Analysis of Route Choice Between Toll Road and National Highway in Palembang - Prabumulih, South Sumatera

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Abstract: The Palembang–Prabumulih Toll Road, as part of the Trans-Sumatra Toll Road network, was developed to enhance travel efficiency and alleviate congestion on the national highway. However, its traffic volume remains below expectations, with 9,914 vehicles/day recorded on the Palembang–Indralaya section and 5,600 vehicles/day on the Indralaya–Prabumulih section, compared to 15,456 vehicles/day on the national route. This study analyzes the factors influencing travelers' route choices between the toll road and the national highway and proposes strategies to improve toll road utilization. The research employed the Stated Preference (SP) method and the Binomial Logit Model based on responses from private vehicle users. Results show that most respondents were male (78.5%), aged 31–40 years (37%), self-employed (40.5%), and earned IDR 3–4 million per month. From five travel cost–time saving scenarios, 62–81% of respondents preferred the toll road at lower costs, but preference declined as costs increased. The estimated Value of Time (VoT) was IDR 365 per minute. The model produced a chi-square value (χ^2_a = 8.373) lower than the critical value (χ^2_t = 14.067), indicating a good model fit. The findings confirm that travel cost is the dominant factor affecting route choice, while time efficiency acts as a compensatory factor to encourage toll road usage along the Palembang–Prabumulih corridor.

Keywords: Binomial Logit, Stated Preference, Toll Road, National Highway.

1. INTRODUCTION

Transportation problems in Indonesia are still dominated by traffic jams, road damage due to traffic density (Edi Kadarsa et al., 2017) (Bęczkowska, 2019) In various regional areas, this problem is becoming increasingly complex with increasing population growth and increasing mobility needs. South Sumatra Province, which consists of 13 regencies and 4 cities, with Palembang as its capital, is one of the regions with rapid infrastructure growth in the past five years (Agustien & Yulinar, 2022). Road network development is being undertaken to accommodate high traffic volumes, but the increasing number of vehicles is actually putting pressure on road capacity. Data from the South Sumatra National Road and Transportation Agency (BBPJN 2024) shows that the traffic volume on the Palembang-Prabumulih eastern cross-country road has reached 15,456 vehicles/day. This high traffic volume makes road access increasingly difficult (Al Qubro et al., 2022). In an effort to reduce the burden on national roads, the government is building the Trans Sumatra Toll Road (JTTS), including the 22 km Palembang–Indralaya (Palindra) Toll Road and the 64.5 km Indralaya–Prabumulih Toll Road. However, the actual toll traffic volume in 2024 has not yet reached the set target. For example, the Palindra toll road only recorded 9,914 vehicles/day out of a target of 31,600 vehicles/day, while the Indralaya–Prabumulih toll road only recorded 5,600 vehicles/day out of a target of 13,344 vehicles/day (PT Hutama Karya, 2024).

Several previous studies have examined route choice behavior Halen et al. (2020) analyzed the preferences of private vehicle users in choosing between toll roads and arterial roads using the *Stated Preference* method. The results showed that cost and travel time variables are strongly correlated and have a significant influence on toll road route choice Adi et al. (2020) conducted an analysis of route choice between the Terbangi Besar–Pematang Panggang Toll Road and the National Road using a *Binomial Logit Model*. The study revealed that an increase in toll rates reduces the likelihood of users choosing the toll road, whereas greater travel

time savings increase the probability of choosing it. Furthermore, Budiman et al (2021) examined the factors influencing route choice between the Rangkasbitung–Serang arterial road and the Serang–Panimbang toll road using the *Stated Preference* method. Based on travel time attributes, the toll road route was found to be 76.7% faster compared to the regular road.

