

Transport Mode Choice Behavior of Urban Commuters: A Case Study of the Mamminasata Agropolitan Area

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Abstract

Metropolitan Mamminasata faces challenges with traffic congestion during peak hours, largely caused by urban commuters' high reliance on private vehicles. Private vehicles' growing demand for commuting has further impacted this problem. The current research examines the transportation mode choice of government employees from South Sulawesi, Indonesia, and analyzes the impact of vehicle ownership, socio-demographic aspects, travel cost, and travel time on this choice. The study conducted a quantitative survey of 750 respondents. The travel mode choice of the respondents was analyzed using the Multinomial Logit Regression (MNL) model. The respondents were classified into two groups: those with ownership of both a motorcycle and a car, and those with only motorcycle ownership. According to the analysis, the probability of transport mode choice for people owning two vehicles was 42.09%, while for individuals owning only motorcycles, the probability was 72.19%. Travel cost, travel time, gender, income, and vehicle ownership significantly influence mode choice. These findings indicate that improving public transportation requires policies that reduce travel cost and travel time while targeting commuter groups based on vehicle ownership.

Keywords: Mamminasata Area, Multinomial Logistic Regression, Transport Mode Choice, Travel Behavior, Urban Commuters

1. Introduction

Urban transportation systems remain a crucial factor in the daily functioning of metropolitan areas, especially in developing nations, many of which have high urbanization rates. With the growth of urban settlements, the need for an efficient, accessible, and sustainable public transit system is even more apparent [1]. In Indonesia, as in many other Southeast Asian nations, rapid urban development will undoubtedly pose significant challenges to public transportation planning, mainly in the form of traffic congestion, vehicle emissions-related pollution, and inequities in access to mobility services [2], [3]. Specifically, regional governments' decisions on planning the main modes of public transportation will play an important role in shaping the dynamics of urban mobility. As such, government workers and civil servants must also make routine commutes between their homes and their workplaces, which are largely located in the city center.

The mode choice decision for each individual is not influenced only by the availability of transport infrastructure. The mode choice is also influenced by the socio-economic attributes of an individual, the urban space, and behavioral attitudes. Variables such as income, gender, travel costs, and age are the most

documented mode choice determinants [4]. The factors cited become even more intricate in transport studies conducted for cities in Indonesia due to inadequate transport funding, limited and/or irregular provision of transport by the government, informal transport, and increasing private vehicles. This situation warrants the execution of studies that incorporate a wide variety of population segments, such as civil servants from multiple ministries and government agencies.

Despite progress and the expansion of studies and literature on the issue of transportation mode choice, the majority of studies conducted in Indonesia have been centered on the capital city of Jakarta [5], or on the general population without regard for different segments of commuters [6], for example, government employees. This group has displayed diverse mobility assets (such as ownership of multiple vehicles and multiple vehicle types) and has also exhibited more consistent travel patterns. In addition, although multinomial logit models have been widely used to model transportation mode choice in various contexts [7], they have yet to demonstrate their applicability in differentiating mode choice by criteria such as levels of vehicle ownership, as the literature remains limited. As such, it is an indication of a potential opportunity to adjust transportation

management and implementation strategies to accommodate those diverse commuter profiles.

The goal of this research is to understand the socio-economic factors and attributes of commuting and how they influence transportation mode choice, specifically differentiated in terms of civil servants in South Sulawesi. There are two major types of transport systems in South Sulawesi: formal and informal. They include cars, motorcycles, and other personal means of transport, and include organizational systems (such as buses) and on-demand transportation (such as online taxis) [8]. In this context, government employees may have specific preferences and attitudes toward the transportation system; such preferences may be informed by the mobility assets available to government employees and their attitudes toward the cost and time of transportation.

Indonesia is developing national public transportation systems and transforming mobility services digitally. However, in practice, these policies have not adequately considered the needs of a segmented commuter base, particularly individuals who can choose between personal vehicles and public transit. Without disaggregated data on commuter behavior, an intervention would surely disregard key variables that will impact the commuter's decision in a real-life context.

Previous research has examined Indonesian cities. For example, Hartwig et al. [9] found that the purpose of the trip, travel time reliability, and perceived safety affect the switch from private car use to public transport [10]. Other research has shown that gender shapes perceptions of comfort and safety, particularly for female employees [11]. However, these studies tend to focus less on public sector employees, who occupy professional positions, earn higher salaries, and may be able to use several different types of personal transport, all of which affect transport decisions. Also, the advent of Gojek and Grab has added a technology-based private transport option to the public and private transport alternatives, thereby adding to the complexity of the transport ecosystem.

In particular, studies that use MNL or mixed logit methods to assess mode choice in Indonesia have confirmed that a combination of personal characteristics and trip characteristics is critical in determining mode choice [12], [13]. However, there is still a gap in studies that define respondents by dual-vehicle ownership and study the impact of this ownership on preference patterns [14]. This gap is critical because growing vehicle ownership is one of the primary drivers of urban congestion and poor environmental quality in Indonesian cities [15].

