Modeling motorcycles dependency for commuting among low-income communities in Yogyakarta, Indonesia: The perspective of the theory of planned behavior

Nindyo Cahyo Kresnanto [a,*], Wika Harisa Putri [b], Rini Raharti [c]

[a] *Janabadra University, Department of Civil Engineering, Yogyakarta 55231, Indonesia*
[b] *Janabadra University, Department of Accounting, Yogyakarta 55231, Indonesia*
[c] *Janabadra University, Department of Development Economics, Yogyakarta 55231, Indonesia*

ABSTRACT

The high degree of reliance on motorcycles for daily commuting in low-income communities of the Special Region of Yogyakarta has emerged as a pressing transportation issue, stemming from economic disparities that have led many low-income individuals to experience transport or mobility poverty, further constricting their overall mobility. This reliance on motorcycles as the predominant mode of transport demands attention, as it conflicts with the principles of sustainable mobility. The present study collected survey data from 430 respondents in order to explore this phenomenon. The study then examined socioeconomic conditions, mobility patterns, and behavioral factors among the respondents using the theory of planned behavior (TPB) framework, with the structural equation model (SEM) serving as the analytical tool. The findings of the study reveal that cost savings, time efficiency, and societal factors exert a significant influence on the high reliance of low-income communities on motorcycle use. These findings underscore the practicality and affordability of motorcycles, which, in the absence of viable alternatives, become the primary mode of daily commuting.

1. Introduction

In the Special Region of Yogyakarta, a prominent transportation-related issue pertains to the high rate of motorcycle ownership and usage. In this context, motorcycles serve as the primary mode of transport and daily commuting, particularly for work and school (Kresnanto & Wicaksono, 2021). This phenomenon can be attributed to economic inequality, which compels certain communities to experience transport or mobility poverty. Transport poverty can be further explained as a condition that engenders specific communities to have limited mobility due to the following factors: (1) a significant distance between the community's residences and the hub of activity, otherwise known as geographical disadvantage; (2) a lack of access to transportation infrastructure, otherwise known as transportation disadvantage; and (3) low income, otherwise known as social disadvantage (Lucas, 2012; Lucas et al., 2016).

As previously mentioned, social disadvantages are a contributing factor to transport or mobility poverty. A particularly salient concern is the tendency of low-income or socially disadvantaged communities, who are employed or enrolled in educational institutions in urban areas, to reside in suburban areas, where housing is more affordable (Kahachi & Brown, 2021; Rahmadaniyati et al., 2016). This phenomenon is referred to as a "spatial mismatch," which occurs when an individual with low income must travel longer distances to reach their place of employment or the center of activity (Titheridge et al., 2014). In such cases, the distance from a major metropolitan region or hub can be significant, potentially leading to a greater isolation from physical transportation infrastructure, such as the road networks, and from public transportation services. These services, if available, could serve as an alternative mode of mobility. Consequently, low-income communities face a dual burden of transportation and geographical disadvantages. This predicament forces these communities to rely on motorcycles, which, while more practical and cost-effective (Herwangi et al., 2015, 2017), contributes to exacerbating traffic congestion and overcrowding on roads, especially during peak hours.

It is essential to direct particular attention to the issue of low-income populations' reliance on motorcycles as their primary mode of transportation, as this practice stands in direct opposition to the fundamental

principles of sustainable mobility. The cornerstone of sustainable mobility is predicated on the objective of reducing the usage of private automobiles, a practice that has been identified detrimental to the environment and a significant contributor to air pollution (Hou et al., 2022). While the prevailing narrative attributes the decision to opt for a motorcycle to a lack of alternatives, the employment of a behavioral theory-based approach is arguably essential to accurately quantify the extent of this dependency. Therefore, this study was designed to examine behavioral variables such as habits, self-identity, moral principles, and individual norms within the community. These variables were selected based on a preceding study by Pojani and Stead that investigated into the adoption of sustainable mobility in low-income communities (Pojani & Stead, 2015) The study's findings are expected to provide insights that will assist stakeholders and transportation policy makers to promote inclusivity in transportation (Ajzen, 1991a, 2011). It is noteworthy that recent studies have already adopted this theoretical framework to investigate sustainable transportation from a variety of perspectives (Ibrahim et al., 2020; Irtema et al., 2018; Pojani et al., 2018; Ru et al., 2019).

