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ANALYSIS OF THE PROBABILITY OF CHOOSING A PUBLIC TRANSPORTATION MODE USING A BINOMIAL MODEL OF DIFFERENTIAL LOGIT

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ABSTRACT

Urbanization and increased population mobility have led to greater demand for efficient transportation systems, particularly for trips between Cirebon and Jakarta via the Cipali toll road. This study analyzes the probability of travelers choosing between buses and travel services, focusing on critical factors such as cost, travel time, and access time. The objective is to determine which mode of transportation is preferred and why. Primary data was collected through questionnaires using the stated preference method from 95 respondents, while secondary data was sourced from relevant studies. The data was analyzed using linear Regression and a binomial logit difference model. The results indicate that 99.9% of respondents prefer buses due to lower travel costs, with fare being the most significant factor in mode selection. The sensitivity analysis reveals that a Rp 25,000 reduction in shuttle fares could improve the likelihood of travelers choosing shuttles over buses. These findings suggest that transportation service providers should adjust pricing strategies to compete effectively. The implications of this study are significant for transportation policy, as they provide insights into optimizing public transportation services on intercity routes, ensuring better service offerings that align with traveler preferences.

Keywords: Public Transportation, Stated Preference, Probability, Regression Analysis, Binomial Logit Model

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INTRODUCTION

Interaction between a city and the surrounding area increases mobility in line with regional growth and movement routes. As mobility increases, transportation facilities, and infrastructure development are needed to meet this demand (Ramadhona, 2023). Public transportation plays a crucial role in meeting the community's mobility needs, and the choice of passenger transportation mode is a critical decision that can affect the efficiency and comfort of travel. The growth of urbanization and population mobility in recent years has intensified the demand for a more efficient, effective, and comfortable transportation system for its users, especially on trips to metropolitan areas such as Cirebon to Jakarta and vice versa.

Cirebon City has been designated as a metropolitan area that functions as a National Activity Center in the development of the metropolitan city area, especially in strategic areas consisting of Cirebon City, Cirebon Regency, Indramayu, Majalengka, and Kuningan. Cirebon City is the center of rapid economic growth in the Ciayumajakuning area, which triggers an increase in urbanization flows in line with social changes that deserve attention. Cirebon City plays a role as a center of economic growth. This can happen due to various urban activities such as business and trade centers, industry, culinary, tourism, services, and government. As a result, there has been an increase in the number of populations, both permanent and non-permanent residents (Novriani et al., 2023)

Urbanization has significantly transformed transportation systems, particularly in rapidly growing metropolitan areas like Cirebon and Jakarta. The Cipali toll road connects these cities, a crucial corridor facilitating a high volume of passenger and goods transportation. With the increased mobility between these two cities, the demand for efficient public transportation has intensified. As a result, the transportation infrastructure must address traffic congestion and pedestrian safety, especially in areas around significant hubs and intersections along the Cipali route.

Traffic congestion along the Cipali toll road has become a persistent issue, particularly during peak travel times. This congestion often leads to traffic conflicts at critical points, such as intersections and toll gates, exacerbating delays for public transportation users. Pedestrian safety is also a concern, especially in areas with inadequate or poorly maintained pedestrian infrastructure. Studies show that the lack of safe pedestrian crossings near transportation hubs contributes to accidents and conflicts between vehicles and pedestrians, making public transportation less attractive to potential users (Ramadhona, 2023); (Wahab & Andika, 2019).

Given the current transportation challenges, there is a need to understand better the factors influencing travelers' decisions when choosing between public transportation modes. Cost, travel time, and access time are critical factors that affect the probability of choosing a particular mode. This study employs a binomial logit difference model to analyze the probability of selecting a transportation mode, focusing on buses and travel services on the Cirebon-Jakarta route. By addressing traffic conflicts and pedestrian safety issues, this research aims to contribute to developing more efficient and safer transportation policies, ultimately improving the quality of public transportation services in the region (Firdausi & Putra, 2022); (Supit et al., 2018).