Studies confirm that vehicle ownership does not have a simple answer (do or don't own). It is important to examine the relationship of vehicle ownership with other related variables such as income, size of the household, and the cost of travel, among others. Zhang et al. [16] argue that households are unlikely to engage with public transport, with the belief that private transport is flexible and convenient. In contrast, Selzer and Lanzendorf [17] claim that the era of mass car ownership, especially in developing countries, means that, apart from the practical considerations, owning a car has become a social status accessory and affects travel behavior, regardless of the

economic considerations. Such arguments support the need to study travel behavior and the complexities of household planning, especially in developing countries, with the rapid growth of motor vehicle ownership.

This research aims to supplement existing literature and study travel behavior in developing urban areas of Indonesia. The majority of previous studies have analyzed travel behavior and have focused on income, trip distance and purpose, and the level of available infrastructure. However, they have not sufficiently considered the impact of different levels and varied patterns of vehicle ownership and usage on travel behavior. In rapidly motorizing societies like Indonesia, the greater availability of private vehicles, especially cars and motorcycles, affects the likelihood of different modes of transport being used. The objective of this study, therefore, is to construct a multinomial logistic regression model to determine civil servants' transport mode choice in South Sulawesi Province, as part of the Mamminasata Study [12], [14]. This study aims to expand its analytical scope by employing a two-way analytical model and categorizing respondents into vehicle ownership groups: those who own cars and motorcycles, and those who own only motorcycles.

This research is original in employing a segmented modeling approach based on vehicle ownership to demonstrate sensitivities to travel determinants that are often hidden in mean-level models. This study is the first to estimate the effects of socio-demographic and trip characteristics (including gender, income, age, education, trip distance, trip cost, and travel time) on the propensity to choose public transport, ride-hailing, car, and motorcycle transport by modeling each socio-demographic group separately. This study both conceptually and methodologically advanced the understanding of the relationship between vehicle ownership and mode choice in urban Indonesia, solidifying the basis for the formulation of effective and sustainable transport policies [15].

Few studies have explicitly operationalized ownership structure as a behavioral segmentation framework within increasingly motorized secondary urban systems, despite prior discrete-choice studies including vehicle ownership as an explanatory variable. Households in many developing countries have multi-vehicle configurations that combine cars and motorcycles, resulting in diverse substitution patterns that differ significantly from binary ownership classifications. By estimating ownership-specific multinomial logit models in an agropolitan setting with significant motorcycle dependency and hybrid formal-informal transportation services, this study advances the body of research on transport mode choice. This research offers a more behaviorally nuanced and policy-relevant understanding of mode choice dynamics in growing urban regions by explicitly modeling differential sensitivity to travel time and cost across ownership groups and connecting these to probability-based policy simulations.

2. Methodology Research

2.1. Collecting Data

The study takes a quantitative approach in determining what influences the selection of modes of transport by South

Sulawesi province civil servants in Indonesia. The study examines the impact of demographic, economic, and travel characteristics on individual mode of transport preferences using structured questionnaires and statistical modeling, particularly the modes of transport and ownership of multiple vehicles (cars and motorcycles), and sole ownership of motorcycles [12]. The studies developed a framework centered on respondent classification and the collection, classification, and multinomial logistic regression estimation of data. This method aligns with established standards in transport behavior studies that use discrete choice modeling to analyze individual choices under varying conditions and attributes [7], [18].

This sample was drawn from the total number of urban commuters in South Sulawesi Province, spread across the Mamminasata Area agropolitan region, namely Makassar, Maros, Gowa, and Takalar. The number of samples obtained

from secondary data, based on the total population of commuters working in 30 government offices, was 6,600. Subsequently, the sample size was determined by interpreting the Mamminasata area based on the origin or place of residence of commuters, with the number of samples per area shown in Table 1 above. The minimum sample size was determined using the Slovin formula.

$$n = \frac{N}{1+N(e)^2} = \frac{6600}{1+6600(0,05)^2} = 377.41 = 378 \quad (1)$$

Where:

n = Minimum number of samples/respondents

N = Total Population

e = Margin of Error (5%)

Table 1. Name and Number of Samples for each Agency/Office.

No	Office/Agency	Sample Total	Area of Residence			
			Makassar	Maros	Gowa	Takalar
1	Department of energy and mineral resources	20	10	5	4	1
2	Department of culture and tourism	21	9	4	7	1
3	Department of Forestry	55	29	8	6	12
4	Department of Marine Affairs and Fisheries	20	7	2	7	4
5	Department of Health	48	11	12	15	10
6	Department of Food Security	19	5	4	8	2
7	Department of Cooperatives Small and Medium Enterprises	19	3	5	2	9
8	Department of Women Empowerment	6	2	1	2	1
9	Department of Community and Village Empowerment	19	8	2	2	7
10	Department of Youth and Sports	21	5	8	6	2
11	Department of Investment	20	6	2	10	2
12	Department of Education	43	9	10	12	12
13	Department of Environment	6	4	1	1	0
14	Department of Trade	25	9	4	9	3
15	Department of Transportation	42	13	16	10	3
16	Department of Industry	7	2	1	3	1
17	Department of Library	24	6	12	2	4
18	Department of Land, Housing & Urban Development	19	9	4	2	4
19	Department of Livestock and Animal Health	8	2	1	4	1
20	Department of Public Works	75	26	10	21	18
21	Department of Social Affairs	42	10	13	15	4
22	Department of Food Crops	30	13	7	9	1
23	Department of Manpower	25	7	4	8	6
24	Department of Demographics and Civil Records	17	10	4	1	2
25	Department of Public Information and Communications	13	2	4	6	1
26	Inspectorate of South Sulawesi Province	7	1	4	1	1
27	Regional Revenue Office	30	11	8	6	5
28	Regional Development Planning Agency	28	19	4	4	1
29	Regional Personnel Agency	11	8	1	2	0
30	General Bureau	30	16	7	3	4
Total		750	272	168	188	122

2.2. Research framework

Fig. 1 below presents a structured research flow that systematically describes the methodological framework in this study, from population identification to policy.

