Modal Choice Probability Study from Bus to Train At Jombang – Babat Railway Line Reactivation Design

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Abstract
Currently, the transportation mode which connects Jombang City to Babat City in Lamongan Regency on trip is still using bus. This current transportation mode is under appropriated to serving passengers because there are lack of comfortable, unclean, and long headway time approximately 2 – 3 hours for a same routes. Based on these problems, research about intermodal transportation and modal choice probability is suitable. Intermodal transport is designed to revitalize train routes from Jombang to Babat City. A modal choice probability study obtains the number of predicted passengers which can be switched from the existing transportation mode (bus) to the designed transportation mode (train) by using the Stated Preference method. By creating intermodal transportation, obtained train circulation time plan was 303,49 minutes, the headway time plan was 118,6 minutes, the rolling stock plan requirements are three sets of trains and the ticket price plan is IDR 11,500/passenger. According to the difference between train and bus ticket price when the price of train ticket is lower than bus the result of modal choice probability is 0,88. According to the difference between train and bus travel time when train travel time is faster by 42 minutes than bus the result is 0,87. Then due to departure frequency between train and bus when the number of train departures is more than five times per day, the probability analysis results is 0,83.

Keywords: intermodal transportation, modal choice probability study, revitalizing

INTRODUCTION

Intermodal transportation is a goods or people transportation system on one unit transport vehicle that uses two or more transportation modes continuously without changing the handling process of goods or people themselves [1]. An intermodal transportation system is a combination method of transportation in sustainability with several configurations of transportation mode choices, such as through highway and railway, railway and sea transportation, railway and water transportation, and railway and air transportation [2].

By this time connecting transport from Jombang City to Babat City at Lamongan Regency is an intercity bus in province. However, the available bus is under appropriated to serving passengers, because there are lack of comfortable, unclean, and long headway time approximately 2 – 3 hours for a same routes. Otherwise, many people still use private vehicles to travel from Jombang City to Babat City at Lamongan, the emerging potential of traffic congestion and accidents [3]. Historically, Jombang – Babat was connected by railway line built by Dutch colonial government in Indonesia in 1898. After Indonesia gained its independence in 1945, for some reasons of getting lose in competitions with another transportation mode, ironically these railway service must ends at years 1981. As a brief information related to existing intermodal transportation facility that available at Jombang and Babat City giving a choice to transportation mode user and affecting people mobility [4]. A available at Jombang and Babat City gives a choice to transportation mode user and affect by RINPS 030, Jombang – Babat railway lines included to the one that will be reactivated [5]. By this research, in order to obtaining a value of intermodal transport probability which become an option of traveler so evaluation due to the factors giving occasion to traveler that using connect transport from Jombang to Babat City should be held. This evaluation method is distributing questionnaire about social-economic and trip characteristics to definite respondent by using Stated Preference method. After primary data from distributing questionnaire is obtained, then analyzed with regression analysis to determine probability value and decision of intermodal choice traveler.
RESEARCH METHODS

Data collecting
Primary data
Primary data is a data which obtained by direct observation. Primary data include data from survey outcome with questionnaire distributions.

Secondary data
Secondary data is a data which obtained from concerned instance. Due to this research secondary data include data of passenger population at Jombang Terminal with related route Jombang – Babat, and train operations cost data from Operational Area (DAOP) 8.

Sampling technics
To determining amount of minimum sample, formula as listed below is used [6]:

\[ n = \frac{z^2 \cdot p \cdot (1-p)}{d^2} \cdot N \] ..........................(1)

Where:
\( n \) = amount of minimum sample or respondent
\( N \) = amount of available population
\( p \) = prediction of measured percentage
\( d \) = confidence interval or required accurate (0.1)

Load factor
Load factor (LF) is a ratio between passengers amount from public transportation with available seat capacity. Load factor calculation is based on formula listed below:

\[ LF = \frac{P_{sg} \times 100\%}{c} \] ..........................(2)

Where:
\( P_{sg} \) = Number of passengers which transportable
\( c \) = Transport capacity