METHOD

This study employs a quantitative descriptive research design to determine which factors affect the selection of transportation modes, focusing on independent variables such as travel costs, travel time, and access time, as well as dependent variables related to user considerations. Data were collected through a survey of 95 respondents using Primajasa bus and Bhineka Shuttle travel services. Primary data were gathered via questionnaires, while secondary data included information on passenger numbers, travel fares, and area coverage.

The study utilized the stated preference method for data collection, the Slovin formula for sample size determination, and validity and reliability testing. Data were analyzed using regression analysis and the binomial logit difference method to assess the probability of choosing between the two transportation modes. Sensitivity tests were also conducted to evaluate how changes in transportation policies, such as cost adjustments, would affect mode selection.

The findings offer practical insights for transportation service providers, highlighting key factors influencing public transportation choices. This research provides valuable input for optimizing pricing strategies and improving service efficiency. Policymakers can leverage these findings to design more effective transportation policies, enhance travel experience, and address traffic congestion and pedestrian safety issues. Furthermore, the results have implications for promoting sustainability in transportation systems by encouraging more efficient mode choices.

In this research study, the sample determination was determined using a sampling method that was developed with a significant 90% with an error rate (e) of 10% or 0.1

$$n = \frac{N}{1+N\,(e)^2}$$

Information:
n = Sample Size
N = Population Size
e = Percentage of Tolerance Limit (0.1)

This test determines the validity of the questions presented in this research study questionnaire. Some of the questions in the questionnaire presented can be said to be valid if the value (r) of the table < (r) is calculated or vice versa by the data interpretation method using the Product Moment Correlation Test using a significance level of 5% or 0.05.

This reliability test is used to determine whether or not the questions presented in the research study questionnaire are reliable. The method used in this research study uses the Cronbach Alpha technique so that the questions in the questionnaire presented can be declared reliable if the reliability coefficient (r) > 0.60.

This research study uses SPSS and Microsoft Excel programs to analyze regression testing. This regression test was carried out to obtain data in the form of whether or not some factors or attributes affect the decision of mode users in choosing transportation for the Cirebon to Jakarta travel route. The results are in equations with the number of regression coefficients to be obtained and analyzed.

$$\mathbf{Y = a + bx}$$

Information:
Y = Bound Variable
X = Independent Variable
a = Constanta
b = Regression Coefficient

The difference logit binomial model is a mode selection model that considers the difference in utility between two juxtaposed modes of transportation to determine the probability of selecting the available modes (Ramadhona Ayu, 2023).

$$\mathbf{UBus - U_{Travel} = \beta 0 + \beta 1\,(X1Bus - X1Travel) + \beta 2\,(X2Bus - X2Travel) + \beta 3\,(X3Bus - X3Travel)}$$

Information:

UBus – U_{Travel}	= Individual Response to Choice Statement
b0	= Constants β1, β2, β3 are the coefficients of each attribute determined through regression analysis
X1Bus – X1Travel	= Difference in bus and travel costs
X2Bus – X2Travel	= Difference in travel time between bus and travel
X3Bus – X3Travel	= Difference in bus and travel access time

Then, the value of chance or probability in the bus mode can be seen in the form of the following equation:

$$PBus = \frac{1}{1 + e^{(UBus - UTravel)}}$$

Meanwhile, the value of opportunity or probability in travel is seen in the form of the following equation:

$$PTravel = 1 - Pbus$$

The sensitivity test is used to find out if there is a change in the probability value by making changes to transportation management using a binomial logit difference model where attributes such as changes in costs are reduced or increased, travel time is slowed down or accelerated, the scope of regional access is expanded or reduced, and many other things can be changed. In this research study, the sensitivity test was carried out only on travel costs/fares changes.

RESULTS AND DISCUSSION

Population and sample determination

The population in this research study was taken from the large average number of passengers on Primajasa buses and Bhineka Shuttle travel. The sample of filling out the questionnaire was dominated by students and employees on the Cirebon to Jakarta travel route, which was taken from the average number of passengers in one month in 2024 with an average number of passengers of 1,590 passengers/month.

$$n = \frac{N}{1 + N\,(e)^2} = \frac{1.590}{1 + 1.590\,(0{,}1)^2} = 94{,}08 \approx 95 \text{ Sample}$$

So, the number of samples needed in this research study is 95 samples.