This research begins by defining the target population segment, estimating the sample size, and collecting primary data through a structured questionnaire. The data are then grouped into categories of socio-demographic, vehicle ownership, and trip attributes. Respondents are sorted by vehicle ownership structure to ensure that each respondent's available options are

considered and to capture behavioral differences during the transportation mode decision-making process.

The analytical phase includes statistical testing, model specification, and model estimation within the MNL framework and Random Utility Theory. Model validity is assessed through goodness-of-fit, significance tests, and multicollinearity

checks. Subsequently, changes in travel cost and time are examined on the mode choice behavior through probability and sensitivity analyses, respectively. The final phase discusses findings of policy interest with a focus on recommendations for transportation policy aligning with different vehicle ownership groups.

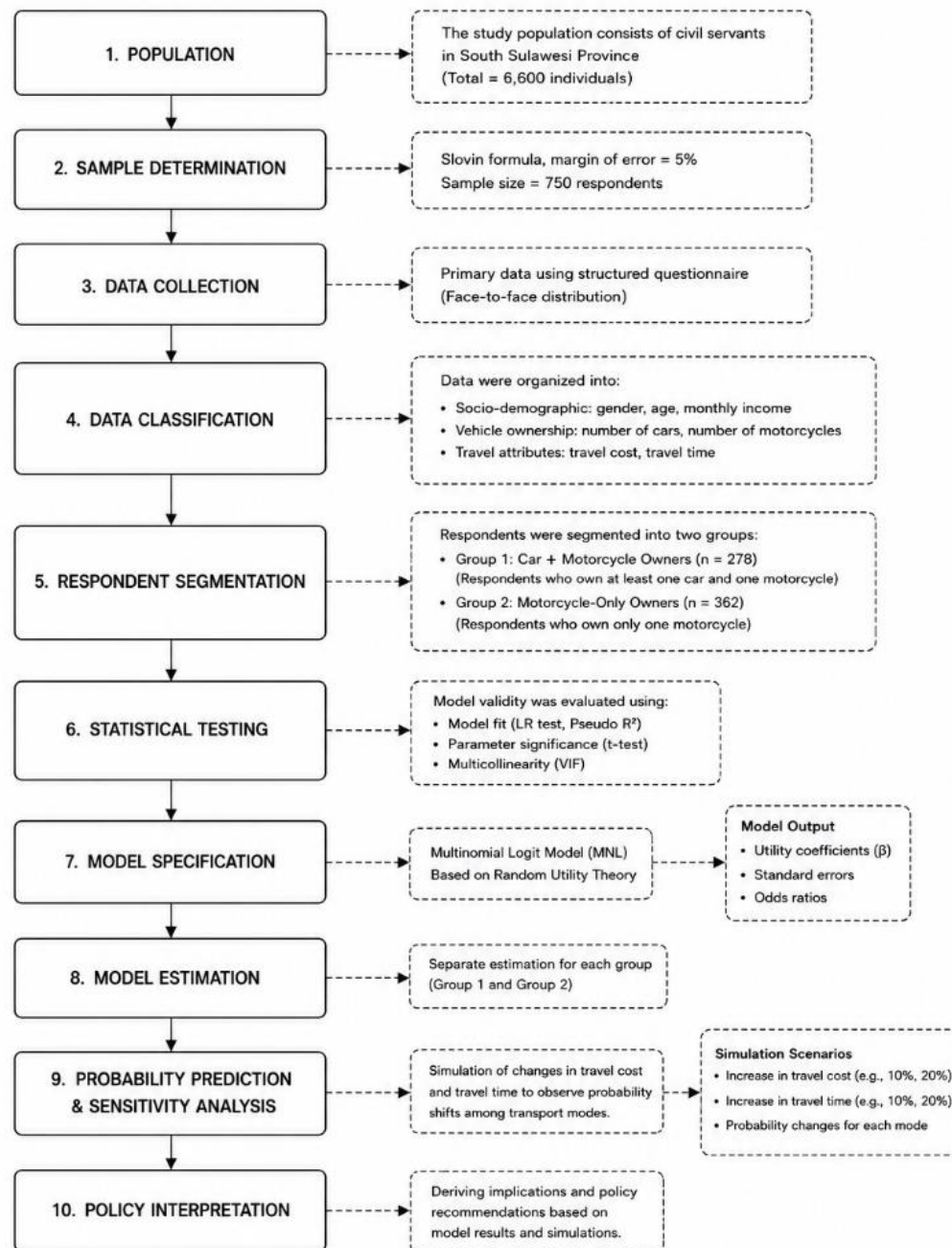


Figure 1. Research flow.

2.3. Instrument of Research

Data collection for this research includes survey activities to gather information on individual characteristics and travel patterns, as well as travel attributes and modes of transportation to the office. Primary data collection was conducted through questionnaires in the form of direct interviews.