Circulation Time
Trip circulation time is a public transportation travel time from a certain spot to another spot that consist of travel time, travel time deviation and stopping time [7]. Trip circulation time is expressed on formula below:

\[ CT_{ABA} = (T_{AB} + T_{BA}) + (\sigma_{AB}^2 + \sigma_{BA}^2) + (T_{FA} + T_{FB}) \] ..........................(3)

Where:
\( CT_{ABA} \) = Circulation time from A to B, back to A
\( T_{AB} \) = Average travel time from A to B
\( T_{BA} \) = Average travel time from B to A
\( \sigma_{AB} \) = Travel time deviation from A to B
\( \sigma_{BA} \) = Travel time deviation from B to A
\( T_{FA} \) = Vehicle stopping time at A
\( T_{FB} \) = Vehicle stopping time at B

Headway
Headway is a time between two transportation mode to pass through certain spot defined as bus shelter or train station [8]. Headway is determine according to formula listed below:

\[ H = T_{A:B} + t_i + c \] ..........................(4)

Where:
\( H \) = Headway (minutes)
\( T_{A:B} \) = Train travel time (minutes)
\( t_i \) = Travel time from head signal appears to railway station (minutes)
\( c \) = Service time of automatic block signaling including rail switch (minutes) according with certain value of \( t \)

0.5 minutes for mechanic signal
5.5 minutes for mechanic signal block
2.5 minutes for electric signal
0.75 minutes for electric signal with central operating system

Number of trains rolling stock
Number of train rolling stock per circulation time required calculated with equations expressed below [9]:

\[ \frac{2 \times TWT + 2 \times TT}{H \times 1} \] ..........................(5)

With :
\( TWT \) = Terminal Waiting Time
= Passengers boarding and alighting time
= 25 minutes
\( TT \) = Travel Time (minutes)
\( H \) = Headway time (minutes)
100%= Vehicle/rolling stock availability factors

Stated Preference Methods

Stated Preference methods indicated with using experiment design presence to build hypothesis alternative due to observed situations, then laid to respondent [10]. Furthermore, selected respondent asked about what choice they prefer to doing something or how they make rating or definite choice in one or several predicted situations. By using this stated preference methods, researcher can fully control factors that exist on situation which hypothetic analysis is done. Stated preference data that obtained from respondent then analyzed to determine a certain model as formulation which reflecting individual utility on their trips [11].

Respondent Choice Based on Rating

On this approach, respondent is asked to showing their Degree of Preference to recent choice with using
definite numeric [12]. As example, for two choice A or B responses can be expressed on choice form 1 – 5, where:
1 = Affirmative to choose A
2 = Possibly to choose A
3 = Balanced choosing
4 = Possibly to choose B
5 = Affirmative to choose B

Those five options then transformed into the probability forms (Berkson-Theil Transformation) as expressed below:
Choice 1 having a probability scale 0,1
Choice 2 having a probability scale 0,3
Choice 3 having a probability scale 0,5
Choice 4 having a probability scale 0,7
Choice 5 having a probability scale 0,9

Later, those five-probability scale transformed into Symmetric Scale that will be turned into utility value which synchronizing with probability scale. This transformation process using logit binomial equations.
Probability score for each point rating of symmetric scale value is a dependent variable on regression analysis and as an independent variable is difference between two transportation modes [13]. Symmetric Value Transformation presented on table 1 below:

<table>
<thead>
<tr>
<th>Point Rating</th>
<th>Symmetric Value Transformation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Probability Scale</td>
</tr>
<tr>
<td>1</td>
<td>0,9</td>
</tr>
<tr>
<td>2</td>
<td>0,7</td>
</tr>
<tr>
<td>3</td>
<td>0,6</td>
</tr>
<tr>
<td>4</td>
<td>0,3</td>
</tr>
<tr>
<td>5</td>
<td>0,1</td>
</tr>
</tbody>
</table>

Correlation Coefficient

Descriptive statistics are statistics used to analyze data in ways that describe or depict the data that has been collected as it is without intending to generally accepted conclusions or generalizations [14].