Despite extensive research on transportation and mobility challenges, there has been limited attention paid to understanding the behavioral and societal factors contributing to motorcycle dependency in low-income communities, particularly in relation to economic inequality and transport poverty. The present study aims to address this gap by employing the TPB to analyze the interplay between attitudes, subjective norms, and perceived behavioral control in shaping transportation mode choices. By focusing on these behavioral dimensions, the study provides valuable insights into the systemic issues influencing mobility decisions and offers a framework to inform more inclusive and sustainable transportation policies.

The primary limitation of this study is its focus on low-income communities in the Special Region of Yogyakarta. This geographic context may restrict the generalizability of the findings to other regions with different socioeconomic and infrastructure conditions. Furthermore, the reliance on self-reported data via questionnaires may have introduced response bias or oversimplified complex behavioral factors. To enhance the rigor of future research in this area, it is recommended that researchers expand the scope by exploring different urban and rural environments, integrating longitudinal data to capture time-based behavioral changes, and using geospatial analysis to provide more profound insights into transportation behavior.

2. Transport/mobility poverty

The high cost of transportation is indicative of economic disparity within a population. Transportation affordability, in contrast, refers to an individual's capacity to conveniently access critical services and needs, such as commuting to work, receiving medical attention, attending school, making basic purchases, and socializing (Litman, 2014). Individuals experiencing social disadvantages frequently encounter additional challenges, including limited transportation affordability, given their residence in distant locations away from activity center. The decision to reside in areas distant from activity centers is often influenced by factors such as cost, which can be compounded by limited income, underemployment due to skill deficiencies, and poor health (Sharghi et al., 2021). Fig. 1 below presents a geographical plotting of housing in Yogyakarta, converted based on data collected from https://www.reijogja.or.id/register-perumahan.

As previously delineated, low-income populations face geographic disadvantages due to their housing's distance from activity center, necessitating greater travel time expenditure. This elevated transportation cost burden is a salient concern, particularly in low-income communities where it is often disproportionately high compared to moderate- or high-income communities (Wassmer & Baass, 2006). The disparity persists, with transportation expenses constituting approximately 8.35 % of total monthly expenditures for low-income communities within Yogyakarta's Non-Transport Disadvantage Area (NTDA) (Herwangi, 2018). This proportion considerably increases for low-income communities located within the Transportation Disadvantaged Area (TDA), where it reaches 20.90 % of total monthly expenses
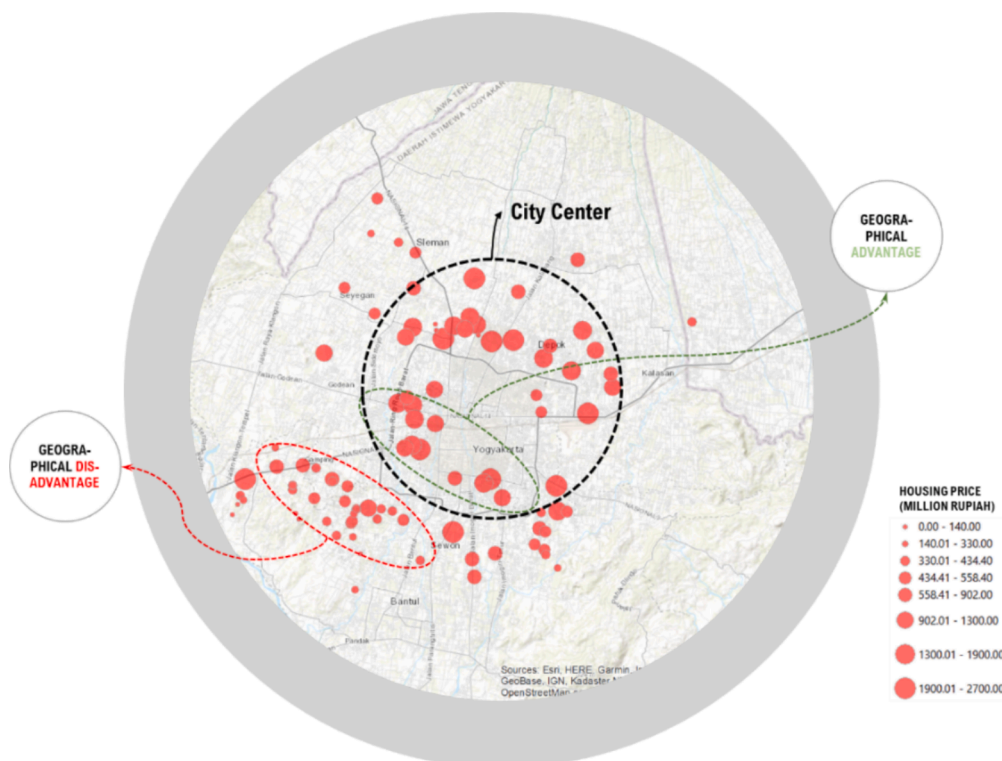