The demographic categories in the questionnaire included seven age groups, ranging from 18 to 25 years old to over 66 years old. It also recorded five educational levels, from secondary school to doctorate, and six income groups, ranging from Indonesian Rupiah (IDR) 500,000 per month to over IDR 5,500,000 per month. Vehicle ownership status for cars and motorcycles is categorized into five levels, from owning no vehicles to owning 5 vehicles. At the same time, different

modes of transportation include minibus, taxi, online motorcycle taxi, car, and motorcycle. This classification is presented in Table 2.

Table 2. Category Characteristic Respondent.

Characteristics	Categories of Characteristics	
Gender	a. Male	b. female
Age (Years)	a. 18 – 25	e. 50 - 57
	b. 26 – 33	f. 58 - 65
	c. 34 – 41	g. 66 - 73
	d. 42- 49	
Education	a. Senior High School	e. Master
	b. Diploma (D4)	f. Doctor
	c. Bachelor	
Income (IDR)	a. 500,000-1,500,000	d. 3,500,000 - 4,500,000
	b. 1,500,000 – 2,500,000	e. 4,500,000 – 5,500,000
	c. 2,500,000 – 3,500,000	f. > 5,500,000
Motorcycle Ownership	a. 0	d. 3
	b. 1	e. 4
	c. 2	
Car Ownership	a. 0	d. 3
	b. 1	e. 4
	c. 2	f. 5
Transportation Mode	a. Microbus	d. Car
	b. Taxi car	e. Motorcycle
	c. Taxibike	
Travel Cost (IDR)	a. <5,000	d. 25,000-35,000
	b. 5,000-15,000	e. 35,000-45,000
	c. 15,000-25,000	f. 45,000-55,000
Travel Time (Minute)	a. <15	f. 35-40
	b. 15-20	g. 40-45
	c. 20-25	h. 45-50
	d. 25-30	i. 50-55
	e. 30-35	j. 55-60
Travel Distance (Meters)	a. < 2,000	e. 10,000 - 12,000
	b. 2,000 - 4,000	f. 12,000 - 14,000
	c. 4,000 - 6,000	g. 14,000 - 16,000
	d. 6,000 - 8,000	h. > 16,000
	e. 8,000 - 10,000	

Respondents were divided into two groups. For example, individuals who did not own a car could not use motorized vehicles, thus requiring a separate modeling approach. The main mode of transportation for each group was the dependent variable. This was determined by the respondents' answers, which were classified as Motorcycle and Car Ownership. The options included public transportation, online transportation, car, and motorcycle. Meanwhile, Motorcycle Ownership alone did not have the car option, with the available modes of transportation instead being public transportation, online transportation, and motorcycle.

Respondents were divided into two main groups based on their vehicle ownership. The first group included those who owned both a motorcycle and a car ($n = 278$). The second group included respondents who owned only a motorcycle and no car ($n = 362$). 110 respondents did not own a vehicle, so this data could not be used because the model results produced were not significant, and it has also been interpreted in the previous 2 respondent group models that those who do not choose private vehicles can be grouped into this section. This allowed us to analyze how different factors affected their transportation mode choices while accounting for changes in travel costs and time, as shown in Table 3.

Table 3. Classification of Number of Vehicles.

Vehicles	Motorcycle		Total
	Own Vehicles	No Vehicles	
Car	Own Vehicles	278	0
	No Vehicles	362	110
	Total	640	110

Respondents without private vehicle ownership were excluded from the segmented modeling framework because they had limited options. Individuals without access to a car or motorcycle are considered engaged users of public or ride-hailing services; including them in the same multinomial specification may bias the estimates of substitution elasticities across ownership groups. This modeling decision, by limiting the findings to the broader commuter population, therefore does not reflect the behavior of commuters with access to private mobility, as it is not representative of the entire urban workforce.

2.4. Analysis Method

The model will be analyzed using the principles of MNL to evaluate civil servants' transportation mode choices among four alternatives: public transportation, online transportation, private cars, and motorcycles. Estimates were made separately by vehicle ownership status to identify differences in preference structures, namely between those who own motorcycles and cars and those who own only motorcycles [12], [19].

Based on Random Utility Theory, the utility of individual n towards mode j in vehicle ownership group g is expressed as:

$$U_{nj}^{(g)} = V_{nj}^{(g)} + \varepsilon_{nj}^{(g)} \quad (2)$$

Where:

$U_{nj}^{(g)}$: The total utility obtained by individual n for mode j in vehicle ownership group g

$V_{nj}^{(g)}$: Deterministic utility components

$\varepsilon_{nj}^{(g)}$: Error components

with deterministic components formulated as:

$$U_{nj}^{(g)} = \alpha_j^{(g)} + \beta_{nj}^{(g)} X_n + \gamma_j^{(g)} + Z_{nj} \quad (3)$$

Where:

$\alpha_j^{(g)}$: Constants for mode j in group g

$\beta_{nj}^{(g)}$: Individual characteristic coefficient parameters

X_n : The individual characteristic variable (gender, age, education, etc)

$\gamma_j^{(g)}$: Coefficient parameters for alternative characteristics

Z_{nj} : Represents specific alternative travel characteristics (travel cost and travel time).

