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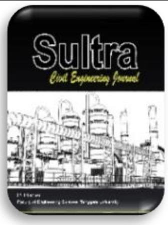

Analyzing The Modal Shift From Private Vehicles To Bicycles Through The Stated Preference Method: A Case Study Of Bicycle Lane Planning At Universitas Muhammadiyah Yogyakarta

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ABSTRACT

Urban transportation systems face increasing challenges due to traffic congestion, air pollution, and the overreliance on private vehicles. Promoting a shift to more sustainable transport modes, such as bicycles, is one strategy to address these issues. This study analyzes the potential for a modal shift from private vehicles to bicycles among students at Universitas Muhammadiyah Yogyakarta. Using the Stated Preference (SP) method, data were collected through questionnaires to assess individuals' willingness to switch transport modes under various scenarios, such as improvements in cycling infrastructure, safety, and travel time. The analysis identifies key factors that influence mode choice and estimates the probability of modal shift under different policy interventions. The findings provide essential insights for urban planners and university stakeholders in developing effective bicycle lane networks and supporting facilities. The study concludes that with adequate infrastructure and supporting policies, the potential for bicycle use on campus can be significantly increased.

1. Introduction

The rapid development of the transportation sector has significantly improved mobility for the general public, including university students. However, this convenience has also introduced new challenges, particularly within campus areas characterized by high activity levels. The growing use of private motorized vehicles such as motorcycles and cars on university campuses has led to various negative impacts, including traffic congestion, increased fossil fuel consumption, air pollution, noise, and limited parking availability. These issues contradict the principles of sustainable campus development (*green campus*), which emphasize energy efficiency, environmental preservation, and the promotion of a healthy lifestyle in higher education environments.

Sustainable transportation is a movement that prioritizes environmental concerns and plays a key role in promoting public health. Transportation mode choices directly affect environmental quality by reducing reliance on emission-producing vehicles such as buses and motorcycles (Mundorf et al., 2018). The goal of sustainable transportation is to provide better and healthier ways to meet the needs of individuals and society while minimizing the environmental impacts of mobility (Mihyeon, 2005). Environmentally-conscious transportation development includes the advancement of mass transit systems, the use of eco-friendly vehicle technologies, and the support of Non-Motorized Transport (NMT) programs—urban spatial planning initiatives aimed at reducing motor vehicle usage by providing facilities such as bicycle lanes (Rusmandani, 2015).

Cycling represents a healthy, low-cost travel option that is accessible to nearly everyone. It is one of the most energy-efficient forms of transportation, producing no emissions, requiring no external energy sources, and utilizing land efficiently. Bicycles can effectively transport individuals from one location to another with minimal environmental impact (AASHTO Guide for the Development of Bicycle Facilities, 2012).

One of the transportation modes considered efficient, economical, and environmentally friendly is the bicycle. This mode not only produces zero emissions but also contributes to improved quality of life by increasing the user's physical activity (R. Rahim 2019 & A. Gatersleben 2016). On university campuses, bicycles are particularly relevant due to the relatively short distances between facilities and the primary users—students—who are within a productive age group and generally more adaptable to changes in mobility behavior. However, the adoption rate of bicycles as the primary mode of transport remains very low, primarily due to infrastructure limitations such as the lack of safe bike lanes, proper lighting, designated parking, and an underdeveloped cycling culture (A. Götschi et al, 2016).

Previous studies have shown that the success of sustainable transportation programs is strongly influenced by an understanding of user preferences and behaviors. One widely used approach in examining mode choice preferences is the Stated Preference (SP) method. This method allows researchers to evaluate individuals' tendencies to choose transportation alternatives based on hypothetical scenarios that include specific attributes such as comfort level, safety, or cost (L.Fitri et al, 2022). The SP method is also commonly applied in micro-scale studies, such as campus mode choice research, as it can capture subjective variables that are not typically measurable through real-world data (R. Handayani, 2020 & D. Wulandary, 2021).

