1/[1 + exp(A + BXi)] | Xi^2 |
|-----|--------------|--------------|---------------|--------|--------|-----------------|-------|----|------------|--------------------------|-----|
| 1   | 1,694        | 4,716        | 3,022         | 0.888  | 0.111  | -0.903          | 0.402 | 0.074 | -0.445     | 1.801                    | 0.198 |
| 2   | 1,685        | 4,667        | 2,982         | 0.983  | 0.016  | -1.786          | 0.790 | 0.075 | -0.442     | 1.794                    | 0.196 |
| 3   | 1,658        | 4,479        | 2,821         | 0.833  | 0.166  | -0.699          | 0.302 | 0.079 | -0.432     | 1.759                    | 0.186 |
| 4   | 1,712        | 4,819        | 3,107         | 0.933  | 0.066  | -1.146          | 0.515 | 0.072 | -0.449     | 1.816                    | 0.202 |
| 5   | 1,715        | 4,825        | 3,110         | 0.972  | 0.027  | -1.552          | 0.697 | 0.072 | -0.449     | 1.816                    | 0.202 |
| 6   | 1,702        | 4,755        | 3,053         | 0.700  | 0.300  | -0.368          | 0.164 | 0.073 | -0.446     | 1.806                    | 0.199 |

\[

d = \frac{\sum_x \sum_y y \cdot (\sum_x y + 1) - \sum_x \sum_y y^2}{N \cdot \sum_x y}
\]

\[

B = \frac{N \cdot \sum_x y \cdot (\sum_x y + 1) - \sum_x y^2}{N \cdot \sum_x y^2 - (\sum_x y)^2}
\]

\[

\beta = \frac{\sum_x y - 1}{\sum_x y + 1}
\]

\[

\alpha = \frac{1}{2.549}
\]

4. Result and discussion

Analysis using the binomial-logit difference model and the binomial-logit ratio model can be illustrated in the form of the curve of figure 2 showing that with the greater cost difference, the opportunity for the selection of private transport modes (Pp) will be even greater, and vice versa. Next figure 2 shows that to get the same opportunity, subsidies must be given to public transportation at least 2,800 rupiah.

**Figure 1.** Calculation deviation coefficient of determination

**Figure 2.** The relationship between the difference in travel costs and opportunities for use of private vehicles

**Figure 3.** The relationship between the cost of travel ratios and opportunities for use of private vehicles
5. Conclusions
Travel behavior and mode choice patterns are very important and influential in transportation policy for decision making. Travel attributes that influence mode choice in Berau district are travel time, transportation costs, space availability, comfort and safety. Even though the cost of private transportation is the same as the cost of public transportation, around 79% of people will still choose to use private transportation, as shown in figure 3. To attract public transportation use, this condition will be achieved if public transportation costs are 1.4 times cheaper compared to the cost of private transportation.

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