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MODE CHOICE PROBABILITY BETWEEN BUS AND RAILWAY CIANJUR-PADALARANG ROUTE

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Abstract. Travel between cities in the Bogor, Sukabumi, and Cianjur areas is only accommodated by road-based public transportation that is interstate bus. The government issued a policy to reactivate railroads from Bogor to Padalarang, so that the southern region of West Java are connected to the rail network. This research intention to analyze characteristics of socio-economic users, characteristics of trip users, and analyze how much passengers move from the current bus to the Cianjur-Padalarang train. Data were collected by distributing questionnaires using stated preference techniques and analyzed using binary logit difference model with linear regression. The attributes to be analyzed are the difference between travel costs, travel time, and frequency of departure. The characteristic of users were analyzed with descriptive statictic method. The socio-economic characteristics of the passengers obtained were majority is male, aged 21-30 years old, education level senior high school, worked as entrepreneurship, income Rp2.000.001-Rp3.000.000, transportation costs for a month Rp100.001-Rp300.000. The characteristics of trip users are dominated by origin from Cianjur destination to Padalarang to work (economy), the frequency of trips is 1-2 times per week, the reason choosing the bus because of the bus have more easier mobility, the main travel time is 121-150 minutes. The results of the calculation of model sensitivity, the potential for passenger transfer from bus to train will increase if the difference in cost and travel time between trains and buses is getting smaller, and the difference in frequency is getting bigger.

Keywords : Binary logit, Characteristic of trip users, Stated preference, Transportation mode choice

1. INTRODUCTION

Cianjur Regency serves as a connection between Bandung, Sukabumi, and Bogor in the distribution of commodities and passengers [1]. This involves the implementation of a public transportation mode that is efficient, safe, pleasant, and environmentally friendly. The railway mode is a public transportation option alternative to the problem of inland transportation systems [2]. This is because railway travel time is more accurately guaranteed than highway-based modes of transportation, and the degree of road safety is significantly better. The train has a less fuel consumption value of 0.002 lt/km/org than the bus mode, which has a value of 0.0125 lt/km/org [3].

The government issued a policy on reactivating the Sukabumi–Cianjur–Padalarang railway [3]. With the reactivation of this route, the Bogor, Sukabumi, and Cianjur regions will be connected by train to the city of Bandung. As a result, there will be a competition between bus and train [4]. According to the study [5] there is an 80% chance of transferring modes of transportation to the Surabaya-Porong KRL route. This indicate the existence of intermodal competition, which affects mode selection. Based on the previous study review, it is also necessary to analyze the choices of bus and train modes of the Cianjur-Padalarang route to calculate the probability of passengers transferring from bus to train if it has been operating, as well as socio-economic and user trip characteristics.

Mode selection is a part of the travel demand modeling process, which is crucial in transportation policy [6]. This step calculates and predicts the number of people and/or commodities flows from the origin zone to the

destination zone [7]. In other words, mode selection aims to calculate the proportion of passangers who will use each mode of transportation.

The train is a low-cost mode of land transportation that uses locomotive-driven vehicles to draw gates with a high carrying capacity and cargo [8]. The quality of railway service is split into five categories: travel safety and dependability, timeliness, ease of service, comfort, and speed [9].

Improving the quality of bus services can be accomplished through better administration and operation of bus firms, as well as increased private sector engagement in the purchase of bus transportation services. In terms of service operations, public transportation buses require a consistent route and can be strictly patterned [10].

Stated preference is a data collection method for obtaining information on respondent preferences among several scenario hypothesis options [11]-[12]. Respondents were asked to select their preferred future sustainability strategies [13]-[14]. The respondents evaluation based on a 5-point scale (degree of preference) [15].