In line with Universitas Muhammadiyah Yogyakarta's (UMY) commitment to developing a green and environmentally friendly campus, a comprehensive study is needed to assess the potential for a modal shift among students toward bicycle use. Currently, bicycle lane development on the UMY campus remains limited and has yet to be systematically integrated into the internal transportation system. Therefore, an analysis based on student preferences is essential to support the planning of bicycle lanes that are not only technically efficient but also socially and culturally acceptable to users.

This study aims to identify the key factors influencing students' decisions to choose bicycles as their primary mode of transportation on the UMY campus, using the Stated Preference approach. Through the developed analytical model, the findings of this research are expected to serve as a reference for formulating campus transportation policies and planning infrastructure that promotes broad and sustainable bicycle use.

2. Literature Review

A. Modal Shift and Sustainable Transportation

Modal shift from private motorized vehicles to non-motorized modes such as bicycles is a key strategy for achieving sustainable transportation systems (Zhou et al., 2020). Bicycles are considered environmentally friendly due to their zero-emission nature, reduced dependency on fossil fuels, and contribution to public health. In university settings, cycling is particularly suitable due to the short and routine nature of campus mobility (Rahayu & Surbakti, 2021).

In the Indonesian context, the main challenge to shifting to bicycles lies in the lack of supportive infrastructure such as dedicated bike lanes, signage, and complementary facilities. Rachmawati and Sari (2020) found that public perception regarding safety and comfort is the dominant factor influencing the willingness to switch to bicycles in urban areas.

B. Factors Influencing Bicycle Mode Choice

Individuals' transportation mode choice is influenced by both internal and external factors. Internal factors such as environmental concern, cycling habits, and health awareness significantly affect bicycle preference (Yang et al., 2022). External factors include infrastructure conditions, road safety, parking availability, and weather (Putri & Hariani, 2019).

A study by Zulfa and Mahendra (2018) at Universitas Indonesia showed that students are more likely to choose bicycles when bike lanes are physically separated from motorized traffic and bicycle parking is conveniently located near academic buildings. Similarly, Liu et al. (2021) emphasized the importance of cycle-friendly urban design in influencing behavioral change among urban residents.

C. The Stated Preference Method in Transportation Studies

The Stated Preference (SP) method is widely used in transportation research to examine individuals' preferences based on hypothetical scenarios. This method allows researchers to assess user choices toward attributes or features that are not yet available, such as proposed bicycle lanes (Moraes et al., 2017).

Kusuma and Rahmawati (2023) argued that SP is an effective approach in evaluating potential modal shifts and shaping transportation planning strategies. For example, through SP analysis, it is possible to identify that improved safety and reduced travel time significantly increase the likelihood of individuals choosing bicycles over private vehicles.

D. Bicycle Lane Planning in Campus Environments

University campuses are ideal locations for promoting bicycle mobility. A study by Astuti and Kurniawan (2020) at Universitas Gadjah Mada revealed that integrated bike lane planning with campus spatial design could increase student and staff interest in cycling. Green campus policies often discourage the use of motor vehicles and encourage cycling as a primary mode of transport within the campus area.

Furthermore, Mohammadi et al. (2021) found in a study at Iranian universities that providing supportive facilities such as secure bicycle parking, proper lighting, and clear signage significantly increased the number of cyclists within campus environments.

E. User Behavior and Modal Shift Relevance

User behavior in mode selection is shaped by perceptions of risk, comfort, and social norms. Transport psychology research shows that people are more likely to shift modes when their environment supports safe and convenient cycling (Kroesen, 2017). Among university students, travel time efficiency and support from a cycling community also play a role (Saputra et al., 2022).

These findings underline the importance of integrating behavioral and preference-based data into the planning of bicycle infrastructure, particularly in academic environments where daily mobility is frequent but spatially limited.

F. The Role of the Built Environment and Infrastructure Design

Built environment factors such as land use mix, road connectivity, and dedicated bike lanes significantly influence cycling behavior (Liu et al., 2021). Bicycle infrastructure that is integrated into urban design—rather than added as an afterthought—can encourage more people to cycle by reducing the perceived risks of sharing space with motor vehicles.