Characteristics of Moda Users

Passenger characteristics were taken from questionnaire data distributed to 95 respondents who had been determined. Passenger characteristics are divided into 2 (two), namely social and economic characteristics data and travel characteristics data of mode users.

Table 1. Results of Percentage of Characteristic Survey Data Processing Social and Economic Respondents'

Characteristic	Percentage Results	Information
Gender	57,9%	Male
Age	72,6%	20 – 30 Years
Work	44,2%	Students/Students
	35,8%	A .....
Average Monthly Income	58,9%	< IDR 2,500,000
	13,7%	IDR 4,500,000 – IDR 5,500,000

Source: Researcher analysis data, 2024

Table 2. Results of Percentage of Characteristic Survey Data Processing Respondent's Journey

Characteristic	Percentage Results	Information
Experience using bus and travel modes	72,6%	Ever Both
Frequently Used Mode Between Bus and Travel	64,2%	Bus Mode

Bus Usage Frequency	41,1%	Rarely Use Bus Mode
Travel Usage Frequency	46,3%	Rarely Use Travel Mode
Background of the trip	36,8%	Jobs/Business
	28,4%	Family Affairs

Source: Researcher analysis data, 2024

Table 3. Results of the Percentage of Respondents' Travel Characteristics Survey Data Processing on the Difference in Travel Costs

Cost Difference	Percentage Results				
	Choose a Bus	Maybe Choose Bus	Balanced Choice	Choose Travel	Maybe Choose Travel
-IDR 100,000	32,6%	29,5%	11,6%	7,4%	18,9%
-IDR 50,000	45,3%	13,7%	6,3%	26,3%	8,4%
IDR 0	41,1%	7,4%	11,6%	30,5%	9,5%
IDR 50,000	37,9%	24,2%	6,3%	21,1%	10,5%
IDR 100,000	31,6%	29,5%	11,6%	16,8%	10,5%

Source: Researcher analysis data, 2024

Table 4. Results of the Percentage of Respondents' Travel Characteristics Survey Data Processing on the Difference in Travel Time

Travel Time Difference	Percentage Results				
	Choose a Bus	Maybe Choose Bus	Balanced Choice	Choose Travel	Maybe Choose Travel
-20 Minutes	32,6%	22,1%	12,6%	16,8%	15,8%
-10 Minutes	43,2%	11,6%	8,4%	29,5%	7,4%
0 Minutes	37,9%	12,6%	14,7%	28,4%	6,3%
20 Minutes	24,2%	30,5%	11,6%	16,8%	16,8%
10 Minutes	36,8%	21,1%	4,2%	25,3%	12,6%

Source: Researcher analysis data, 2024

Table 5. Results of the Percentage of Respondents' Trip Characteristics Survey Data Processing on the Difference in Travel Access Time

Travel Access Time Difference	Percentage Results				
	Choose a Bus	Maybe Choose Bus	Balanced Choice	Choose Travel	Maybe Choose Travel
-20 Minutes	28,4%	25,3%	12,6%	20%	13,7%
-10 Minutes	42,1%	15,8%	8,4%	26,3%	7,4%
0 Minutes	37,9%	9,5%	20%	26,3%	6,3%
20 Minutes	25,3%	28,4%	12,6%	17,9%	15,8%
10 Minutes	36,8%	18,9%	10,5%	20%	13,7%

Source: Researcher analysis data, 2024

Table 6. Question Point Rating Scale

	Skala Point Rating
1	Cheaper Cost Considerations
2	Safety and Comfort Considerations

3	Faster Time Considerations
4	Consideration of Convenience and Access to/from
5	Considerations of Services Provided

Source: Data used by researchers, 2024

Table 6 shows the point rating scale used as a reference for the percentages in Figure 1.