This phenomenon indicates that the presence of toll roads has not yet fully attracted public interest as an alternative travel route. With the availability of two route options, road users face a decision on which route to take for their journey (Suganda et al., 2023). Therefore, it is important to identify the factors that influence road users' preferences in choosing between toll roads and national roads. Several key variables that may affect this decision include travel distance, travel time, and travel cost. The *Stated Preference (SP)* method has been widely used in transportation studies to understand individuals' preferences toward specific travel scenarios (Fisaini et al., 2024) (Roza et al., 2017). By applying the SP method, user behavior in decision-making within a road network context can be represented, and user perceptions can be directly measured based on travel attributes (Dovyanto & Widyastuti, 2024). Furthermore, analysis can be conducted using the *Binomial Logit Model* to determine the probability of individuals choosing between toll roads and national highway (Tong et al., 2025).

The purpose of this study is to analyze the socio-economic characteristics and travel characteristics of users of the Palembang – Prabumulih toll road and national highway routes. Analyze the results of the stated preference survey and the binomial logit model in choosing the Palembang – Prabumulih toll road and national highway routes.

2. MATERIALS AND METHOD

This study uses a quantitative approach with the Stated Preference (SP) method and the Binomial Logit Model to analyze route choice in the Palembang–Prabumulih toll road and national highway (Padri et al., 2022). The research location is on the Palembang–Prabumulih toll road and the national highway Palembang–Prabumulih. The research objects are private vehicle users traveling on both route.

Figure 1: Map of the Location of the Palembang - Prabumulih Road Route
(Source: PT. Hutama Karya)

──────── : The blue line indicates the toll road route

──────── : The yellow line indicates the national highway route

2.1 Penentuan Skenario Stated Preference

This study employs five choice scenarios, which were designed in the form of a questionnaire for the stated preference survey. The choice scenarios used in this study are as follows:

Scenario 1: Travel cost difference of IDR 67,500, 15 minutes faster than the toll road.
Scenario 2: Travel cost difference of IDR 78,500, 30 minutes faster than the toll road.
Scenario 3: Travel cost difference of IDR 85,000, 45 minutes faster than the toll road.

Scenario 4: Travel cost difference of IDR 102,000, 60 minutes faster than the toll road.
Scenario 5: Travel cost difference of IDR 126,000, 75 minutes faster than the toll road.

The calculation of the proportion of route choices was carried out to determine the comparison between the number of respondents who chose the toll road and those who chose the national highway in the Palembang–Prabumulih choice. This proportion is expressed as a ratio $(1-P)/P$, where P is the probability of respondents choosing the toll road, while $1-P$ is the probability of respondents choosing the national highway.

Next, the values of the dependent and independent variables are determined in order to derive the linear regression equation. The dependent variable (Y_i) can be expressed by the following equation:

$$Y_i = log\left[\frac{1-P^I_1}{P^I_1}\right] \dots\dots\dots (1)$$

Where Y represents the road users and P denotes the proportion of route choice. The independent variable (X_i) in this equation is the logarithm of the ratio of the total combined cost of the toll road and the national highway for each route choice combination. The determination of the independent variable (X_i) is expressed by the following equation:

$$X_i = log\left[\frac{C^I_1}{C^I_2}\right] \dots\dots\dots (2)$$

Where X is the logarithm of the ratio of travel time and travel cost between the toll road and the national highway, and C represents the travel time and travel cost for the chosen route.

The nonlinear equation can be reformulated into a linear form as $Y_i = A + B X_i$, where Y_i represents the proportion of route choice and X_i is the logarithm of the ratio of the total combined cost of the toll and national highway. Therefore, by applying the linear regression analysis in SPSS 22.0 for Windows, the values of $\alpha = 10^A$ and $\beta = B$ are obtained, along with the coefficient of determination (R^2) for the regression equation."

Route choice uses a binomial logit model. The known α and β values obtained from the regression equation are then entered into the equation as the final model for mode choice for each combination, namely the binomial logit model (Tamin, 2008):

$$P_I = \frac{1}{1 + \alpha \left(\frac{C_1}{C_2}\right)\beta} \dots\dots\dots (3)$$

Where P_1 represents the proportion of route choice for the toll road, C_1 is the total combined cost for the toll road route, and C_2 is the total combined cost for the national highway route. α is the antilogarithm of the intercept (A) in the equation $Y_1 = A + B X_1$, and β is the coefficient of the independent variable, which is equal to B.