Consumers will be provided with two options. By comparing perceptions based on existing free variables, the mode selected has the highest utility value [6]-[16]-[17]. In determining the linear regression value, the train mode shift can be calculated using the formula:

$$\ln \frac{P_{KA}}{1-P_{KA}} = (U_{KA} - U_{BAK}) \quad (1)$$

$$(U_{KA} - U_{BAK}) = b_0 + b_n(\Delta Xn) \quad (2)$$

After getting the linear regression Eq. (1), the probability of selecting the mode with the binary logit difference can be calculated as follows [11]-[16].

$$P_{KA} = \frac{e^{(U_{KA}-U_{BAK})}}{1+e^{(U_{KA}-U_{BAK})}} \quad (3)$$

$$P_{BAK} = \frac{1}{1+e^{(U_{KA}-U_{BAK})}} = 1 - P_{KA} \quad (4)$$

P_{BAK} = Probability of bus mode selected
P_{KA} = Probability of train mode selected
U_{BAK} = Utility value of bus mode
U_{KA} = Utility value of train mode
ΔX_n = Attribute difference between train and bus

2. METHODS

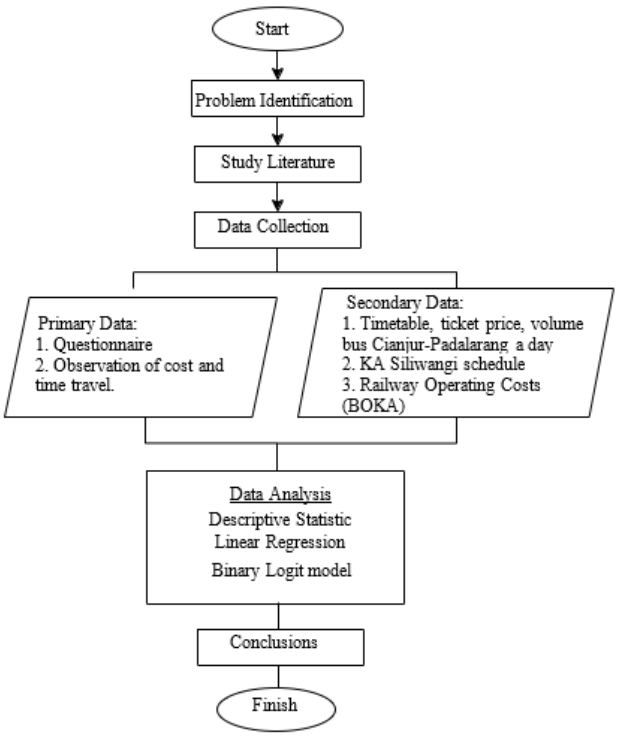


Figure. 1 Flowchart

Based on Figure 1, this research begins with problem identification and collecting literature studies. Furthermore, data collection obtained by direct observations, interviews, data from related company, questionnaire, and literature studies.

Research Sample

The Slovin formula is used to determine the number of research samples [5]-[18]-[16].

$$n = \frac{N}{1+N(\propto)^2} \quad (5)$$

The average number of passengers on the Cianjur-Padalarang bus is 240 passengers per day and the significant level is 95%, then:

$$n = \frac{240}{1+240(0.05)^2} = 150 \text{ respondents}$$

Data Collection

This study involves three independent variables, including the difference in travel time, travel costs, and travel frequency [13]-[19]. The dependent variable is a numerical scale value [20]. Secondary and primary data are required for this research. Primary data was collected by distributing questionnaires to bus passengers on the Cianjur-Padalarang route at Rawabango Station, Pasir Hayam Station, and the surrounding bus stop area. A preliminary survey was conducted prior to the distribution questionnaire to estimate travel time and costs [21].

The questionnaire consists of three sections: respondents socio-economic characteristics, trip user characteristics, and stated preference experiments [22]. The social and economic characteristics of respondents consisted of age, occupation, gender, education, income, and monthly transportation expenditures. The second part contains characteristics of trip users including origin and destination, purpose of travel, frequency, travel time, and rationale for selecting bus transportation, decent fares, and maximum train fares [2]-[23].

Respondents were asked a plan scheme question in the last section, which included attributes such as changes in ticket prices, travel time duration, and departure frequency. Secondary data was collected from UPTD Rawabango, Pasir Hayam Bus Station, and Bus Company in the form of bus departure schedule and daily bus volume. KA Siliwangi scheduled departure and railway operating cost (BOKA) from PT KAI Daop II Bandung [24]. The results of data collection are shown in Table 1.