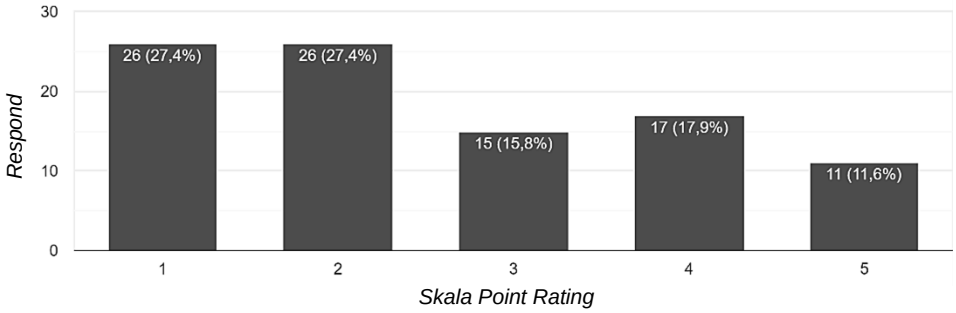

Figure 1. Percentage of respondents to reason chart

Selection of frequently used modes

Figure 1 shows that the percentage of survey results regarding how much the reason for considering the choice of mode that will be used later and obtained the dominant percentage results are more likely to be considered for cheaper costs and safety and comfort considerations with a percentage of 27.4% balanced, this can happen because employees and students dominate most respondents.

Validity Test

The validity test of the data used *the Pearson Product Moment correlation test* by obtaining a table value (r) for 95 respondents (N) with a significance level of 0.05 (5%) of 0.202. The attributes tested in the validity test are the difference in travel cost (X1), the difference in travel time (X2), and the difference in travel access time (X3).

Table 7. Validity Test Results

Variable	Correlation Coefficient (r) Calculate	Big Value. (2-tailed)	Value (r) Table	Result
X1.1	0,865	0,000	0,202	*Valid Question Items*
X1.2	0,896	0,000	0,202	*Valid Question Items*
X1.3	0,824	0,000	0,202	*Valid Question Items*
X1.4	0,894	0,000	0,202	*Valid Question Items*
X1.5	0,823	0,000	0,202	*Valid Question Items*
X2.1	0,918	0,000	0,202	*Valid Question Items*
X2.2	0,912	0,000	0,202	*Valid Question Items*
X2.3	0,875	0,000	0,202	*Valid Question Items*
X2.4	0,908	0,000	0,202	*Valid Question Items*
X2.5	0,928	0,000	0,202	*Valid Question Items*
X3.1	0,894	0,000	0,202	*Valid Question Items*
X3.2	0,897	0,000	0,202	*Valid Question Items*
X3.3	0,894	0,000	0,202	*Valid Question Items*
X3.4	0,904	0,000	0,202	*Valid Question Items*
X3.5	0,909	0,000	0,202	*Valid Question Items*

Source: SPSS Output, 2024

Table 7 shows that all question items in the three attributes tested are declared valid because the value (r) calculates > (r) of the table, and by the basis of the *Pearson Product Moment correlation test, the* question item can be said to be valid if the value is sig. (2-tailed) < a significance value (0.05).

Reliability Test

Table 8. Total Reliability Test Results

Reliability Statistic		
Cronbach's Alpha	**Cronbach's Alpha Based on Standardized Items**	**N of Item**
.975	.975	15

Source: SPSS Output, 2024

Table 8 shows that *Cronbach's Alpha* value is> 0.60, so it can be concluded that the reliability value is accepted or can be said to be reliable with a value of 0.975 > 0.60.

Coefficient of Determination

Table 9. R Square

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.337a	.114	-.055	1.401

Source: SPSS Output, 2024

Table 9 shows that the value of the determination coefficient between variables simultaneously is 0.114. Judging from the *R Square* table above, with an N value of 95 and an error rate of 5% or 0.05, a value of 0.202 < 1.401 (the standard SPSS error) is obtained, so the magnitude of the determination coefficient value can be declared significant.