Fig. 1. Spatial distribution of housing location in Yogyakarta.

(Herwangi, 2018). Fig. 2 elucidates the issue of transportation inequality, as previously explained.

The situation has led to a significant reliance on efficient yet economical private vehicles, which are often motorcycles, by low-income communities. Notably, motorcycle ownership is particularly prevalent in Asian countries, accounting for approximately 77 % of global motorcycle ownership. This is largely due to the perception of motorcycles as an alternative, affordable and efficient mode of transportation (Bastos et al., 2020).

3. Theory of planned behavior in the context of transportation

The theory of planned behavior (TPB) is a psychological theory that links beliefs with behavior. Developed by Ajzen (1991b), the TPB posits that three core components—attitudes, subjective norms, and perceived behavioral control—constitute an individual's behavioral intention. The TPB has found extensive application in various fields, as a means of predict behavior (adjustment theory or application) (Bosnjak et al., 2020) including transportation behavior (Forward, 2004; Heath & Gifford, 2002; Parkany et al., 2004).

A number of studies in the domain of transportation have employed the TPB as a methodoligical framework to examine the behavior of mode usage intentions. A study by Ansori et al. (2023) that investigated public intentions towards autonomous vehicles (AVs) in Indonesia applied the TPB to understand acceptance levels for both partially and fully autonomous vehicles. A comparative study by Zheng et al. (2023) examined green transportation behaviors in Beijing, Tokyo, and Klang Valley. The TPB was utilized to analyze how attitudes, subjective norms, and perceived behavioral control influenced intentions to engage in eco-friendly travel. Aditya et al. (2024) conducted a study examining the adoption of electric motorcycles in Indonesia, once more using the TPB as an analytical framework. This study found that older individuals with higher levels of education and income were more likely to adopt electric motorcycles. These examples demonstrate the efficacy of the TPB in informing transportation analysis by identifying key psychological factors that influence individual decisions regarding transportation-related choices.

The theory of planned behavior (TPB) has traditionally served as the prevailing theoretical framework for studying transportation mode selection. It has been employed in a variety of studies exhibiting different degrees of complexity and predictability (Ajzen, 1985). The TPB posits that humans decisions are influenced by multifaceted set of factors, including attitudes, subjective standards, and perceived behavioral restrictions. The term "attitude" is defined as psychological feelings influenced by the belief in the repercussions of one's actions, whether positive or negative. Individual perceptions of expectations to have a significant impact on significant individuals in life are referred to as subjective norms. An individual's impression of the potential ease or difficulty of engaging in a certain activity is considered to represent their perceived behavioral control (Ajzen, 1991a).