On descriptive statistics there are several hypothesis, one of that is associative hypothesis which must be tested. Associative hypothesis is a temporary results due to associative or relation problems. Associative hypothesis is tested with correlation methods such as Pearson Product Moment correlation. Hypothesis testing is carried out to obtaining descriptions whether if there is a relationship or not between variable X to Y. There are guidance to giving an interpretations of correlation coefficient that shown on table 2 below:

<table>
<thead>
<tr>
<th>Coefficient interval</th>
<th>Grade of relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,00 - 0,199</td>
<td>Very low</td>
</tr>
<tr>
<td>0,20 – 0,399</td>
<td>Low</td>
</tr>
<tr>
<td>0,40 – 0,599</td>
<td>Medium</td>
</tr>
<tr>
<td>0,60 – 0,799</td>
<td>Strong</td>
</tr>
<tr>
<td>0,80 – 1,000</td>
<td>Very strong</td>
</tr>
</tbody>
</table>

Source: Sugiyono (2009)

RESULTS AND DISCUSSIONS

Amount of sample calculation:
1. The number of passengers which boarding and alighting at Babat Terminal noted that congested number of passengers on month of July 2018 are 549.327 persons.
2. The number of passengers which boarding and alighting at Jombang Terminal noted that congested number of passengers on month of October 2018 are 528.966 persons.

So, the total number of n population at Babat and Jombang Terminal is amount:

\[ n = 549.327 + 528.966 \]
\[ n = 1.078.293 \text{ passengers} \]

To determine a number of sample is using equation which expressed below:

\[ N = \frac{z^2 \cdot (p) \cdot (1-p) \cdot n}{d^2} = \frac{1.96^2 \cdot (0.5) \cdot (1-0.5) \cdot 1.078.293}{0.05^2} = 525.547.2 \]
\[ \approx 5473.13 \]
\[ \approx 96,023 \]
\[ \approx 100 \text{ respondent.} \]

Ticket Price Probability Analysis

F-test or coefficient test is using to determine effects of all independent variable simultaneously whether if have significant effect to dependent variable with laid on decision making as stated below:

1. Variance of parameter
   a. If a value of \( F_{count} < \) value of \( F_{table} \) then \( H_0 \) accepted and \( H_1 \) rejected
   b. If a value of \( F_{count} > \) value of \( F_{table} \) then \( H_0 \) rejected and \( H_1 \) accepted
2. Based on probability
   a. If a value of probability > 0,05 then \( H_0 \) accepted and \( H_1 \) rejected.
   b. If a value of probability < 0,05 then \( H_0 \) rejected and \( H_1 \) accepted.
Hypothesis:
H₀ = No effect between ticket price with modal choice
H₁ = Effect existed between ticket price with modal choice

From Analysis Of Variance test or F-test by taking all attributes on modal choice between train and bus so can be determined \( F_{\text{count}} = 197.3157 \) with probability value 0.000, then \( F_{\text{table}} \) can be located on statistic table in significanition 0.05 that is a value of \( F_{\text{table}} = 19.5 \). According to variance analysis result that \( F_{\text{count}} > F_{\text{table}} \) and probability value < 0.05 then \( H_0 \) rejected and \( H_1 \) accepted. It means that difference of ticket price effect to modal choice.

From the result of analysis obtained probability value of both transportation mode (train and bus), after that analysis of ticket price attribute alteration is done as presented on table 3 following:

<table>
<thead>
<tr>
<th>No</th>
<th>∆X1</th>
<th>(UKA - UB)</th>
<th>PKA</th>
<th>PB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-6500</td>
<td>1.9896</td>
<td>0.88</td>
<td>0.12</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0.9921</td>
<td>0.73</td>
<td>0.27</td>
</tr>
<tr>
<td>3</td>
<td>6500</td>
<td>-0.0054</td>
<td>0.50</td>
<td>0.50</td>
</tr>
</tbody>
</table>

From table 3 can be described as line chart as presented on figure 1 below:

From figure 1 also known that when ticket price of train (∆X1) is more expensive IDR 6500 than bus possibly respondent can still choose same mode transportation that is train or bus. Whether train or bus is having a same opportunity on modal choice.