Table 1. Assumptions of Existing Conditions Attributes (Economy Class)

Attributes	Bus	Train
Cost Travel	Rp25.000,00	Rp5.000,00
Time Travel	2 hours 20 minutes	1 hour 35 minutes
Frequency	15 times a day (03.40– 19.00 WIB) every 30 minutes	3 times a day 07.16 WIB 13.16 WIB 19.16 WIB

Data Analysis

The descriptive statistics approach with the Microsoft Excel program was used to determine the characteristics of bus passengers on the Cianjur-Padalarang route [16]. Individual responses are an option for rating points on a semantic scale [17], and primary data acquired from questionnaire results are qualitative data that must be transformed into quantitative data. This semantic scale is converted into a probability scale range from 0 to 0.9. The scale is transformed into a numerical scale using a binary logit model on Eq. (1). Table 2 shows the following changes in scale values as dependent variables.

The utility difference function equation in Eq. (2) then obtained by analyzing linear regression with SPSS v.25.0. Following that, an exponential value (e) is being acquired, which is used to calculate the probability value of the mode in Eq. (3) and Eq. (4) [19]-[20].

Table 2. Numerical Scale Transformation

Option	Response	Probability Scale (P)	Numeric Scale $\ln \frac{P_{KA}}{1-P_{KA}}$
1	Definitely choose the bus	0,1	-2,1972
2	Maybe choose the bus	0,3	-0,8473
3	Balanced options	0,5	0,0000
4	Maybe choose the bus	0,7	0,8473
5	Definitely choose the train	0,9	2,1972

Model Sensitivity Analysis

The application of model sensitivity analysis in linear equations to determine the accuracy of future changes in one of the variables [25]. A modification in one attribute value is performe with the assumption that it has no impact on the other variable [26].

3. RESULTS AND DISCUSSION

A minimum sample size of 150 respondents is required for this research. During the survey, 186 respondents were obtained, but only 172 were suitable for analysis.

3.1 Analyze Characteristics of Socio-Economic Users

Based on the results of the gender distribution of respondents of Cianjur-Padalarang bus mode users dominated by men by 61%, while 39% were women. Because male passengers feel more safe and comfortable using bus transportation. The majority of respondents are aged 21-30 years with a percentage of 37%, the society of bus users to Padalarang is dominated by productive age. The education is dominated by high school graduates/equivalent by 45%. This can be because the level of equalization of education in the Cianjur area is relatively low so that the education is generally up to high school/equivalent.

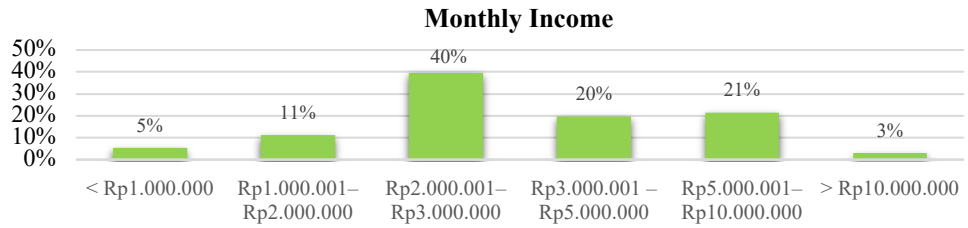


Figure 2. Respondents Income Characteristic Diagram

Figure 2 shows that respondents' monthly income of Rp2,000,001-Rp3,000,000 dominates with a percentage of 40%. This might be related to Cianjur's City Minimum Wage (UMK) of Rp2,500,000, whereas those with higher incomes include entrepreneurs and civil servants.