In a study conducted by Bandyopadhyaya (2022), the modified TPB was used to ascertain the public's intention to use public transport. The study's findings indicated that behavioral beliefs, such as awareness of the potential to alleviate traffic congestion through public transport use, subjective norms and normative beliefs, such as the influence of family and closest people's encouragement to use public transportation, and control beliefs, such as the quality of public transportation (safety, comfort, and time savings), significantly influence the intention to use public transport (Bandyopadhyaya & Bandyopadhyaya, 2022) It has been observed that an individual who believes that a certain behavior will lead to positive outcomes will have a favorable attitude toward performing said behavior, and vice versa (Ajzen, 1985).The TPB has proven to be a reliable explanatory model in the context of mode use behavior, as evidenced by a case study conducted by Bertazzo (2020). In this study, the TPB was employed to investigate the influence of psychological factors on mode choice in school trips (Bertazzo et al., 2020).

A case study in Iran, conducted by Ehteshamrad (2022), employed a structural equation model based on the TPB. This model incorporated constructs, such as perceived behavioral control, subjective norm, and attitude factors, with the objective of examining the intention of parents and children to use public transport. The study's findings suggest that attitude, norm, and perceived behavior control (PBC) shape intention, which in turn directly leads to a specific behavior (Ehteshamrad et al., 2022). The study's findings, based on the TPB, indicated that cognitive aspects of the behavior mereged as the strongest predictor of public transport usage, followed by public transport infrastructure accessibility as the second predictor of the behavior.

In the context of Indonesia, a case study conducted by Zudhy (2020) employed the theory planned behavior, modeled through structured equation modeling, to analyze the phenomenon of the shifting tendency of air passengers to car mode due to the presence of the Trans Java Toll Road and increased airfare on Java Island (Zudhy et al., 2020). The study demonstrated that the TPB effectively indentified factors that significantly influenced mode of choice behavior. These factors included socioeconomics factors, such as gender, age, income, and air travel frequency (Table 1).
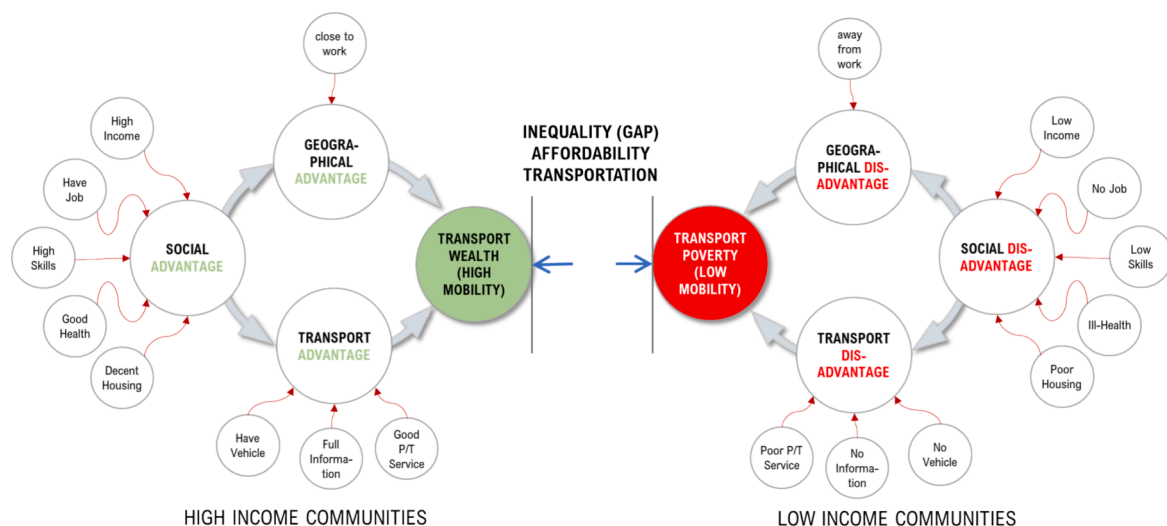

Fig. 2. Transportation inequality within the population.