Research by Zulfa and Mahendra (2018) on UI Depok Campus demonstrated that students were more likely to switch to bicycles when bike lanes were physically separated from roads and connected to key destinations on campus. International studies echo this; Mohammadi et al. (2021) argued that infrastructure continuity, lane width, and lighting conditions are key to encouraging safe and regular cycling on university campuses.

Moreover, user-friendly facilities such as showers, lockers, bike repair stations, and navigational signage further increase cycling satisfaction and frequency (Miller et al., 2020). Integration of bike-sharing systems, as explored by Dissanayake and Morikawa (2019), also serves as a supporting system that enhances last-mile connectivity and encourages broader adoption of cycling.

G. University Settings as Living Labs for Modal Shift

University campuses offer a unique and controlled environment to test sustainable mobility initiatives. With a high concentration of young adults, predictable travel patterns, and institutional support for green initiatives, campuses can serve as “living laboratories” for transportation innovation (Astuti & Kurniawan, 2020).

Studies at various campuses, including Universitas Gadjah Mada, Universitas Indonesia, and several international institutions, show consistent patterns: infrastructure improvements, coupled with awareness campaigns and incentive programs (e.g., bike-to-class discounts), effectively increase the share of bicycle commuters (Mohammadi et al., 2021; Liu et al., 2021).

However, these programs must be integrated with broader urban transport networks to ensure continuity and long-term adoption. Without connectivity to citywide bike lanes or transit hubs, campus initiatives risk becoming isolated (Dissanayake & Morikawa, 2019)

3. Method

A descriptive quantitative approach was adopted, utilizing a survey method to explore students' preferences for using bicycles as a mode of transportation within the campus. Data were collected using the Stated Preference (SP) method, which involves presenting respondents with hypothetical scenarios requiring them to choose between alternative transport modes based on predefined attribute combinations (M. Ben et al, 2018).

1. **Research Design**
   This study employs a quantitative approach using the Stated Preference (SP) method to identify respondents' preferences regarding a shift from private vehicles to bicycles. The SP method allows researchers to evaluate individual responses to various hypothetical scenarios involving infrastructure availability, safety, travel time, and cycling needs.
2. **Study Location and Population**
   The research was conducted within the campus area of Universitas Muhammadiyah The study population comprises all users of private vehicles on campus, including students, lecturers, and administrative staff.Yogyakarta**.**

3. **Sampling Technique**
A purposive sampling method was used to select respondents who regularly use private vehicles (motorcycles or cars) for daily mobility on campus. The sample size was determined using the Slovin formula with a 95% confidence level, resulting in a total of n respondents (to be adjusted based on actual data).
4. **Data Collection**
Primary data were collected through Stated Preference questionnaires, distributed both online and in person. The questionnaire was divided into two sections:
    a. Respondents' characteristics and current transport mode usage
    b. Mode choice preferences based on alternative scenarios involving variables such as bicycle lane availability, safety, travel time, supporting facilities, and cost
5. **Research Variables**
The variables used in this study are categorized as follows:
    a. Dependent Variable**:**
        1) Mode shift decision (0 = continues using private vehicle, 1 = shifts to bicycle)
    b. Independent Variables**:**
        1) X1: Gender – the sex of the respondent (male/female)
        2) X2: Age – the respondent's age (in years)
        3) X3: Occupation – respondent's main activity (student, lecturer, staff)
        4) X4: Income – monthly income level
        5) X5: Trip Purpose – the main reason for commuting (study, work, others)
        6) X6: Type of Vehicle – the type of private vehicle currently used (motorcycle/car)
        7) X7: Travel Frequency – number of trips made to campus per week
        8) X8: Need for a Bicycle – whether the respondent feels a personal need for a bicycle (yes/no)
6. **Data Analysis Technique**
After all data were collected, the data were compiled and categorized based on the required variables. The analysis was then conducted using SPSS version 25.0. The results of the analysis were discussed in accordance with the research objectives.

4. Result and Discussion

1. **Modal Shift Analysis Based on Sample Size**

The number of respondents who agreed to shift modes based on their characteristics can be seen in Table 1.