The probability that individual n in group g chooses mode j is formulated as:

$$P_{nj}^{(g)} = \frac{\exp(V_{nj}^{(g)})}{\sum_{k=0}^J \exp(V_{nk}^{(g)})} \quad (4)$$

Where:

$P_{nj}^{(g)}$: The probability of individual n in group g choosing the mode j

$(V_{nj}^{(g)})$: The deterministic utility component of individual n with respect to mode j

$\sum_{k=0}^J$: Total alternative modes

k : Alternative index (all modes)

j : Alternative modes

n : Respondent/individu

g : Data groups in the model

Separating estimates by vehicle ownership allows identification of differences in the influence of socio-economic variables and travel characteristics on mode choice across civil servant groups. This approach can yield more specific data on the diversity of commuter behavior.

3. Result and Discussion

3.1. Result

The total number and percentage of respondents for each question category in the survey are shown in Table 4 below.

From the sample distribution, the proportion of males was 48.7%, and the proportion of females was 51.3%. There were 9.78% of respondents between the ages of 18 to 25, and 2.30% of respondents in the age group of 58 and older. The group of respondents between ages 34 to 41 had the highest representation at 25.55% of the sample. For participants' education, there were 61.68% of respondents with a bachelor's degree, 21.06% with a master's degree, and 11.28% with a high school diploma. For participants' income distribution, 33.53% of the sample indicated that their income was above IDR 5,500,000. As for the respondents' income distribution, 21.16%

indicated that their income was between IDR 3,500,000 and IDR 4,500,000.

Table 4. Total Characteristic.

Characteristics	Categories	Frequency (Percentage (%))
Gender	Male	359 (47,870)
	female	391 (52,13)
Age (Years)	18 - 25	76 (10,13)
	26 - 33	167 (22,27)
	34 - 41	189 (25,20)
	42- 49	151 (20,13)
	50 - 57	157 (20,93)
	> 58	10 (1,33)
Education	Senior High School	84 (11,20)
	Diploma (D4)	33 (4,40)
	Bachelor	469 (62,53)
	Master	156 (19,47)
	Doctor	18 (2,40)
Income (IDR)	500,000-1,500,000	
	1,500,000 – 2,500,000	23 (3,07)
	2,500,000 – 3,500,000	69 (9,20)
	3,500,000 – 4,500,000	124 (16,53)
	4,500,000 – 5,500,000	157 (20,93)
	5,500,000 – > 5,500,000	131 (17,47)
		246 (32,80)
	< 2,000	84 (11,20)
	2,000 - 4,000	89 (11,87)
	4,000 - 6,000	105 (14,00)
Travel Distance (Meters)	6,000 - 8,000	99 (13,20)
	8,000 - 10,000	112 (14,93)
	10,000- 12,000	96 (12,80)
	12,000- 14,000	53 (7,07)
	14,000- 16,000	70 (9,33)
	> 16,000	42 (5,60)
	< 5	64 (8,52)
	5-15	270 (35,95)
Travel Cost (IDR)	15–25	195 (25,97)
	25–35	113 (15,05)
	35-45	44 (5,86)
	45–55	65 (8,66)
	< 15	108 (14,40)
Travel Time (Minute)	15-20	202 (26,93)
	20–35	175 (23,33)
	35–40	141 (18,80)
	40-45	56 (7,47)
	45–50	20 (2,67)
	50-55	19 (2,53)
	55-60	29 (3,87)
Transportation Mode	Microbus	31 (4,13)
	Taxicar	49 (6,53)
	Taxibike	98 (13,07)
	Car	197 (26,27)
	Motorcycle	275 (50,00)

The spread of travel distances demonstrated a fairly even pattern of movements. The 8,000-10,000-meter distance segment accounted for 14.37% of the total movements. This was immediately followed by the 4,000-6,000-meter distance segment, accounting for 13.77% of the total movements. For travel costs, the segments Rp5,000-Rp15,000 and Rp15,000-Rp25,000 accounted for 35.03% and 27.35% of total travel costs, respectively. For travel time, 26.93% of respondents took 15 to 20 minutes to reach their destination. Travel time data also indicate that 23.33% of participants took 20 to 35 minutes to reach their destination, and 18.80% took 35 to 40 minutes to reach their destination. The new transport system evidently favors motorcycles, since 44.91% of the respondents acknowledged using motorcycles as the primary mode of transport. Cars were used by 21.26%, respectively. Overall, the data emphasize the prevalent use of private motorized transport for urban travel among civil servants, as a prevailing national trend [2].

3.1.1. Instrumen validation

The reliability test utilized in the study measures the internal consistency of the assessed variables with Cronbach's Alpha.

From Table 5, it can be said that the measurement tool is reliable since the obtained alpha value is greater than 0.60. The average Cronbach's alpha was 0.8761, which means the

questionnaire has very good reliability and high inter-item correlations across all the components of the measurement tool.

Table 5. Result Reliability Test.

Cronbach's Alpha	Reliable (Alpha>0.6)
0.8761	Reliable

3.1.2. Model analysis

• Respondents with Car and Motorcycle Ownership

Included in this study were 278 participants who owned both cars and motorcycles. Participants in this group had access to public transportation, online transportation, cars, and motorcycles. With motorcycles as the primary mode of transport, a multinomial logistic regression model was used to analyze the variables that affected the choice of transport mode.