Table 1
TPB Variables and the Derived Questionnaires.

Latent Variable	Type of Variable	Manifest Variable	Manifest Variable Measurement Questions
Opinions regarding the usage of motorcycles for commuting (*attitude*)	Exogenous	0A.1. Time Savings 0A.2. Cost Savings 0A.3. Mode flexibility 0A.4. Punctuality 0A.5. Comfortability	0A.1. Riding a motorcycle saves time. 0A.2. Riding a motorcycle reduces transportation costs. 0A.3. Riding a motorcycle allows for greater flexibility during travel. 0A.4. Riding a motorcycle ensures timely arrival at destinations. 0A.5. Using a motorcycle contributes to enhanced comfort during travel.
Opinions of family members, close friends, supervisors, and coworkers regarding the usage of motorcycles for commuting (subjective norm)	Exogenous	0S.1. Immediate family consent 0S.2. Family permission 0S.3. Community norm	0S.1. My family, close friends, boss, and coworkers have acknowledged the convenience of my motorcycle commuting to work/school/other daily activities. 0S.2. People around me have expressed their consent for me to use the motorcycle for work, school, and other daily trips. 0S.3. Most individuals, including myself, would prefer to ride a motorcycle to get to work/school/other everyday activities.
Behavioral control of motorcycle use (perceived behavioral control)	Exogenous	0P.1. No available alternative 0P.2. Transit facility 0P.3. Ability to use public transport-ation	0P.1. I do not have any alternatives to motorcycles for transportation. 0P.2 Public transportation is not available in my neighborhood. 0P.3. I am confident in my ability to ride competently and safely for daily commuting.
Behavioral intention to ride a motorcycle (behavior intention)	Endogenous	0B.1. Requirement 0B.2. Intention	0B.1. I intend to use the motorcycle for daily commuting (work/school/other). 0B.2. I intend to use the motorcycle for daily transportation (work/school/other).

4. Methodology

4.1. Respondents

The respondents were selected randomly from the population of Special Region of Yogyakarta, abbreviated as DIY (*Daerah Istimewa* Yogyakarta in Indonesian). The Slovin formula was used to determine the minimum required sample size (Susanti et al., 2019). Based on this formula, if the population at the time of survey implementation was 4,021,816 (source: BPS DIY 2022), with a margin of error of 5 %, then the minimum sample size should be 399 ≈ 400. The sampling design aimed for even distribution across DIY, with a particular focus on respondents from low income groups. To ensure accurate targeting of this demographic, the sampling distribution was informed by an analysis of the proportion of the population with an undergraduate degree in the districts within the region (Fig. 3), operating under the assumption that educational attainment exerts a significant influence on income levels (Bartik & Hershbein, 2018; Stryzhak, 2020).

4.2. Questionnaire of respondent characteristic and transport behavior

The data were collected via questionnaire, with the question items pertaining to the respondents' socioeconomic situation and the impact of behavior variables on their usage of motorcycles as their primary mode of transportation. The questionnaire incorporated a series of characteristic questions, including: (1) residential address, which was collected to measure and analyze spatial distribution; (2) employment and education; (3) monthly income data, which were collected to examine the correlation between the income and mobility patterns; and (4) mobility patterns data, including private vehicle ownership and daily travel activities.

The questionnaire was specifically designed to elicit information regarding behavioral variables that were hypothesized to exert a significant influence on the selection of transportation modes within these communities. The assessment of latent behavioral variables was facilitated by the utilization of question items derived from the TPB. Furthermore, the respondents were requested to respond to the questionnaire based on their personal preferences for a particular statement. The measurement of the respondents' preferences was conducted using a 5-point Likert scale, 1 representing "strongly disagree", 3 representing "neutral", and 5 representing "strongly agree."