Table 1. Number of Respondents Who Agreed to Shift Modes Based on Their Characteristics

No	Respondent Characteristics	Category	Agreed to Use Campus Bicycle	Disagreed	Total
1	Gender	Male	38	6	44
		Female	51	5	56
2	Age	< 20	5	0	5
		20–30 yrs	63	10	73
		31–40 yrs	14	2	16
		> 40	7	0	7
3	Occupation	Student	55	5	60
		Lecturer	9	1	10
		Staff	25	5	30
4	Income (IDR)	< Rp. 500,000	2	0	2

		Rp. 500,000 – Rp. 1,500,000	35	7	42
		Rp. 1,500,000 – Rp. 2,500,000	31	1	32
		Rp. 2,500,000 – Rp. 5,000,000	8	2	10
		> Rp. 5,000,000	13	1	14
5	Trip Purpose	Studying	46	6	52
		Working	34	6	40
		Others	9	1	10
6	Vehicle Type	Motorcycle	64	8	72
		Public Transport/Bus	6	1	7
		Ride-Hailing Service	6	1	7
		Others (Car & Motor)	8	6	14
7	Trip Frequency	1–5 times/week	11	3	14
		5–10 times/week	44	4	48
		10–15 times/week	23	1	24
		> 15 times/week	4	1	5
8	Need for Bicycle	Needs	75	10	85
		Does not need	7	8	15

2. **Modal Shift Analysis Based on Vehicle Type**

Based on the modal shift analysis by vehicle type, it was found that 82% of private vehicle users—including motorcycle and car users—agreed to shift to using campus bicycles. This is illustrated in **Figure 1**.

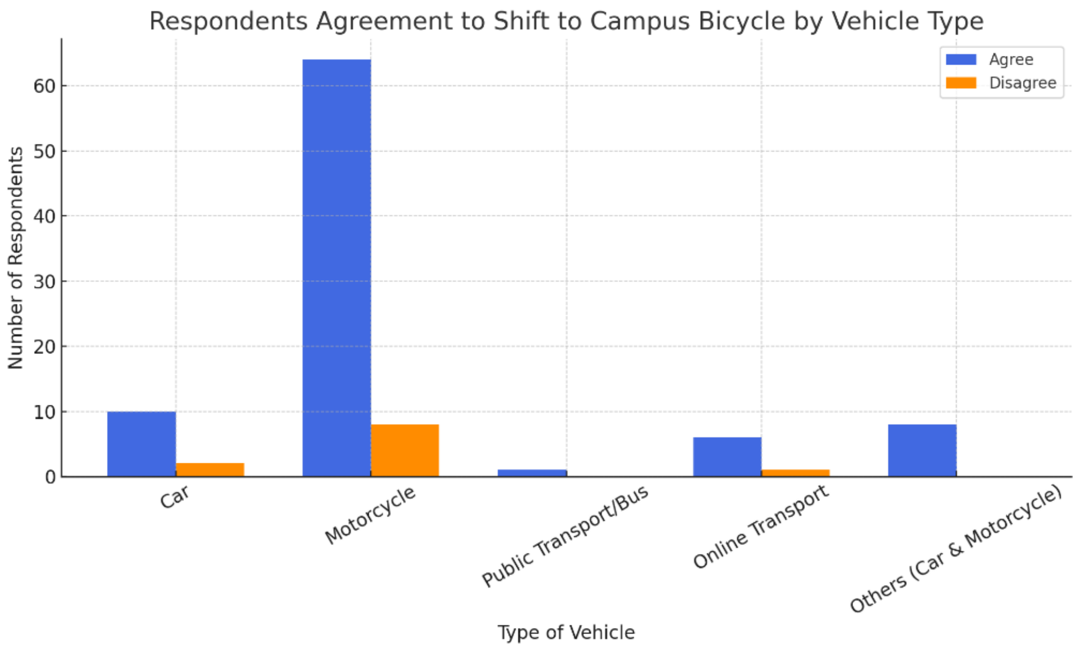

Figure 1. Number of Respondents Agreeing and Disagreeing to Shift to Campus Bicycles by Type of Vehicle Used

3. **Assumption Tests Prior to Binary Logistic Regression Analysis**

Before performing binary logistic regression, the data were subjected to preliminary assumption tests, commonly referred to as classical assumption tests, to assess the distribution characteristics of the dataset. The classical assumption tests applied in this study are as follows:

a. Normality Test

The results of the normality test are presented in Table 2.