Linear Regression Analysis

Table 10. Coefficients Regression Analysis Value

Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Mr.**
		B	**Std. Error**	**Beta**		
1	Constant	2.386	.347		6.870	.000
	X1.1	.071	.184	.077	.384	.702
	X1.2	1.385	.212	-.418	-1.814	.074
	X1.3	.251	.186	.277	1.351	.180
	X1.4	.301	.235	.318	1.278	.205
	X1.5	.009	.210	.009	.045	.964
	X2.1	-.268	.282	-.291	-.950	.345
	X2.2	.061	.247	.065	.221	.826
	X2.3	.013	.270	.013	.047	.963
	X2.4	.052	.345	.054	.150	.881
	X2.5	-.204	.310	-.225	-.658	.513
	X3.1	.497	.302	.520	1.648	.103

X3.2	-.323	.310	-.341	-1.041	.301
X3.3	-.041	.288	-.042	-.142	.887
X3.4	-.045	.300	-.047	-.149	.882
X3.5	.049	.277	.054	.179	.859

Source: SPSS Output, 2024

Based on Table 10, a selection of values (t) is carried out to determine suitable variables so that further testing can be carried out; if the value (t) is > 1, then the variable is considered suitable. From the results of the analysis that has been carried out, the regression model obtained is as follows:

Y = 2,386 + (0,251 X1.3) + (0,301 X1.4) + (X2) + (0,497 X3.1)

Binomial Model of Difference Logic

$$\textbf{PBus=}\ \frac{1}{1+e^{(\text{UBus - UTravel})}} = \frac{1}{1+e^{(2{,}386+(0{,}251\,X1.3)+(0{,}301\,X1.4)+(X2)+(0.497\,X3.1)}} = \frac{1}{1+2{,}72^{-18{,}8561}} = \mathbf{0,999}$$

PTravel = 1 – 0,999 = 0,001

The probability of choosing a bus transportation mode at a fare difference/cost of Rp. 75,000, and a difference in travel time of 30 minutes with a travel access time of 7 minutes was obtained as a percentage of 99.9%, while the probability of choosing a travel mode was only 0.1%.

Sensitivity Test

Table 11. Utility value change data and probability based on Data on Changes in Travel Costs

Cost Difference	UBus - UTravel	PBus	PTravel
-100000	-18.8561	0.9999	0.000
-90000	-17.6011	0.9999	0.000
-80000	-16.3461	0.9999	0.000
-70000	-15.0911	0.9998	0.000
-60000	-13.8361	0.9999	0.000
-50000	-12.5811	0.9997	0.000
-40000	-11.3261	0.9999	0.000
-30000	-10.0711	0.9996	0.000
-20000	-8.8161	0.9998	0.000
-10000	-7.5611	0.9981	0.002
0	-6.3061	0.9981	0.002
10000	-5.0511	0.9936	0.006
20000	-3.7961	0.9780	0.022
30000	-2.5411	0.9270	0.073
40000	-1.2861	0.7836	0.216
50000	-0.0311	0.5077	0.492
60000	1.2239	0.2271	0.773

70000	2.4789	0.0772	0.923
80000	3.7339	0.0232	0.977
90000	4.9889	0.0067	0.993
100000	6.2439	0.0019	0.998