4.3. Structural equation model for analysis

This study included several factors that could not be studied directly through descriptive techniques or correlation analyses. To address these limitations, the structural equation model (SEM) was employed to analyze the data. The SEM integrates factor analysis and multiple regression analysis to ascertain the structural interelationship between measured variables and latent constructs. This approach was adopted because it enables the assessment of multiple interconnected dependencies in a single study. This study incorporated both endogenous and exogenous variables. Endogenous variables are equivalent to dependent variables since both have the same value as the independent variable (Carrasco, 2010; Civelek, 2018; Ferdinand, 2006).

The SEM is a statistical technique that is used to examine the relationship between observed variables and unobserved (latent) constructs within a theoretical framework (Dash & Paul, 2021). It combines factor analysis and regression, allowing for the testing of complex models. The SEM consists of a measurement model that relates latent variables to observed indicators and a structural model that explores the relationships among latent variables. Results are interpreted using path coefficients (strength and direction of relationships) and significance levels (Hair et al., 2021; Knoke, 2004). This methodological approach offers a sophisticated strategy for the analysis of multidimensional relationships, thereby providing more profiund insights than traditional statistical methods.

The SEM has been widely used in the analysis of human behavior related to transportation. This includes the observation of general travel behavior (Golob & Golob, 2001), the analysis of individual preferences and behaviors concerning the use of public transportation (Aditjandra et al., 2016; Ashraf Javid et al., 2021) and pedestrian behavior (Zhou et al., 2016), and the study of the association between housing prices and accessibility (Nurlaela, 2018). The SEM is also employed to
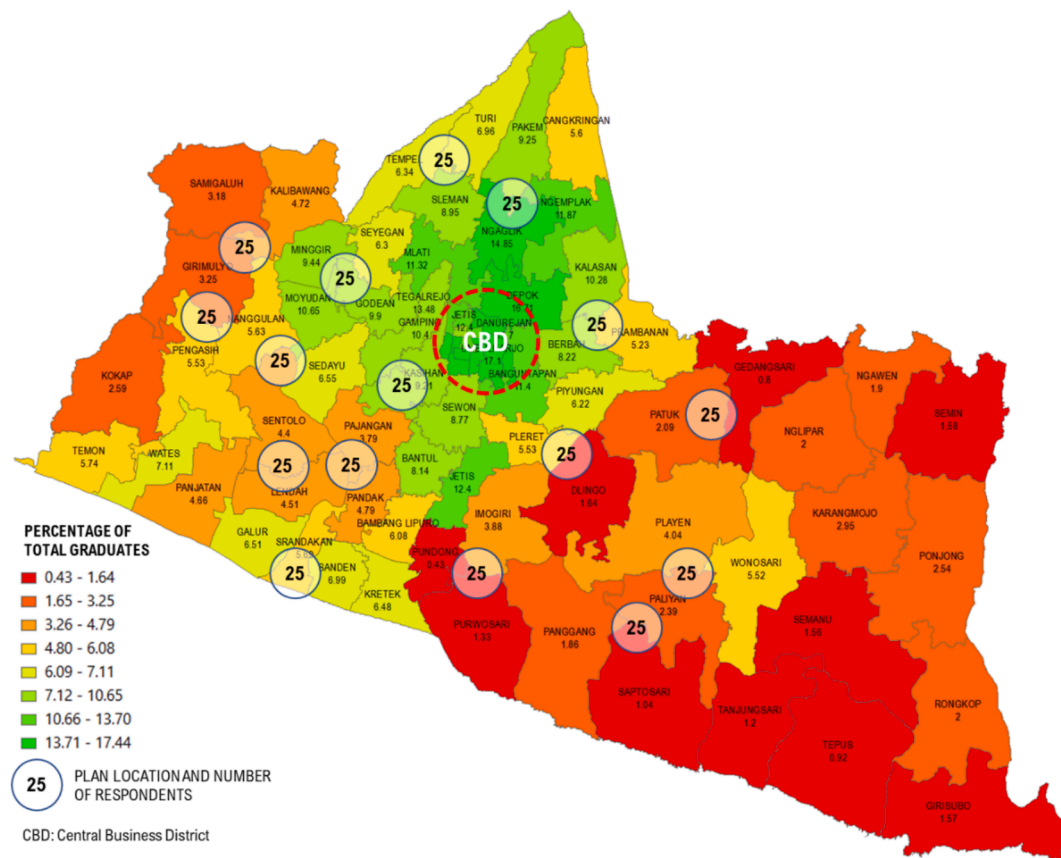
Fig. 3. Planned location and number of respondents.