3 RESULTS AND DISCUSSION

3.1 Respondents' Socio-Economic and Travel Characteristics

Respondents' socio-economic characteristics include age, gender, occupation, highest level of education, income/month, trip purpose, trip frequency. These data are used to analyze socio-economic characteristics respondents in choosing the Prabumulih – Palembang toll road and national highway.

3.1.1 Respondent characteristics based on age

According to the Decree of the Ministry of Health of the Republic of Indonesia (2009), age categories are classified into several stages: early childhood, childhood, adolescence, adulthood, elderly, and advanced elderly. The characteristics based on

respondents' age in choosing between the Toll Road and the National Highway Road on the Palembang–Prabumulih route can be illustrated in the following figure.
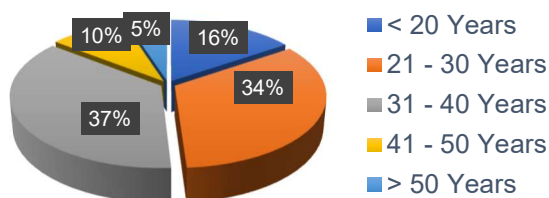

Figure 2: Characteristics Based on Age

Based on Figure 2, respondents aged 31–40 years are the most dominant group in choosing the Palembang–Prabumulih route, with a percentage of 37%.

3.1.2   Respondent characteristics based on gender

Gender-based characteristics can illustrate the dominant gender of respondents on the Palembang-Prabumulih toll road and national highway. The survey results show the gender-based characteristics of respondents in the following figure.
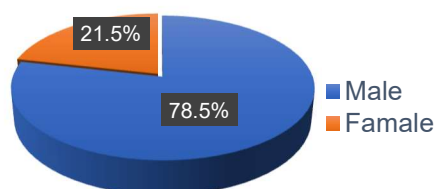

Figure 3: Characteristics Based on Gender

According to Figure 3, the male resspondents represent the highest percentage among all participants, accounting for 78.5%.

3.1.3   Respondent characteristics based on type of Occupation

Job type characteristics can describe the number of job professions among respondents. Based on the questionnaire results, the types of jobs among respondents can be seen in the figure below.
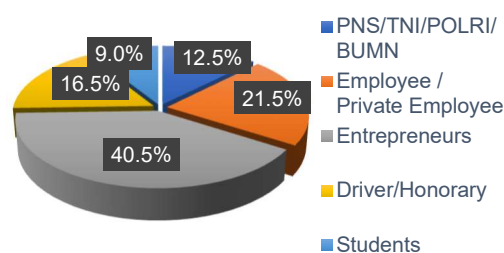

Figure 4: Characteristics Based on Occupation

Figure 4 shows that the highest percentage of respondents by occupation are entrepreneurs or self-employed, accounting for 40.5%. The second-highest percentage is private employees, representing 21.5%.

3.1.4 Respondent characteristics based on the highest level of education

The educational characteristics of the respondents reflect the intellectual level of road users, both on toll roads and national highway. The results of the questionnaire survey regarding respondents' educational backgrounds are presented in the figure below.
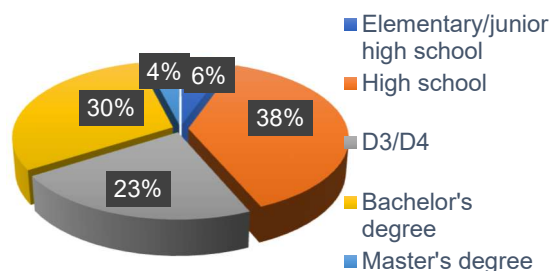

Figure 5: Characteristics Based on the Highest Level of Education

Figure 5 shows that the highest percentage of respondents by educational background is senior high school graduates, accounting for 38%. The second-highest percentage is bachelor's degree holders, representing 30%.