Correlation test of ticket price factor effect to modal choice presented on table 4 below:

<table>
<thead>
<tr>
<th>No.</th>
<th>∆X2 (minutes)</th>
<th>(UKA-UB)</th>
<th>PKA</th>
<th>PB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-42 minutes</td>
<td>-0.4944</td>
<td>0.38</td>
<td>0.62</td>
</tr>
<tr>
<td>2</td>
<td>0 minutes</td>
<td>0.7061</td>
<td>0.67</td>
<td>0.33</td>
</tr>
<tr>
<td>3</td>
<td>42 minutes</td>
<td>1.9067</td>
<td>0.87</td>
<td>0.13</td>
</tr>
</tbody>
</table>

**Source: Analysis result**

From figure 1 can be explained that when ticket price of train (∆X1) is cheaper IDR 6500 than bus, so respondent prefer to choose train. This condition can be described from probability line chart that located on left side. Blue line (PKA) show probability value 0.88 then red line (PB) show probability value 0.12.
From table 5 can be described as line chart as presented on figure 2 below:

![Figure 2. Probability of travel time line chart](image)

From figure 2 can be explained that when train travel time (ΔX2) is slower 42 minutes than bus, so respondent prefer to choose bus. This condition can be described from probability line chart that located on left side. Blue line (PKA) shows probability value 0.36 then red line (PB) show probability value 0.64.

From figure 2 also known when train travel time (ΔX2) is faster 42 minutes than bus, so respondent prefer to choose train. This condition can be described from probability line chart that located on right side. Blue line (PKA) shows probability value 0.87 then red line (PB) show probability value 0.13. Therefore when train travel time is faster than bus, so respondent will moving to use train.

Correlation test of travel time factor effect to modal choice presented on table 6 below:

<table>
<thead>
<tr>
<th>No</th>
<th>ΔX2</th>
<th>(UKA - UB)</th>
<th>PKA</th>
<th>PB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-3x</td>
<td>-0.5666</td>
<td>0.36</td>
<td>0.64</td>
</tr>
<tr>
<td>2</td>
<td>-5x</td>
<td>0.4991</td>
<td>0.62</td>
<td>0.38</td>
</tr>
<tr>
<td>3</td>
<td>-7x</td>
<td>0.5648</td>
<td>0.83</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Source: Analysis result

From table 7, so can be described as line chart as presented on figure 3 below:

![Figure 3. Probability of departure frequency line chart](image)

From figure 3 can be explained that when bus departure frequency (ΔX3) is more of 3 times than train, so respondent prefer to choose bus. This condition can be described from probability line chart that located on left side. Blue line (PKA) shows probability value 0.36 then red line (PB) show probability value 0.64. Therefore, when bus departure frequency is more than train so respondent will moving to use bus.

From figure 3 also known that when bus and train departures frequency designed similar which is 5 departures for each transportation mode so respondent

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**Probability of Departure Frequency**

From Analysis of Variance test or F-test by taking all attributes on modal choice between train and bus so can be determined F\(\text{count}\) 133.961 with probability value 0.000, then F\(\text{Table}\) can be located on statistic table in signification 0.05 that is a value of F\(\text{Table}\) 19.5. According to variance analysis result that F\(\text{count} > \text{F}\text{Table}\) and probability value < 0.05 then H\(_0\) rejected and H\(_a\) accepted. It means that difference of departure frequency effect to modal choice.

From the result of analysis obtained probability value of both transportation mode (train and bus), after that analysis of travel time alteration is done as presented on table 7 following:

<table>
<thead>
<tr>
<th>Attributes</th>
<th>PKA</th>
<th>PB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Correlation Test result

From table 6 can be explained that value of Pearson Correlations for relationship between travel time (X2) with modal choice (Y) is 1.00. Due to table 2 about Correlation Coefficient means that is a very strong relationship between travel time variable and modal choice.
prefer to choose train. This condition can be described from probability line chart that located on the middle. Blue line (PKA) shows probability value 0.62 then red line (PB) show probability value 0.38. So, when bus and train departures frequency designed similar, then respondent will moving to use train.

From figure 3 can be explained that when train departure frequency (ΔX3) is more of 7 times than bus, so respondent prefer to choose train. This condition can be described from probability line chart that located on left side. Blue line (PKA) shows probability value 0.83 then red line (PB) show probability value 0.17. Therefore, when train departure frequency is more than bus, so respondent will moving to use train.