investigate the effect of attitudes, subjective norms, and perceptions of behavioral control on physical activity intentions and behavior. The present study also included the behavior of the individual in taking the main routes on a daily basis.

5. Results and discussion

5.1. Characteristics of respondent mobility

The respondents of this study were residents of 50 districts in the DIY who commuted daily from their residences to the hub to get to work or school, as well as to acquire essential goods and services (Yogyakarta Urban Agglomeration or Central Business District (CBD)). A random

purposive sampling was used as the sampling method. It should be noted that several districts contributed the highest number of respondents. These districts incldued Ngaglik (Sleman Regency), Pleret (Bantul Regency), and Pengasih (Kulonprogo Regency). The distribution of the number of respondents within each district is outlined in Table 2 and Fig. 4.

Fig. 4 demonstrates that low-income communities were more dispersed spatially, with a greater distance from urban areas (Yogyakarta City and Sleman Regency) in comparison to middle- or high-income communities. This data further substantiates that low-income communities exhibit a higher population density compared to those in the middle-income and high-income categories.

The distribution of respondents based on educational attainment

Table 2
Number of Respondents per District.

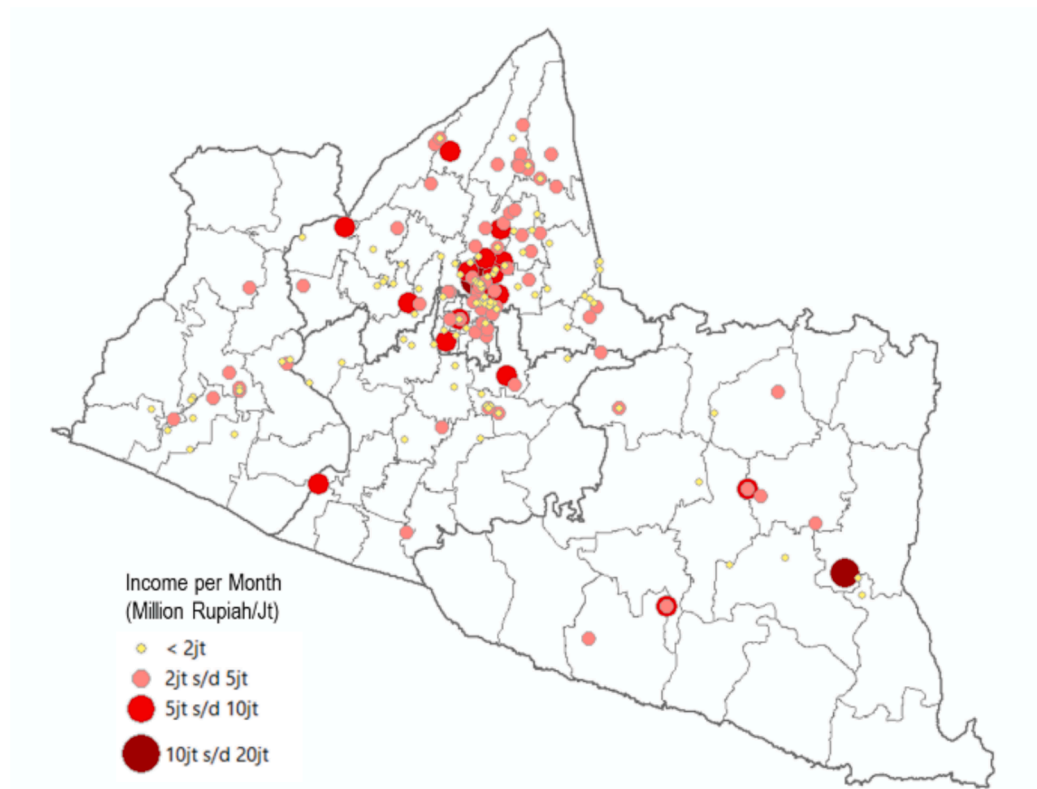| No	District	Number of Respondents	No	District	Number of Respondents	No	District	Number of Respondents
1	Banguntapan	4	18	Mantrijeron	1	35	Prambanan	8
2	Bantul	2	19	Mergangsan	1	36	Rongkop	3
3	Berbah	1	20	Minggir	2	37	Sapto Sari	3
4	Cangkringan	3	21	Mlati	3	38	Sedayu	10
5	Danurejan	3	22	Moyudan	1	39	Semanu	2
6	Depok	32	23	Ngaglik	14	40	Sentolo	3
7	Gamping	5	24	Ngampilan	1	41	Sewon	2
8	Gedong Tengen	1	25	Ngemplak	5	42	Seyegan	2
9	Girimulyo	1	26	Nglipar	2	43	Sleman	1
10	Godean	10	27	Pakem	11	44	Srandakan	1
11	Gondokusuman	4	28	Panjatan	1	45	Tegalrejo	3
12	Imogiri	1	29	Patuk	2	46	Temon	1
13	Kalasan	2	30	Pengasih	13	47	Tempel	3
14	Karangmojo	7	31	Piyungan	2	48	Turi	1