The coefficients and their corresponding p-values are shown in Table 6. In relation to all modes of transportation, the negative sign on the travel cost and travel time indicates the trade-off concerning cost and time for all modes of transport. It is evident that from an economic viewpoint and in accordance with the theory of transport economics, participants aimed to minimize travel cost [7].

Table 6. Model Respondents with Car and Motorcycle.

Variable	Coef.		P> Z			
Attribute						
Travel Cost	-.0000671		0.096			
Travel Time	-.0376655		0.071			
Base Category			Motorcycle			
Category	Public Transportation		Online Transportation		Car	
Variable	Coef.	P> Z	Coef.	P> Z	Coef.	P> Z
Independen						
Gender (Male) (X1)	-1.0987	0.008*	-1.8251	0.001*	-1.1557	0.001*
Age (Years Old) (X2)	0.0375	0.051**	0.0017	0.947	0.0382	0.014*
Education (Bachelor) (X3)	-0.3243	0.433	-0.1244	0.803	-0.2174	0.522
Income (IDR) (X4)	0.0004	0.012*	2.0001	0.989	0.0003	0.005*
Family Number (X5)	-0.2709	0.108	-0.0750	0.700	0.2761	0.041*
Transportation Type (Motorcycle) (X6)	-1.5765	0.011*	-1.2978	0.062**	-1.9834	0.000*
Car Ownership (X7)	-0.8662	0.024*	-1.0932	0.082**	1.1711	0.000*
Motorcycle Ownership (X8)	-0.0192	0.951	-0.3969	0.044*	-0.2286	0.068**
Constanta	-2.4406	0.005	1.1847	0.075	-1.1947	0.004
Prob > chi2			0.0000			
Total Obs			1112			
Case			278			

Note:

*Level Signifikansi 95%

**Level Signifikansi 90%

Gender affected all modes of transport ($p < 0.05$), with a 95% confidence level. Negative coefficients indicated that men were less likely to take private cars, public transport, and online transport and more likely to take motorcycles. Therefore, the authors inferred that women employees preferred other transport modes, including more transport methods [11]. For age and income, there was a significance of two alternative variables, public transport and private cars. Older participants preferred these two transport methods over motorcycles. This finding is also consistent with the earlier findings which showed that income affected the preference and the perception of the comfort and status of different transport methods [16], [20].

At the educational level, there is no significant indication of alternative modes, suggesting that education is not a key factor in respondents' mode choice. In the family size variable, there is one significant alternative mode: car, indicating that larger families are more likely to choose private cars. The car ownership variable shows a strong effect, with all alternative mode variables having a significant influence. Although car ownership increases the probability of choosing a car, compared with public and online transportation, respondents are more likely to choose motorcycles, thereby decreasing the probability of choosing public and online transportation. Conversely, motorcycle ownership has a negative coefficient on car selection (-0.2286), indicating an increase in the likelihood of choosing personal motorcycles over cars and online transportation.

The model fit statistics indicate a high level of significance ($\text{Prob} > \chi^2 = 0.000$), confirming the model's strength. The predicted probability of mode choice is 42.09% for cars, 32.73% for motorcycles, 15.47% for public transportation, and 9.71% for online transportation.

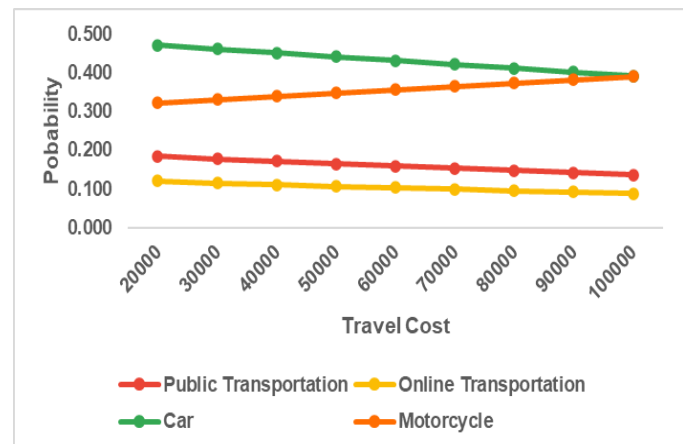
Fig. 2.a above shows that the probability of choosing a mode of transportation based on travel costs indicates that the probability of choosing cars, public transportation, and online transportation will decrease as travel costs increase by IDR 10,000, where the average decrease in the probability of choosing these three modes of transportation is 0.6% for every additional IDR 10,000 in costs. Conversely, the probability of choosing motorcycles as a mode of transportation increases by an average of 0.8% for every additional IDR 10,000 in travel costs. These sensitivity results indicate that as travel costs increase, the tendency to switch to motorcycles will become stronger. Similarly, in Fig. 1.b, the three modes of transportation show a decrease in probability, while one mode of transportation experiences an increase in probability due to an additional 5 minutes of travel time.

