Transportation mode choice model between private car and railway for responding the operation of Makassar - Parepare railway for Makassar - Pangkep route

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Abstract

The choice of a mode of transportation is influenced by the characteristics of the traveler and the trip’s characteristics. Based on this, a study was conducted on the many types of transportation modes that can be used by travelers [4].

1 Introduction

The construction of the Trans Sulawesi Railway (KA) is an effort to support the integration of the national transportation system. The Trans-Sulawesi railway line is a network of railway lines built to reach important areas on the island of Sulawesi. The Trans Sulawesi railway project is targeted to reach a length of 2000 kilometers from Makassar to Manado. This railroad network was built starting in 2015 which started from phase I, namely the railroad from Makassar to Pare-Pare. This route consists of several segments, namely Makassar - Maros - Pangkep - Barru - Pare-Pare. The construction of the Maros-Barru Railway Line (± 71 KM) has been completed. [1-3].

In the context of the Operation of the Makassar - Parepare Regional Railway, it is important to carry out studies that are urgently needed in planning and making transportation policies. The results of this study are expected to contribute to the Prospects for the Development of the Maros – Barru Railway Operation Plan in the future after the end of the Government Subsidy Scenario. The study analyzed the characteristics of the community/population as potential passengers along the operational area of the Makassar-Parepare Railway (demographic characteristics - stratification, and travel characteristics), which then created a Community Preference model in the Use of the Rail Mode based on the scope of the administrative area/railway stations throughout the area. Makassar-Parepare Pioneer Train operation plan.

Mode choice is a unique issue and cannot be determined casually. This is because there are subjective variables; satisfaction, comfort, security, availability of modes, and others, depending on one's needs and conditions. The choice of transportation mode involves many parties including mode users (users), government (regulators), and public transport owners (operators). The selection of a mode of transportation is an important stage in transportation planning and policy, as well as the many types of transportation modes that can be used by travelers [4].

The choice of a mode of transportation is influenced by the characteristics of the traveler and the trip’s characteristics. Based on this, a study was conducted on the probability of the selection of private vehicles and public transportation as a means of traveling. By knowing the travel behavior that affects the probability of the selection of modes, efforts will be made to improve and improve services for the mode users concerned. For the Makassar – Parepare line, the passengers prefer to choose one of both travel modes.
when the mode has travel time faster than the other one, as well as for the lower travel cost. In addition, the inter-city travelers more considered the transfer travel cost attribute than the transfer travel time attribute, when they face both travel mode choice, the new railway mode, and the existing private car mode [15].

This research was conducted to identify the characteristics of travelers, and travel characteristics, and create a model for selecting the mode of passenger transportation between cars and trains for the operation of the Makassar Regional Train - Parepare Makassar Pangkep Route. This model can explain the probability of travelers choosing the mode of transportation between private vehicles and trains when viewed from the perspective of travel costs (cost) and travel time (time) and to determine changes in the probability of travelers choosing the mode of choice if changes are made to the costs and travel time. The output of this study provides an overview of demographic-stratification characteristics, travel characteristics of the potential passengers of the Makassar-Parepare Pioneer Train route Makassar - Pangkep, and the Mode choice Probability Model between Private Vehicles and Trains for Prospective Use of the Makassar-Parepare Pioneer Train Mode based on the Random Utility approach Maximization (RUM) Model.

2 Theoretical basis

Transportation is movement from one place to another. To carry out transportation, modes are needed as a means of moving, which is called transportation. Transportation is generally defined as a tool or means that can be used to move goods or people from one place to another. Public transportation is passenger transportation that is carried out with a rent or pay system, including city transportation (buses, minibusses), trains, water transportation, and air transportation. The main purpose of the existence of passenger public transportation is Organize good and decent transportation services for the community [5].

The measure of good service is service that is safe, fast, cheap, and comfortable. In addition, the existence of passenger public transport also creates jobs. Transportation planning and policy are based on 3 components that directly intersect with the operation of the railway, namely, the government as the regulator, the owner of the transport as the operator, and the public who use the mode as the user. Mode choice is the most important model in transportation planning and design. This is due to the main role of public transport in various transportation policies [6].