Table 2. Normality Test

		Gender	Age	Occupation	Income	Vehicle Type	Trip Purpose	Trip Frequency	Need for bycycle	Agreed to shift model
N		100	100	100	100	100	100	100	100	100
Normal Parameters[a,b]	Mean	1,560	2,270	1,600	2,070	2,270	1,400	1,980	1,150	0,890
	Std. Deviation	0,499	0,827	0,804	1,174	1,033	0,492	0,910	0,359	0,314
Most Extreme Differences	Absolute	0,371	0,438	0,372	0,264	0,443	0,392	0,291	0,512	0,527
	Positive	0,309	0,438	0,372	0,264	0,443	0,392	0,291	0,512	0,363
	Negative	-0,371	-0,292	-0,228	-0,181	-0,277	-0,289	-0,189	-0,338	-0,527
Test Statistic		0,371	0,438	0,372	0,264	0,443	0,392	0,291	0,512	0,527
Asymp. Sig. (2-tailed)		.000[c]	.000[c]	.000[c]	.000[c]	.000[c]	.000[c]	.000[c]	.000[c]	.000[c]

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.

The key values to observe are found in the Kolmogorov-Smirnov and Asymp. Sig. (2-tailed) columns. If the asymptotic significance (Asymp. Sig.) value is greater than 0.05, the data are considered normally distributed. Conversely, if the value is less than 0.05, the data are not normally distributed. Based on the normality test results in Table 2, all variables showed an Asymp. Sig. value of 0.000, indicating that the data are not normally distributed. This non-normal distribution is attributed to the random sampling method used during data collection.

b. Linearity Test

The linearity test results are displayed in Table 3.

Table 3. Linearity Test

			Sum of Squares	Df	Mean Square	F	Sig.
Agreed to shift model	Between Groups	(Combined)	0,207	2	0,103	1,046	0,355
		Linearity	0,031	1	0,031	0,310	0,579
		Deviation from Linearity	0,176	1	0,176	1,782	0,185
	Within Groups		9,583	97	0,099		
	Total		9,790	99			

The focus is on the *Deviation from Linearity* row, specifically the F-value and its significance. If the significance value is less than 0.05, the relationship is considered non-linear; otherwise, it is linear. Based on the analysis shown in Table 3, the F-value obtained was 1.782, suggesting a linear relationship between the variables.

c. Multicollinearity Test

The purpose of the multicollinearity test is to detect whether a strong or perfect correlation exists among the independent variables (X). The results are shown in Table 4.

Table 4. Multicollinearity Test

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistic	
	B	Std. Error	Beta			Tolerance	VIF
1 (Constant)	1.421	0.200		7.115	0.000		
Gender	0.012	0.061	0.019	0.192	0.848	0.861	1.161
Age	0.023	0.076	0.060	0.303	0.763	0.206	4.863
Ocuppation	0.158	0.174	0.405	0.908	0.366	0.041	24.281
Income	0.032	0.042	0.121	0.768	0.444	0.332	3.009
Vehicle Type	0.027	0.028	0.087	0.953	0.343	0.976	1.024
Trip Purpose	-0.349	0.346	-0.546	-1.009	0.316	0.028	35.748
Trip Frequency	-0.024	0.032	-0.068	-0.730	0.467	0.940	1.063
Need for bycycle	-0.388	0.086	-0.443	-4.513	0.000	0.850	1.177

Key indicators include the Tolerance and Variance Inflation Factor (VIF) values. If the tolerance is greater than 0.01 and the VIF is less than 10, there is no multicollinearity; otherwise, multicollinearity is present. The analysis results indicated no multicollinearity issues in the dataset.

d. Autocorrelation Test

The autocorrelation test aims to identify correlations between residuals of one observation period and another. The test results are summarized in Table 5.