• Respondents Motorcycle and No Car Ownership

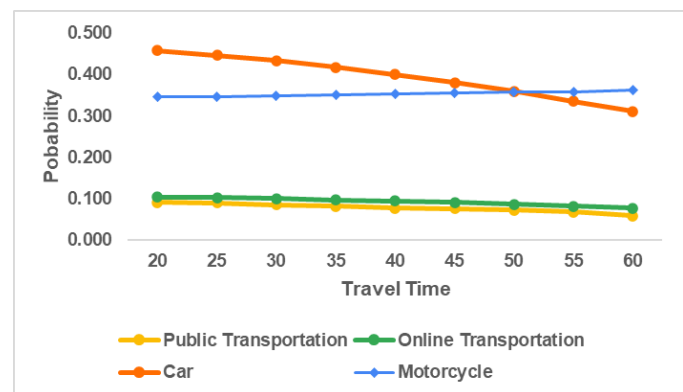
The second group consisted of 362 respondents who owned motorcycles but did not own cars. Their mode choices were more limited and did not include private cars. As in the previous model, motorcycles became the base category.

Table 7 above presents the corresponding coefficients and significance levels. Travel costs and travel time again have negative coefficient values, indicating a lower probability of choosing public and online transportation as they increase.

Although the coefficients are smaller than in the previous model, both travel costs and travel time remain significant at the 90% confidence level.



(a)



(b)

Figure 2. Mode sensitivity based on Cost and Travel Time Model 1.

Gender remains a significant variable, with two modes of transportation affecting an. Male respondents with negative coefficients are less likely to choose public transportation and online transportation, indicating a consistent preference for personal motorcycles, even when they do not own a car. Several studies have observed gender-based behavior patterns [19].

As shown in Table 7 above, positive coefficient values for income and family size significantly influence mode choice. Higher income levels are linked to a greater likelihood of using public transportation. In contrast, larger households are more likely to choose online transportation services over personal motorcycles. Conversely, owning a motorcycle decreases the likelihood of using both public and online transportation, suggesting that households with one vehicle strongly prefer motorcycles.

Based on the overall statistically significant model above, the p-value ($\text{Prob} > \chi^2$) is 0.0001, and the predictive probability shows that motorcycles are the dominant mode of transportation at 72.19%, followed by online transportation at 20.90% and public transportation at 6.91%.

Table 7. Model Respondents with Motorcycle and no car ownership.

Variable	Coef.		P> Z	
Attribute				
Travel Cost	-0.0000131		0.082	
Travel Time	-0.0209790		0.093	
Base Category	Motorcycle			
Category	Public Transportation		Online Transportation	
Variabel	Coef.	P> Z	Coef.	P> Z
Independen				
Gender (Male) (X1)	-0.8399	0.053**	-0.3851	0.050*
Age (Years Old) (X2)	-0.0008	0.970	0.0128	0.673
Education (Bachelor) (X3)	-0.2164	0.634	0.2295	0.424
Income (X4)	0.0002	0.027*	0.0001	0.324
Family Number (X5)	0.7460	0.133	0.4349	0.026*
Motorcycle Ownership (X6)	-0.3419	0.053**	-0.6129	0.072**
Constanta	-2.7508	0.027	-2.0854	0.006
Prob > chi2			0.0001	
Total Obs			1096	
Case			362	

Note:

*Level Signifikansi 95%

**Level Signifikansi 90%

Fig. 3.a above shows the probability of selecting the mode based on travel costs. It shows that the probability of selecting public and online transportation decreases as travel costs increase by Rp. 10,000, with an average decrease in probability of 0.09% per Rp. 10,000 in cost. Conversely, the probability of choosing motorcycle transportation will increase by an average of 1% for every Rp. 10,000 in travel costs. The results indicate that as travel costs increase, there is a tendency to switch to motorcycle transportation. Similarly, in Figure 3.b., it can be seen that both public transportation and online transportation modes experience a decrease in probability. In contrast, motorcycle transportation experiences an increase in probability if there is an additional 5 minutes of travel time. These results indicate that additional costs and travel time will reduce the probability of public transportation and online transportation modes and increase the probability of a shift to motorcycle transportation.

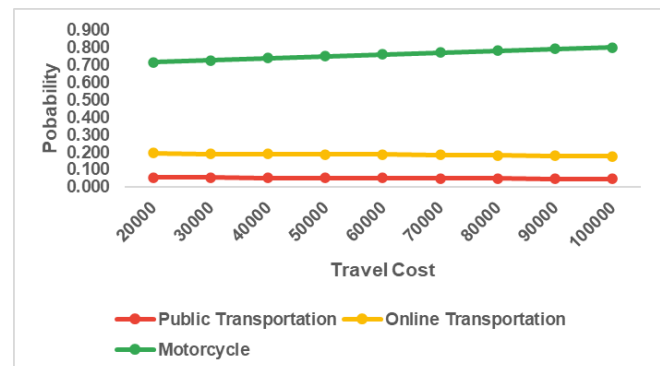
This study has several limitations. The model, by nature, excludes respondents without private vehicles because they have limited mode choices. Nevertheless, the large sample size, stratified sampling strategy, and multinomial logit modeling confer robust validity to these findings.

The results of multicollinearity tests on a number of independent variables in the regression model, as determined by the Variance Inflation Factor (VIF), are shown in Table 8 above. The greatest VIF value, 1.16, and the average, 1.07, are both far below the threshold of 10. This condition indicates that the independent variables are not strongly correlated, which reduces the risk in multicollinearity. Since the predictors do not exhibit excessive linear collinearity, the regression model can be considered complete and adequate.