In terms of making transportation planning policies, Mode choice is an important step that must be taken [7]. The role of the model can help understand how the system works so that it can describe and analyze the reality that is and will occur. The model formed is validated and its validity is determined as a model that can be accepted and used in forecasting [8].

In choosing a mode of transportation, decision-makers (users) tend to maximize the utility of an option. So that the modal alternative that has the highest utility has a great chance of being selected. The choice of transportation mode can be influenced by the travel and service attribute variables of each mode alternative as well as socio-economic conditions. The mode choice model is influenced by the characteristics of the trip (Travel Characteristic Factor), the characteristics of the traveler (Traveler Characteristic Factor), the characteristics of the transportation system (Transportation System Characteristic Factor) and the characteristics of cities and zones (Special Characteristic Factor). Variables that influence are the distance between the residence and the place of activity and population density [6].

2.1 Social demographic conditions

Variables contribute to influencing the users, including Family structure and size, Daily Activity, Availability or ownership of private vehicles, Frequency of vehicle use, How to use the vehicle in the family, and all the variables that affect the choice of mode.

2.2 Disaggregated approach

Analyze individual travel behavior. Individual behavior is formulated into a model of transportation needs [6]. There are two approaches to this, namely:
- Disaggregate deterministic approach, where the choice of something does not change if the traveler is faced with a set of alternatives repeatedly the same.
- The stochastic disaggregate approach, where this approach is taken if the information obtained is very limited so that both the alternative modes and their attributes and the choice of modes taken by the traveler may change due to certain influences. Overcoming this requires a residual element (error element).

2.3 Mode choice model approach

The choice of mode is hypothesized to depend on the characteristics of the mode which reflect costs that are equated with travel costs [9]. From the point of view of mode users, mode choice is influenced by several factors, namely the characteristics of road users, the characteristics of the movement, and the characteristics of transportation mode facilities [10]. Each of these factors is influenced by:

1. Characteristics of road users in the form of availability or ownership of private vehicles, possession of a driving license (SIM), and household structure.
2. Characteristics of road users in the form of availability or ownership of private vehicles, possession of a driving license (SIM), and household structure.
3. Characteristics of road users in the form of availability or ownership of private vehicles, possession of a driving license (SIM), and household structure.

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2.3.1 Discrete choice model

In general, the discrete choice model is expressed as the opportunity for each individual to choose an option which is a function of the socio-economic characteristics and the attractiveness of the choice [12]. To express the attractiveness of an alternative, the concept of utility is used (defined as something that is maximized by each individual). Domencich and McFadden (1975) and Williams (1977), as quoted from Tamin (2008), suggest that each set of \( U_i^n \) utility choices for each individual’s \( n \). The modeler who is also an observer of the system does not have complete information about all the elements considered by each individual who makes the choice [13]. Soon, making the model it is assumed that \( U_i^n \) can be expressed in two components, namely:

1. \( V_{in} \) is a function of the measurable attribute.
2. The random part \( \varepsilon_{in} \) reflects certain things from each individual, including the error factor made by the modeler.

The influence is formulated in general, Equation 1 [14].

\[
U_{in} = V_{in} + \varepsilon_{in} \tag{1}
\]

\( U_{in} \) is alternative \( i \) utilities for mode \( n \).
\( V_{in} \) is deterministic function of utilities for mode \( n \).
\( \varepsilon_{in} \) is error or stochastic component and certain distribution function.

The equation can explain things that are not rational. For example, two individuals with the same attributes and having the same set of choices may have different choices and some individuals may not always choose the best alternative. For the equation to be true, a homogeneous population is required. Individuals who are in a homogeneous population will act rationally and have the right information so that they can usually make choices that maximize their respective individual utilities in accordance with legal, social, physical, time, and money constraints.

2.3.2 Random utility model (RUM) in travel demand management (TDM)

This study is based on the random utility maximization approach in building and calculating individual preference parameters. The utility function for individuals in the selection of passenger transport modes is presented as linear parameters (Equation 2) [14].

\[
U_{in} = \beta_1 \cdot (Time_{in}) + \beta_2 \cdot (Cost_{in}) \tag{2}
\]

The utility function become Equation 3.

\[
U_{in} = \beta_1 \cdot X_{in1} + \beta_2 \cdot X_{in2} + \ldots + \beta_k \cdot X_{ink} \tag{3}
\]

where, the \( U_{in} \) is alternative utilities for \( i \) and decision maker for \( n \), \( \beta_{in1}, \beta_{in2}, \ldots, \beta_{ink} \) are the coefficients that need to be referenced with the available data, also for \( X_{in1}, X_{in2}, X_{ink} \) are several attributes \( k \) which describe the attributes of alternative \( i \) for the maker decision \( n \).