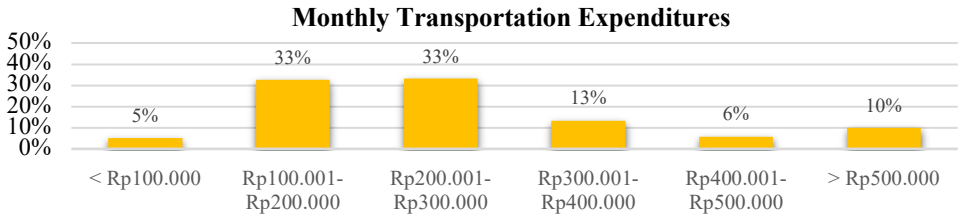


Figure 3. Respondents Montly Transportation Expenditures Diagram

Figure 3 shows that respondents transportation expenditures per month range from Rp100,001 to Rp200,000, with Rp200,001 to Rp300,000 approximately balanced at 33 percent. This is because the majority of people travel 1-2 times a week, therefore estimating bus tickets below Rp50,000 will result in expenditures closer to the nominal.

3.2 Analyze Characteristics of Trip Users

The origin of the trip is dominated by Cianjur with a proportion of 56%. This is because the distribution of questionnaires is intended for Cianjur citizens and surrounding areas who have traveled by bus to the Bandung area. The distribution of respondents with the purpose of travel to Padalarang dominant with 73%. This is because the target respondents are looking for is passengers on the Cianjur-Padalarang route. Respondents who used the bus on the grounds that there was no other mode option by 42%. Due to the fact of public transportation that goes to Padalarang is only a large and medium-sized bus. The majority of respondents aim to work (economy) at 50%. This is because many Cianjur citizens work and do business in Bandung.

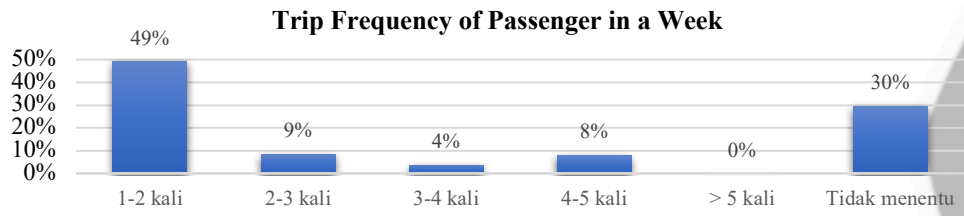


Figure 4. Respondents Trip Frequency Characteristic Diagram

As shown in Figure 4, 49% of respondents perfomed 1-2 trips per week by using the bus. This is because the majority of people who use bus mode are workers who go home and go in 1-2 times a week. The mode of transportation used to go to the station mostly uses motorcycles by 59%. This can be because the location of the bus station where passengers board the bus has easy access so that it is integrated with other public transportation.

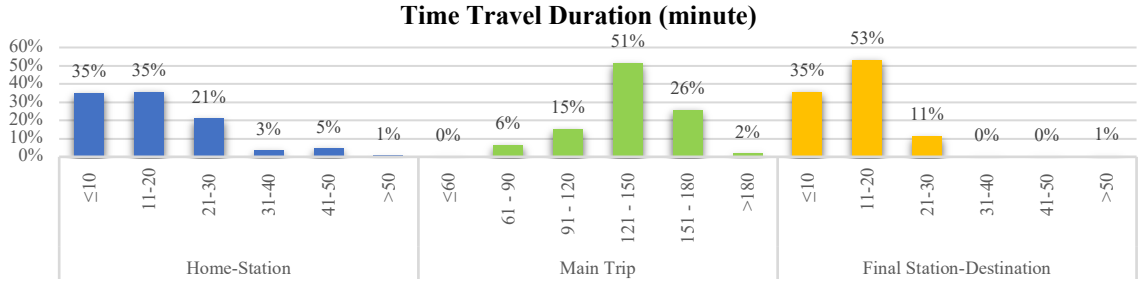


Figure 5. Respondents Time Travel Diagram

In Figure 5 the travel time from home to the bus station is about <20 minutes, which is with a percentage of ≤10 minutes respectively by 35% and 11-12 minutes by 35%. This is because the majority of passengers come from Cianjur City so it is quick to get to the bus station. According to responses, the average main travel time is 121-150 minutes, with a proportion of 51 percent. This might be because traffic conditions vary from trip to trip. The time from the bus station or bus stop to the respondents' destination was at most 11-20 minutes, with a proportion of 53 percent. This might be due to the location of the destination to a bus stop.