Source: Researcher-processed data, 2024

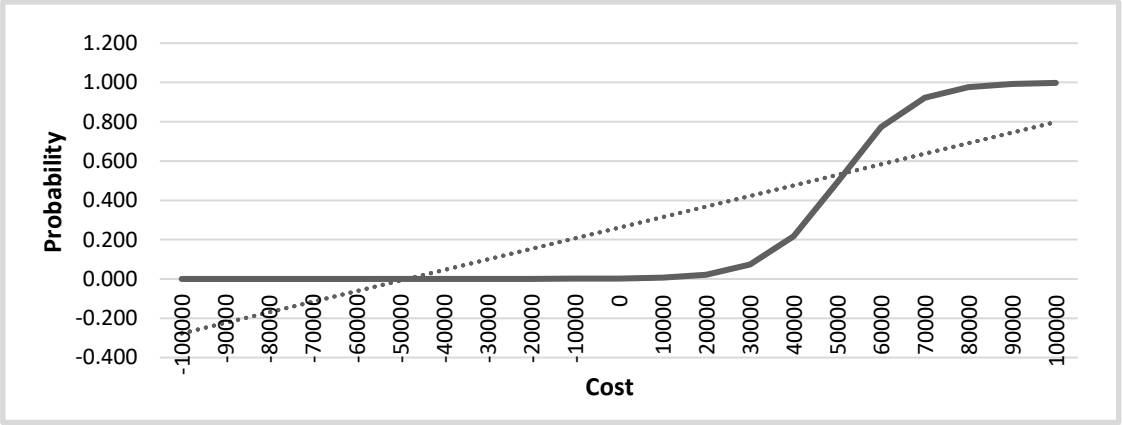

Figure 2. Graph of Sensitivity Test to Changes in Travel Costs

Figure 2 shows that when there is a change in the travel attributes, namely in the fare/cost of the trip, there is a significant percentage, at the fare difference of 0 (zero), the probability of choosing the bus mode is only 0.2%, but in the travel mode, it becomes 99.8% with a difference in travel time of 30 minutes and a difference in access time of 7 minutes. To intensify the chances of being selected for the travel mode to 50% and above, the travel mode must reduce the minimum fare of Rp—25,000 from the bus fare price.

The results of this study show that cost is the most significant factor influencing the selection of public transportation modes on the Cirebon-Jakarta route. With 99.9% of respondents opting for buses over travel services, price sensitivity dominates mode choice. This finding is consistent with previous research (Firdausi & Putra, 2022). who also found that lower fares significantly influence passengers to choose buses over trains on the Surabaya-Yogyakarta route. The results further support the utility theory, which posits that individuals make decisions based on maximizing their utility, in this case, minimizing travel costs (Rosyida Ekayati E et al., n.d.)

Additionally, travel and access time were found to have a secondary impact on transportation mode choice. Although not as critical as cost, shorter travel times and better accessibility still encourage travelers to choose buses, as evidenced by the 64.2% preference for buses. Similar conclusions were drawn in a study by (Supit et al., 2018) on transportation mode selection in Manado, where accessibility and travel time were essential determinants, but price remained the top priority.

The binomial logit model used in this study effectively captures the probability of transportation mode selection by juxtaposing the different utilities associated with buses and travel services. This method has been widely utilized in transportation studies to predict user behavior and mode selection. For instance, (Ramadhona, 2023) applied the same model to evaluate public

transportation choices in Jakarta and found that cost and travel time differences significantly affect mode selection, aligning with the findings of this research.

The sensitivity analysis conducted in this study provides practical insights for transportation service providers. By lowering travel fares by Rp 25,000, travel services could increase their probability of being chosen by over 50%. This finding resonates with the study conducted by (Wahab Andika, 2019), which revealed that price adjustments in public transportation modes in Padang led to significant shifts in user preferences. This highlights the importance of fare adjustments in improving the competitive position of travel services on the Cirebon-Jakarta route.

In line with transportation planning theory, which emphasizes the role of user preferences in transportation mode selection, this study contributes to a deeper understanding of how travelers prioritize cost, time, and access. The findings also have implications for transportation policy, suggesting that by optimizing pricing strategies and improving access times, transportation providers can better meet the needs of their users and encourage more sustainable transportation choices.

Future studies could explore additional factors, such as service quality and safety, which should have been more research that did not cover extensively but could further explain transportation mode choices. Moreover, longitudinal studies could investigate how changes in economic conditions, such as fuel price increases, might alter public transportation preferences over time.

CONCLUSION

Based on the research study's results, it can be concluded that (1) mode users' social and economic characteristics and travel characteristics have significant implications for the selection of transportation modes that travelers will use later. (2) Of the three attributes presented in this research study, the factor or attribute that has the most implications for the selection of transportation modes is the attribute of considering relatively cheap costs when juxtaposed with travel, with a percentage obtained of 27.4% and with a bus ticket price of Rp. 110,000/seat. (3) The probability of transportation modes using binomial logit difference was obtained by 99.9% choosing buses and 0.1% choosing travel with the difference in cost between buses and travel of Rp—75,000 with a difference in travel time of 30 minutes. (4) Testing the sensitivity to travel costs can help transportation modes seize opportunities so that they are in great demand and used by travelers, based on the sensitivity test to changes in travel fares/costs, which can be seen in Figure 2, if at the fare difference (0) zero the probability of choosing a bus mode is 0.2% and travel is 99.8%. It can be concluded that there is a change in management factors that implies the opportunity can be intensified. The selection of a mode that is tested until it can reach 50% and above.

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