Table 5. Autocorrelation Test

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	,504[a]	0,254	0,189	0,28328	0,987

The main indicator is the Durbin-Watson statistic. If the value is close to 2, there is no autocorrelation; values significantly lower or higher than 2 indicate potential autocorrelation. Based on the results in Table 5, the Durbin-Watson value was 0.987, indicating that no autocorrelation was detected in the data.

4. Binary Logistic Regression Analysis

To determine the factors that influence respondents to shift to using bicycles, a binary logistic regression analysis is required. The results of the binary logistic regression analysis can be seen in Table 6.

Table 6. Result of binary logistic regression analysis

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Jenis Kelamin	0.142	0.892	0.025	1	0.874	1.152
	Gender	-0.137	0.818	0.028	1	0.867	0.872
	Age	1.398	2.343	0.356	1	0.551	4.049
	Ocuppation	0.669	0.798	0.703	1	0.402	1.952

	Income	0.504	0.546	0.855	1	0.355	1.656
	Vehicle Type	-3.352	4.611	0.528	1	0.467	0.035
	Trip Purpose	-0.332	0.407	0.662	1	0.416	0.718
	Trip Frequency	-2.858	0.831	11.829	1	0.001	0.057
	Need for bycycle	6.732	3.126	4.638	1	0.031	839.067

From the analysis above, it can be seen that only one independent variable (X) has a significant effect on the dependent variable (Y), which is the variable **"Need for a Bicycle"**. An independent variable is considered to have an influence on the dependent variable if the significance value is < 0.05 or < 5%. The "Need for a Bicycle" variable has a significance value of 0.001, meaning that Ho ($\beta = 0$) is rejected, indicating that the variable "Need for a Bicycle" (X8) has a positive influence on the willingness to shift. Meanwhile, variables with a significance value > 5% have Ho accepted, meaning they do not influence the willingness to shift.
The variables that do not influence the willingness to shift include:

a. Gender (X1)
b. Age (X2)
c. Occupation (X3)
d. Income (X4)
e. Type of Vehicle (X5)
f. Purpose of Trip (X6)
g. Trip Frequency (X7)

After identifying the significant independent variable, the next step is to determine the logit function, which is used to estimate the probability of the binary logistic model for the significant variable, using Equation 1:

Logit (p) = *constant* – coefficient of significant variable
= *constant* – X8
= 6,732 – 2,858
= 3,874

After determining the odds value of the modal shift, the probability that the "Need for a Bicycle" variable influences the shift from motorized vehicles to bicycles is calculated using Equation 2:

$$P = \frac{1}{1+exp^{-\,logit\,(p)}}$$

$$P = \frac{1}{1+exp^{-\,3,874}}$$

$$= 0,9796 \approx 97,96\ \%$$

From the calculation above, it can be concluded that the "Need for a Bicycle" (X8) variable influences the modal shift from motorized vehicles to bicycles by 97.96%.

5. Conclusion

This study concludes the following:

1. The dominant characteristics of motor vehicle users on the Universitas Muhammadiyah Yogyakarta (UMY) campus are female individuals aged between 21 and 30 years. Most respondents are students with a monthly income ranging from IDR 1,500,000 to IDR

2,500,000. Motorcycles are the primary mode of transportation to campus, primarily for academic purposes. Respondents reported a travel frequency within the campus of 5 to 10 times per week and expressed a need for bicycles to support their mobility on campus.
2. The proportion of respondents indicating a modal shift from private motorized vehicles to bicycles is 82%, corresponding to 82 individuals out of the total sample.
3. The prerequisite tests for analysis yielded the following results:
   a. The normality test indicated that the data are not normally distributed.
   b. The linearity test showed that five variables exhibit linear relationships: age (X2), occupation (X3), income (X4), type of vehicle (X5), and travel frequency (X7). Meanwhile, three variables—gender (X1), travel purpose (X6), and the need for a bicycle (X8).
   c. The multicollinearity test revealed no multicollinearity issues in the data.
   d. The autocorrelation test confirmed the absence of autocorrelation.
4. Based on the binary logistic regression analysis, the most influential factor affecting the modal shift to campus bicycles is the need for a bicycle (variable X8), with a significance level of 97.96%.

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