3 Methodology

3.1 The study location

This research research is focused on the Makassar Pangkep route. Makassar is the capital of South Sulawesi Province, while Pangkep is a district area. The following table shows the number and location of survey samples. Minimum Sample Number per City/District based on Buffer Area (Fig. 1).

The Table 1 is showed the minimum number of samples according to the buffer area in Pangkep Regency.

Table 1. The minimum number of samples per buffer area of Pangkep Regency.

<table>
<thead>
<tr>
<th>Number</th>
<th>Subdistrict</th>
<th>Qty</th>
<th>Buffer</th>
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The total samples are limited by the total buffer area each district, which indicates the total area is closely to the railway stations.

3.2 Survey method

In this study, data were obtained through the Stated Preference (SP) technique. The technique was carried out using a combination of two basic methods, namely a questionnaire survey and an interview survey. The data collection used a questionnaire that was distributed both through online media and by survey staff (surveyors) directly to respondents and in this case, the surveyor also acted as an interviewer. This was intended so that the surveyor could provide an overall picture of the research and further clarify the intent of the questions on the questionnaire sheet so that they could assist respondents in filling out the questionnaire properly. The survey was conducted by taking a sample of 250 respondents per segment, route Makassar - Pangkep.

The survey was carried out in two stages (Fig. 2), namely, Phase I carried out a Socio-Demographic Survey and Phase II carried out a Travel Diary Survey.

![Survey Stages](image)

**Fig 2.** Stages of survey implementation.

3.3 Survey model variables, and scenario options

In this study, there are 8 (eight) choices of situations or scenarios that are stated based on the preferred method and use 5 (five) attributes as variables in the conditional logit model approach. Mode choice modeling for the data set uses scenarios with Travel Cost, Travel Time, Travel Frequency, Transfer Cost and Travel time from place of origin to the train station (in minutes) as travel attributes.

3.4 Model construction and calculation methods

Decision-making in the binomial logit model is determined on a pair of discrete alternatives, where the alternative to be chosen is the one with the greatest utility, the utility in this case is seen as a random utility.

In this study, the behavior of selecting passenger transport modes to be observed is between trains and private cars. With the existence of two alternative modes, the equation can be written as Equations 4-5.

\[
P_{\text{mode}} = \frac{\exp^{U_{\text{mode}}}}{\exp^{U_{\text{rail}}} + \exp^{U_{\text{rail}}}} \quad (4)
\]

\[
P_{\text{rail}} = 1 - P_{\text{mode}} \quad (5)
\]

Using the linear-regression estimation method, there is a type of model that is often used, namely the logit-binomial-difference model. In this logit-binomial-difference model, the probability that an individual chooses a train is a function of the utility difference between the two modes. By assuming that the utility function is linear, the difference in utility can be expressed in terms of differences in several attributes between the two modes, formulated as mentioned in Equation 6.

\[
U_{\text{mode}} - U_{\text{rail}} = \beta_0 + \beta_1 (X_{1\text{mode}} - X_{1\text{rail}}) + \beta_2 (X_{2\text{mode}} - X_{2\text{rail}}) + \ldots + \beta_n (X_{n\text{mode}} - X_{n\text{rail}}) \quad (6)
\]

Thus, the probability values of the two modes under review can be written in the form of the following Equations 7-8.

\[
P_{\text{mode}} = \frac{\exp^{U_{\text{mode}}}}{1 + \exp^{U_{\text{mode}} - U_{\text{rail}}}} \quad (7)
\]

\[
P_{\text{rail}} = 1 - P_{\text{mode}} \quad (8)
\]

The utility value as an individual response can also be expressed in terms of the probability of choosing a particular mode, which is known as the Berkson-Theil transformation (Equation 9).