Figure 6. Acceptable and Maximum Train Tickets Fare Diagram

Figure 6 distribution of acceptable train tickets price according to respondents, which is Rp10.000 with a proportion of 48%. A price of Rp7.500 was chosen by 26% of respondents, while a ticket of Rp12.500 is selected by 23%. Respondents chose ticket prices less than Rp15.000, and no one chose Rp17.500 or Rp20.000. Because the majority of respondents income from Rp2.000.001-Rp3.000.000, as many as 49% respondents picked the maximum price of Rp15.000, so that respondents with a maximum price of Rp15.000 can compete with bus fares.

3.3 Alternative Equations of The Difference Function of Train and Bus Utility

Multiple linear regression analysis using independent variables travel cost difference (ΔX_1), the travel time difference (ΔX_2), and departure frequency difference (ΔX_3), and dependent variables by a choice response on a numerical scale (Y). The three independent variables above can be used to create seven different equations. Based on the results of regression calculations, alternative equation 7 was chosen as the best utility difference function with parameters including the value of the smallest constant, the biggest F value, and the highest R^2 value. The result of linear regression shown in Table 3, all the variables considered had significant effect on the mode choice and significant value under 0.05.

Table 3. Result Linear Regression Analysis between Train and Bus

Model	B	S.E.	t	Sig.
(Constant)	,713	,035	9,890	,000
Cost	-7,984E-5	,000	-12,031	,000
Time	-,0438	,001	-11,699	,000
Frequency	,155	,004	10,238	,000

The following is an equation for the utility difference function between trains and buses.

$$U_{KA} - U_{BAK} = 0{,}713 - 0{,}00007984(\Delta X_1) - 0{,}0438(\Delta X_2) + 0{,}155(\Delta X_3) \quad (6)$$

Moda Choice Model

Furthermore, Eq. (6) is substituted into the binary logit model of difference in Eq. (3) and Eq. (4), so that obtaining the mode selection model equation between the train and the bus.

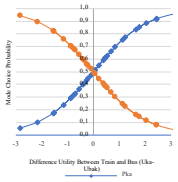
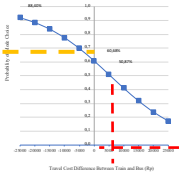


Figure 7. Graph Probability of Mode Choice between Train And Bus

From the model obtained the probability and difference in utility (benefit) between the train and bus as in the mode selection graph in Figure 7. The probability chart of the train moving in a positive direction. This indicates that if the utility or usefulness between the train and the Cianjur-Padalarang bus route increases, then the probability of the selection of the train will increase. Conversely, if the difference in utility value between the train and the Cianjur-Padalarang bus route decreases, then the probability of moving bus users to the train will reduce.

Sensitivity of Model Analysis

The sensitivity analysis of the model aims to determine the change in probability in case of a gradual change in the value of attributes between the selection of train and bus modes. Graphs of the sensitivity of this model are made based on reducing and increasing the portion of value assuming the other variables remain constant.



Condition:

Existing

Pka=Pbak=0,5

Figure 8. Sensitivity Changes in Travel Cost Difference

In Figure 8 the slope of the line on the sensitivity chart in negative direction, indicating that the higher the difference in travel costs between the train and bus routes Cianjur-Padalarang, the lower the probability of train selection. If you review the difference in costs on existing train and bus fares, then the probability of selecting train modes is at the difference in fares –Rp20.000 (train Rp5.000) is 88.4%, while the probability of buses is 11.6%. If the difference in travel costs between train and bus is equal to zero, then the probability of moving bus passengers to train is 60.68%. The probability of moving passengers to the train will be greater than the probability of choosing a bus when the difference in travel costs between the train and the Cianjur-Padalarang bus route is smaller than Rp5.000.