3.1.5 Respondent characteristics based on income/month

The characteristics based on the respondents' income/month can be seen in the figure below.
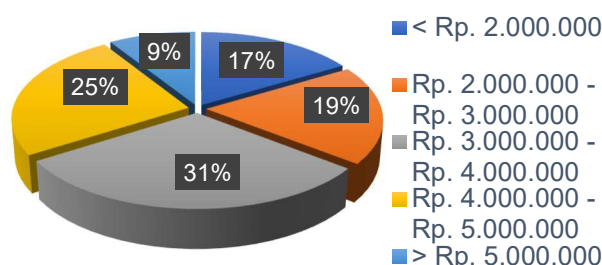

Figure 6: Characteristics Based on Income/Month

Figure 6 shows that the highest percentage of respondents based on monthly income falls within the range of Rp. 3,000,000 – Rp. 4,000,000, which is the most dominant group with a percentage of 31%.

3.1.6 Respondents' characteristics based on trip purpose

The travel purpose characteristics of the respondents provide useful information for identifying the types of activities carried out by the respondents. The travel purposes of respondents on the Palembang–Prabumulih route are presented in the figure below.
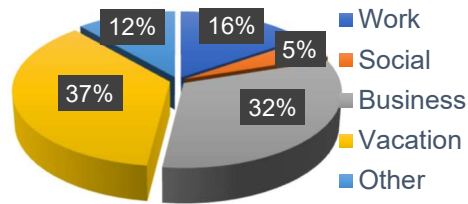
Figure 7: Respondents' Characteristics by Trip Purpose

Based on Figure 7, it is known that the highest percentage of respondents' travel purposes is for leisure, accounting for 37%.

3.1.7 Respondents' characteristics based on trip frequency

The results of the questionnaire survey regarding the respondents' travel frequency are presented in the following figure.
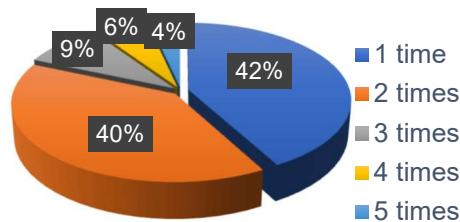
Figure 8: Respondents' Characteristics by Trip Frequency

Figure 8 shows that the highest percentage of respondents make one trip per month, accounting for 40%.

3.2 Route Choice Probability

The aggregated responses from the stated preference survey were utilized to determine the value of variable Y in this study. This variable was then incorporated into the calculations for the Binomial Logit model. The resulting route choice probabilities are shown in Table 1.

Table 1: Route Choice Probability

No	Cost Difference (Rp)	Travel Time	Choosing a Toll Road	Not Choosing the Toll Road	(1-P)/P	Log(1-P/P) <Y>
1	67.500	15 minutes faster than the toll road	19%	81%	4,405405	0,643986
2	78.500	30 minutes faster than the toll road	25%	75%	3,000000	0,477121
3	85.000	45 minutes faster than the toll road	38%	62%	1,631579	0,212608
4	102.000	60 minutes faster than the toll road	27%	73%	2,703704	0,431959
5	126.000	75 minutes faster than the toll road	21%	79%	3,651163	0,562431

Based on the table above, the results of the stated preference survey show the proportion of route choices made by road users at different travel cost differences. At a travel cost difference of Rp67,500, 81% of respondents chose to use the toll road, while 19% chose the national road. When the cost difference increased to Rp78,500, the proportion of toll road users decreased to 75%, while national road users increased to 25%. At a cost difference of Rp85,000, 62% of respondents chose the toll road and 38% chose the national road. Furthermore, at a cost difference of Rp102,000, 73% of respondents preferred the toll road, while 27% chose the national road. Finally, at a cost difference of Rp126,000, 79% of respondents continued to choose the toll road, while only 21% opted for the national road.