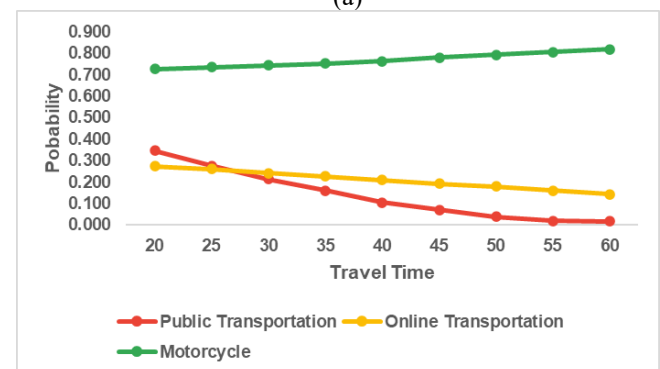
3.2. Discussion

The findings support and contribute to the literature in several ways. First, these results confirm that vehicle ownership is a major factor in mode choice, strengthening Selzer's arguments

[16] and [17] that ownership patterns shape opportunity structures and behavioral preferences. From the results, it is clear that the variables of gender and income, even in combination with vehicle ownership, remain reflective of socio-economic access and culturally embedded patterns of choice concerning a given mode. [9], [11].



(a)



(b)

Figure 3. Mode sensitivity based on Cost and Travel Time Model 2.

Table 8. Result Multicollinearity.

Variable	VIF	1/VIF
Age	1,16	0,8620690
Education	1,14	0,8771930
Income	1,11	0,9009009
Family Number	1,10	0,9090909
Motorcycle Ownership	1,05	0,9523810
Car Ownership	1,02	0,9803922
Travel Cost	1,01	0,9900990
Travel Time	1,00	1,0000000
Average VIF	1,07	

Sensitivity simulations show that increases in travel costs lead to a decrease in the probability of choosing cars and public transportation, but a relative increase in the probability of using motorcycles. This suggests that cost considerations significantly influence mode switching behavior, particularly for motorcycles, which offer greater flexibility and lower marginal costs [21]. Similarly, increases in travel time reduce the attractiveness of public and ride-hailing alternatives, reinforcing preferences for modes perceived as more time-efficient. These findings highlight that commuters' sensitivity depends not only on the presence of transportation attributes but also on their marginal changes in maximizing utility under conditions of limited urban mobility.

One of the most notable contributions of this study is the segmentation of respondents by vehicle ownership, which indicates large differences in behavioral elasticity. This is visible in the first group, where car ownership is associated with high levels of car use, while in the second group, where there are no cars, motorcycles are the dominant mode of transport. The Cervero argument is also supported by the bifurcation modeling approach, which suggests that it is of little use.

To encourage a shift away from private cars, the government will need to act in a differentiated manner. This means that for multi-car households, the improvements brought about in the public transport system will not be sufficient to encourage a shift away from private cars, absent strong incentives or disincentives to reduce car usage, e.g. congestion charging and parking controls. On the other hand, for single-car households, the improved affordability and accessibility of digital transport services will effectively reduce the use of private cars, particularly in inner-city areas.

The pronounced sensitivity to both could significantly enhance public transport's appeal. Future research should incorporate dynamic modeling and consider factors such as trip satisfaction, environmental awareness, and comfort to build more robust models.

This study has some limitations. Excluding respondents without a private vehicle reduces mode choice options, therefore vehicle ownership, thereby reinforcing the model's limitations. However, the validity of the findings is bolstered by the large sample size, the stratified sampling approach, and the multinomial logit modeling.

4. Conclusion

This study shows that the socio-economic, vehicle ownership, and travel behavior characteristics of respondents, especially civil servants in South Sulawesi, are important for transport mode choice. Among civil servants, those who own cars and motorcycles consider cars. However, the situation is contrasting for those civil servants with only one vehicle, especially motorcycles. For them, motorcycles are greatly preferred and there is very little probability of using public transport or on-demand transport.

From the analysis, it can be concluded that transport mode selection is highly influenced by gender, income, travel expense, and travel time. In particular, men preferred motorcycles, whereas women preferred private cars. Concerning travel time and travel expense, there is an inverse relationship with modes of transport, except for motorcycles, which means that an increase in travel time and travel expense encourages the use of motor vehicles and public transport.

This study contributes a new understanding of urban transport division and policy formation. It also presents a new segmentation approach based on ownership.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

Author Contribution Statement

Muhammad Ikhsan Sabil: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Visualization, and Writing – Original Draft.

Muhammad Isran Ramli: Conceptualization, Methodology, Validation, Supervision, and Writing – Review & Editing.

Sakti Adji Adisasmita: Conceptualization, Validation, Supervision, and Writing – Review & Editing.

Muralia Hustim: Methodology, Validation, Supervision, and Writing – Review & Editing.

All authors have read and approved the final version of the manuscript.

Use of LLM and AI

The authors used AI solely to assist with language editing, translation, organization, and readability of the manuscript. All AI-generated outputs were reviewed and revised by the authors, who take full responsibility for the final content. Generative AI was not used to generate or manipulate research data or statistical results.

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Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request. The

data are not publicly available due to privacy and confidentiality considerations related to the study participants.

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