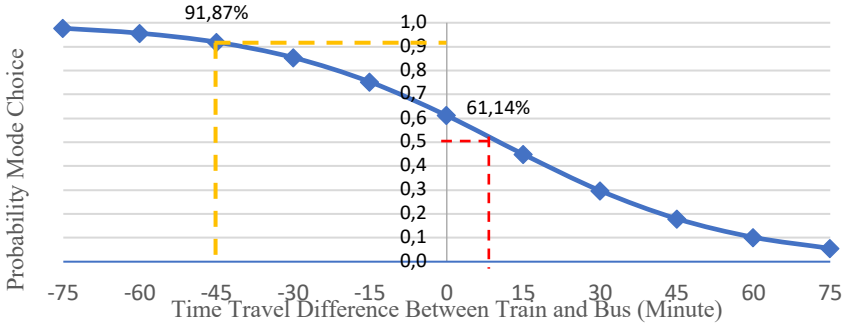


Figure 9. Sensitivity Changes in Time Travel Difference

Figure 9 shows that the slope of the sensitivity graph line is negative, indicating that the larger the value of the difference in travel time between the train and bus routes Cianjur-Padalarang, the less probable train selection. If compare the travel times of existing trains and buses, when trains 95 minutes and buses 140 minutes, the probability of choosing rail modes is 91.87% on the difference in travel time of -45 minutes, while the probability of buses is 8.13 %.

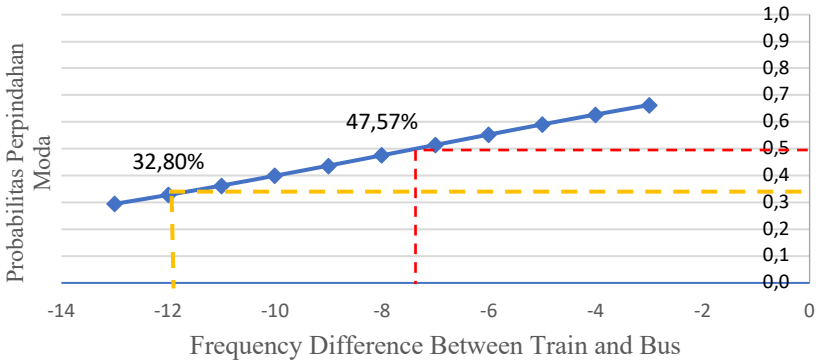


Figure 10. Sensitivity Changes in Frequency Difference

Figure 10 shows the slope of the sensitivity graph line in a positive direction, that indicate the higher the difference in frequency of travel between the train and bus routes Cianjur-Padalarang, the higher the probability of train selection. Consider the difference in frequency of existing train and bus travel, trains have 3 times and buses 15 times departure, the probability of choosing rail modes is 32.8% at a difference in departure frequency of -12 times, while the probability of buses is 67.2%. If the difference in train travel frequency is higher than -8, or as much as 7 times the trip, the probability of a train is higher than 50%.

3.3 Passenger Potential Analysis

If the train route is operational later, the estimated number of passenger movements can be calculated. This calculation used the probability value and the average daily number of passengers bus Cianjur-Padalarang route. Table 4 shows potential passenger transfer to bus.

Table 4. Projected Number of Passenger Transfers from Bus to Train

Attributes	Value	Pka	Daily Potential
Cost	Rp5.000	88,4%	212
	Rp25.000	60,68%	146
Time	150 minutes	61,14%	147
Frequency	7 trip a day	47,57%	114
Existing		92%	220

4. CONCLUSION

Based on the results of socio-economic characteristics dominated by men, aged 21-30 years, entrepreneurs, education high school graduate, monthly expenditure of transportation costs range from Rp200,000-Rp300,000, and has a monthly income at around Rp2,000,001-Rp3,000,000. The characteristics of passenger travel mostly come from Cianjur and aim to Padalarang, using a bus for easier mobility, the purpose of travel to economy with a frequency of 1-2 times per week, and mode of transportation to the station bus using a motorcycle. The trip from home to the bus station takes 11-20 minutes, the main trip takes 121-150 minutes, and from final bus station to the destination takes 11-20 minutes. Train fares start at Rp10,000 and go up to Rp15,000. The equation of utility difference function impacts 78.2%, with the difference in trip costs being the most influential attribute. The potential of rail passengers from the stated preference analysis on the model sensitivity, the probability of moving passengers to the train, will increase when the difference in cost and travel time attributes reduces and the difference in travel frequency attributes increases.

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