3.3 Conversion of the value of time

In this study, the value of time was derived from the average income of respondents on the Palembang–Prabumulih route, calculated as follows:

Table 2: Value of Time

No	Income/Month	Respondents	Median Value (Rp)	Total Income (Rp)
1	< Rp. 2.000.000	33	1.000.000	33.000.000
2	2.000.000 - 3.000.000	38	2.500.000	95.000.000
3	3.000.000 - 4.000.000	61	3.500.000	213.500.000
4	4.000.000 - 5.000.000	50	4.500.000	225.000.000
5	> Rp. 5.000.000	18	7.500.000	135.000.000
	Total	200		701.500.000
	Average Mothly Income			3.507.500
	Value of Time/(minutes)			365

Table 3 shows the results of the value of time calculation, which was derived from the average income of road users and divided by the standard working hours. The standard working time applied in this calculation is 8 hours per day and 5 days per week, equivalent to 160 hours per month. Based on this calculation, the value of time obtained in this study is Rp365 per minute.

3.4 Calculation of combined costs

This model bases its calculations on the concept of combined utility, namely a combination of direct costs (toll rates) and indirect costs converted from travel time using the parameter (Value of Time, VoT).

Table 3: (Generalized Cost) on the Palembang – Prabumulih Toll Road and National Highways Choice Route

No	Cost Difference (Rp)	Travel Time (minutes)	Value of Time/(minutes)	Combined Fees		Ratio
				Toll road	National Road	
1	67,500	15	365	177,941	83,941	0,47174
2	78,500	30	365	205,383	111,383	0,54232
3	85,000	45	365	228,324	134,324	0,58830
4	102,000	60	365	261,766	167,766	0,64090
5	126,000	75	365	302,207	208,207	0,68895

The table above presents the calculation of the combined costs for both the toll road and the national road, from which the cost ratio was derived. The results indicate that, across all five scenarios, the toll road consistently incurs higher costs compared to the national road, rendering it relatively less attractive to users. This further emphasizes that cost remains the dominant factor influencing route choice, whereas travel time acts merely as a compensatory factor that is not sufficiently strong to make the toll road more economically favorable than the national road.

3.4 The Utility Equation

In this analysis, the variable Y denotes the logarithm of the ratio of respondents' preferences between the toll road and the national highway (log Y), whereas the variable X denotes the logarithm of the combined travel cost (log W). The variable Y is estimated using X through a linear regression model approach. The results of the calculations using Equations (1) and (2) for all input data are presented in the table below.

Table 4: Logarithmic Input Data for the Palembang – Prabumulih Toll Road

No	C(Toll)/C(National) $\langle W_1 \rangle$	Log(W) $\langle X_1 \rangle$	C(National)/C(Toll) $\langle W_2 \rangle$	Log(W) $\langle X_2 \rangle$	(1-P)/P	Log (1-P/P) $\langle Y \rangle$
1	2,119829	0,326301	0,471736	-0,326301	4,405405	0,643986
2	1,843936	0,265746	0,542318	-0,265746	3,000000	0,477121
3	1,699799	0,230398	0,588305	-0,230398	1,631579	0,212608
4	1,560305	0,193210	0,640900	-0,193210	2,703704	0,431959
5	1,451474	0,161809	0,688955	-0,161809	3,651163	0,562431

The dependent variable in this analysis is log (Y), whereas the independent variable is log (W). The resulting linear regression equation is expressed as follows:

A = 0,0739

B = 2,0916

The calibration of the parameters α and β in the binary logit ratio model was conducted through linear regression analysis. Once the intercept coefficient (A) and the regression coefficient (B) were obtained from the linear regression equation, these coefficients were used to determine the values of α and β, where β = B, and α is the antilogarithm of the intercept coefficient (A), expressed as $\alpha = 10^A$.

3.5 The Binomial Logit Model

Based on the values of parameters α and β that have been determined, the binary logit ratio model for route choice between the toll road and the national road on the Palembang–Prabumulih corridor can be formulated using Equation (3). The calculated proportion of respondents who chose the Palembang–Prabumulih toll road is presented in the table below.