\[
\ln \left[ \frac{P_{\text{rail}}}{1 - P_{\text{rail}}} \right] = \beta_1 + \beta_1 (X_{1\text{mode}} - X_{1\text{rail}}) + \beta_2 (X_{2\text{mode}} - X_{2\text{rail}}) + \beta_3 (X_{3\text{mode}} - X_{3\text{rail}}) + \beta_4 (X_{4\text{mode}} - X_{4\text{rail}}) \quad (9)
\]

4 Data collection

4.1 Social demographic characteristics

To describe the socio-demographics (Table 2) of the prospective passengers of the Makassar - Pare-Pare train for the Makassar - Pangkep route, the research variables include age, trip frequency, travel purpose, travel partners, number of family members, daily activities, type of work, status marriage, last education, and income.
4.2 Travel characteristics

Travel characteristics which include the number of private vehicles, frequency of use, full/partial use, other transportation to be used, other transportation to be used if you do not have a private vehicle, how to share vehicles, the main mode of transportation in the family, can be seen in the following Table 3.

Table 2. Socio-demographic characteristics.

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>CATEGORY</th>
<th>PERCENTAGE</th>
</tr>
</thead>
</table>

Table 2 (continued). Socio-demographic characteristics.

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>CATEGORY</th>
<th>PERCENTAGE</th>
</tr>
</thead>
</table>

4.3 Mode choice preferences and travel characteristics (travel attribute data)

Mode choice preferences for data sets, namely using scenarios and attribute data in the form of travel cost, time travel, trip frequency, transfer cost dan travel time from the origin place to the station.

The attributes that must be considered in determining community preferences in using the Makassar City - Pangkep route train are:

- 交通方式选择偏好和旅行特性（旅行属性数据）

模式选择偏好对于数据集，即使用场景和属性数据的形式为旅行成本，旅行时间，旅行频率，换乘成本以及从出发地点到车站的旅行时间。

需要考虑的属性包括在使用马卡萨尔市-邦克普路线列车时的社区偏好。
The relationship between mode choice preferences and individual characteristics and travel characteristics on the Makassar - Pangkep route can be seen in Fig. 4. For scenario A, the dominance of the choice is definitely to choose Train. In scenario B, the dominant community's choice might be to use the railroad. Scenario C, the people choose to use private vehicles. Scenario D describes the various community choices with values that tend to be the same for all options. Scenario F illustrates that people tend to use the train. For Scenario G, people tend to choose to use private vehicles. Likewise, with Scenario H.

The relationship between scenario showed the priority choice of respondents with mode choice and scenario I.

5 Result and discussion

5.1 Social demographic characteristics

From the Table 2 before, it describes the condition of the socio-demographic characteristics of prospective Makassar - Pare-Pare train passengers for the Makassar - Pangkep route. The results of the survey data compilation show that the age group of travelers is dominated by people aged 17-24 years, followed by the age level of 25-32 years where the percentage values are 31.2% and 27.6% respectively. Apart from that, the frequency of trips that were more than 2 times accounted for 56.8%. Travel intent is generally dominated by respondents who visit family, relatives, and friends with a percentage value of 41.2%, and for work or business by 38.4%. Most of the trips were made with family members, namely 44.4%, and with friends and co-workers, respectively, 18% and 18.4%. The number of family members (people) for respondents is more than 2 and less than 7 is around 83.2%. In general, respondents are individuals who have permanent jobs as indicated by a percentage value of 64.8%, the type of work is dominated by government services and trade/self-employed businesses. Marital Status Married and Last Education Undergraduate and High School. Revenue amounts range from IDR 2 million to IDR 7.5 million.

5.2 Preference model for choosing the mode of transportation for travelers

The model formulation used attributes in the form of Travel Expenses, Travel Time, Age, Number of Family Members, and Income. The significance and probability
between respondents’ choices with these attributes were analyzed using conditional logit analysis assisted by STATA statistics software. STATA processed results can be seen in Table 5.

**Table 4.** Experimental mode choice with various scenarios based on attribute data.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
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<td>80</td>
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</table>

**Fig. 3.** Stages of survey implementation.

From the significance analysis of the calculation results, an overview is obtained where the 3 attributes are significant probabilities, namely travel costs, travel time, and number of family members. Age and income attributes are less significant with a value greater than 0.05. In general, the resulting model is in the very good category with a possible ratio value of 95%. The probability of passenger response from the results of the analysis of the Makassar - Pangkep route equation shows that the probability of a response for passengers who choose the train is 43% and for those who choose private vehicles 57%.