Correlation test of travel time factor effect to modal choice presented on table 8 below:

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Y</th>
<th>X3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modal choice Pearson Correlation</td>
<td>1</td>
<td>1.00**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Departure frequency Pearson Correlation</td>
<td>1.00**</td>
<td>1</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Source: Correlation Test result
From table 8 can be explained that value of Pearson Correlations for relationship between departure frequency (X3) with modal choice (Y) is 1.00. Due to table 2 about Correlation Coefficient means that is a very strong relationship between departure frequency variable and modal choice.

Calculating circulation Time
Calculating circulation time is expressed as below:

\[ T_{AB} = \text{average travel time from Jombang Terminal to Babat Terminal} \]
\[ = 110,6 \text{ minutes} \]

\[ T_{BA} = \text{average travel time from Babat Terminal to Jombang Terminal} \]
\[ = 110 \text{ minutes} \]

\[ \sigma_{AB} = \text{deviation of travel time from Jombang Terminal to Babat Terminal} \]
\[ = 5\% \times 110,6 \text{ minutes} \]
\[ = 5,53 \text{ minutes} \]

\[ \sigma_{BA} = \text{deviation of travel time from Babat Terminal to Jombang Terminal} \]
\[ = 5\% \times 110 \text{ minutes} \]
\[ = 5,5 \text{ minutes} \]

\[ T_{TA} = \text{vehicle stopping time at Babat Terminal} \]
\[ = 10\% \times 110,6 \text{ minutes} \]
\[ = 11,06 \text{ minutes} \]

\[ T_{TB} = \text{vehicle stopping time at Jombang Terminal} \]
\[ = 10\% \times 110 \text{ minutes} \]
\[ = 11 \text{ minutes} \]

So, circulation time plan \( CT_{ABA} \) from Jombang Terminal to Babat Terminal at Lamongan regency is:

\[ CT_{ABA} = (T_{AB} + T_{BA}) + (\sigma_{AB}^2 + \sigma_{BA}^2) + (T_{TA} + T_{TB}) \]
\[ = (110,6+ 110) + (5,53^2+ 5,5^2) + (11,06 + 11) \]
\[ = 220,6 + 60,83 + 22,06 \]
\[ = 303,49 \text{ minutes} \]

Calculating Headway
Headway plan of Jombang – Babat railway line:

\[ H = t_{AB} + t_i + c \]
\[ = 110,6 + 2,5 + 5,5 \]
\[ = 118,6 \text{ minutes} \]

Calculating the number of train rolling stock

\[ \text{Number of train rolling stock} = \frac{2 \times TWT + 2 \times TT}{H \times 1} \]

Where:

\[ TWT = \text{Terminal Waiting Time} \]
\[ = 25 \text{ minutes} \]

\[ TT = \text{Travel Time} \]
\[ = 110,6 \text{ minutes} \text{ (travel time from Jombang Terminal to Babat Terminal)} \]

\[ H = \text{Headway time} \]
\[ = 118,6 \text{ minutes} \text{ (obtained from headway plan calculation)} \]

\[ 100\% = \text{Vehicle/rolling stock availability factors} \]

\[ \text{Number of trains rolling stock} = \frac{2 \times TWT + 2 \times TT}{H \times 1} \]

\[ = \frac{2 \times 25 + 2 \times 110,6}{118,6 \times 1} \]

\[ = 2,33 \]
\[ \approx 3 \text{ rolling stock} \]

Calculating Load Factor
Load factor calculation according to equation as expressed below:

\[ \text{LF} = \frac{\text{Psg}}{C \times 100\%} \]

Where:

\[ \text{Psg} = 624 \text{ passengers} \]
\[ C = \text{transport capacity of designed rolling stock (745)} \]

Then, load factor can be calculated:
Whenever load factor value is $< 1$ so, train is still can accept demand that caused by passengers movement from bus to train [15]. It means that capacity of train wagon is still can accept the number of passengers caused by transportation mode movement.

**CONCLUSION**

According to result analysis, factors that affecting mode transportation movement from bus to train that are ticket price, travel time and departure frequency which having strong relationship grade based on correlation coefficient interpretation table.

**REFERENCES**


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