Table 5. Proportion of Respondents choice route the Palembang–Prabumulih Toll Road Route

No	C(Toll)/C(National) <W>	W^β	$P=1/(1+(\alpha \times W^\beta)$
1	2,12	4,81	15%
2	1,84	3,60	19%
3	1,70	3,03	31%
4	1,56	2,54	28%
5	1,45	2,18	22%

For the proportion of respondents to the Palembang Prabumulih toll road with the calculated proportion, it can be depicted in the diversion curve as shown in the S curve below:
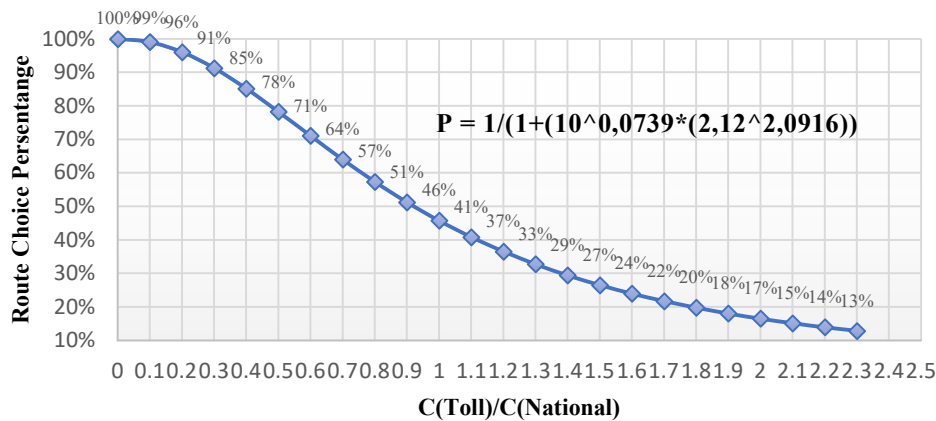

Figure 9: S-Curve Comparison of Toll Roads and National Highway

The results of the s-curve indicate that route choice behavior among road users is significantly influenced by the comparison between travel cost and travel time. When the cost ratio of the toll road to the national road is relatively low, most users tend to choose the toll road as it offers faster travel times and greater driving comfort. However, as the cost ratio increases, the proportion of users choosing the toll road gradually decreases. The equilibrium point occurs when the cost ratio approaches one, where the probability of choosing between the toll road and the national road becomes nearly equal. Beyond this point, a further increase in toll road costs leads to a significant decline in the proportion of toll road users. These findings suggest that road users are highly sensitive to changes in travel costs, particularly when the difference in travel time is no longer perceived as proportional to the additional cost incurred. Therefore, the logit model represented by the s-curve effectively illustrates the realistic relationship between relative cost, travel time, and route choice decisions.

Once the model development was completed, it was validated using the chi-square goodness-of-fit test. The test results revealed a calculated chi-square value (χ^2_a) of 8,373 compared to a critical chi-square value (χ^2_t) of 14,067. Since $\chi^2_a < \chi^2_t$, the null hypothesis (H₀) is accepted, which implies that the observed data align well with the model's predicted averages.

4. CONCLUSION

The analysis of socio-economic characteristics and travel patterns of users on the Palembang–Prabumulih toll and national roads indicates that the majority of respondents are aged 31–40 years (37%) and predominantly male (78.5%). Most respondents work as entrepreneurs/self-employed (40.5%), have completed senior high school education (30%), and earn a monthly income of IDR 3,000,000–4,000,000 (31%). The most common travel purpose is leisure (37%), with an average travel frequency of once per month (42%).

Based on the table above, the stated preference survey results indicate that the proportion of toll road users varies according to differences in travel costs. At lower cost differences (IDR 67,500–85,000), toll road usage ranges from 62% to 81%, while national road usage ranges from 19% to 38%. At higher cost differences (IDR 102,000–126,000), toll road usage slightly increases to 73%–79%, with national road usage at 21%–27%. The binomial logit modeling results show that route choice is influenced by the comparison of travel cost and time, where users tend to prefer the toll road when costs are low, but the proportion decreases as costs rise. Model validation using the chi-square test indicates χ^2 calculated = 8.373 < χ^2 table = 14.067, confirming that the binomial logit model fits the observed data.

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