**5.3 Model sensitivity to attribute changes**

Furthermore, to determine the sensitivity of the Railway selection model, it is necessary to graph the model's sensitivity to changes in attributes. The graph illustrates the sensitivity of the model so that changes in the probability value of choosing a train can be seen if the...
attribute values are changed gradually. Sensitivity based on the Cost and Time Scenario of Makassar-Pangkep Route Trains can be seen in the following graph in Fig. 5-6.

MODE SELECTION BASED ON STATED PREFERENCE SCENARIOS

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Certain To Choose Train</th>
<th>Maybe Choose Train</th>
<th>Balance</th>
<th>Maybe Choose Own Car</th>
<th>Certain To Choose Train</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario H</td>
<td>7.20% 8% 17.60%</td>
<td>64.80%</td>
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<tr>
<td>Scenario G</td>
<td>8.80% 9.20% 27.60%</td>
<td>51.20%</td>
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<tr>
<td>Scenario F</td>
<td>17.60% 30.80% 18%</td>
<td>14.80%</td>
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</tr>
<tr>
<td>Scenario E</td>
<td>10.40% 15.20% 20.80%</td>
<td>24.40%</td>
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<tr>
<td>Scenario D</td>
<td>10.80% 21.20% 24.40%</td>
<td>20.40%</td>
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<tr>
<td>Scenario C</td>
<td>6.80% 13.60% 21.60%</td>
<td>35.60%</td>
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<tr>
<td>Scenario B</td>
<td>22.80% 40.80% 8.80%</td>
<td>11.60%</td>
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<tr>
<td>Scenario A</td>
<td>69.60% 13.60% 4.40% 6.40%</td>
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Table 5. Processed results of STATA Makassar-Pangkep line.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefisien</th>
<th>P(Value)</th>
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<tbody>
<tr>
<td>Travel expense (X1)</td>
<td>-0.22559</td>
<td>0.000</td>
</tr>
<tr>
<td>Travel time (X2)</td>
<td>-0.10552</td>
<td>0.000</td>
</tr>
<tr>
<td>Age (X3)</td>
<td>-0.00969</td>
<td>0.087</td>
</tr>
<tr>
<td>Number of Family Members (X4)</td>
<td>0.13828</td>
<td>0.000</td>
</tr>
<tr>
<td>Income (X5)</td>
<td>0.00003</td>
<td>0.073</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.18171</td>
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Fig 4. Stated preference of mode choice with scenario.

Fig 5. Sensitivity by cost scenario.

The lowest cost scenario is IDR 30,000 and the highest cost scenario is IDR. 80,000. Based on the sensitivity graph, the intersection of the curves is at a value of Rp. 71,000. Thus, the higher the cost, the smaller the probability of people choosing a train with the shifting value of the fare shifting at Rp. 71,000, - and a probability of 45%.

Scenario Lowest Time 110 Minutes and Highest Scenario Time 230 Minutes. Based on the sensitivity graph, the intersection of the curve is at 170 minutes. Thus, the longer the time, the smaller the probability of people choosing a train with the shifting value of a shifting time value of 172 minutes and a probability of 45%.

Fig 6. Sensitivity by time scenario.
6 Conclusion

Travelers on the Makassar - Pangkep Route have characteristics with an age range of 17 to 32 years, making more than 2 trips to visit family and do business. In general, travelers have a family of 2 to 7 people and most have regular jobs at their destination. Most of them work in government services, trade, and self-employment. The preference for the relationship between mode choice and the scenario obtained by scenario A chooses the train, and scenario B might choose the train. Scenario C chooses a private car, scenario D might choose a private car, scenario E might choose a private car, scenario F might choose a train, scenario G chooses a private car, and scenario H chooses a private car. The significance and probability of the response resulting from the conditional logit analysis show that the model is acceptable. The probability of choosing a train and a private car is 43% and 57%, respectively. From the attribute sensitivity graph, it can be seen that the slope of the line indicates the negative direction, which states that the greater/longer the attribute value, the lower the probability of choosing a train.

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