15	Kasihan	3	32	Playen	1	49	Umbulharjo	5
16	Kraton	1	33	Pleret	18	50	Wates	4
17	Kretek	1	34	Ponjong	1			

Fig. 4. Spatial distribution of respondents based on their income.

reveals that the majority (62.30 %) possess a high school (SMA/SMK) diploma or its equivalent, followed by those with an undergraduate (S1) degree (27.32 %). The remaining respondents have completed elementary school (SD), junior high school (SMP), an associate degree, or a postgraduate (S2) degree (Fig. 5a).

The majority of respondents reported an income of less than 2 million rupiahs per month, equivalent to approximately USD 128 (Fig. 5b). This variable demonstrated a precise correlation with the primary research objectives, which aimed to prioritize underprivileged communities. The remaining 35.52 % of respondents reported earnings between 2 and 5 million rupiahs (approximately USD 128 to 318) per month, while the remaining 8.20 % of respondents reported earnings between 5 and 10 million rupiahs (approximately USD 318 to 635) per month. The smallest percentage of respondents reported an income of more than 10 million rupiahs (approximately USD 635) per month,

constituting 1.09 % of the total sample.

The data on respondents' characteristics by occupation (Fig. 6) indicates that the largest group of respondents were private sector employees, accounting for 34.68 % of the total. This was closely followed by students, who constituted 36.58 % of the respondents. The proportion of self-employed individuals was 9.50 %, while freelance workers accounted for 7.36 %. Factory workers and employees comprised 5.23 % of the respondents, and government employees accounted for 1.66 %. The remaining respondents were engaged in a variety of other occupations, including teachers or lecturers (2.38 %), banking professionals (0.24 %), and doctors or health workers (0.24 %), as well as other professionals such as accountants, notaries, lawyers, and pharmacists (1.19 %). This distribution highlights the diversity in employment types among the respondents, with a notable predominance of private-sector employees and students.
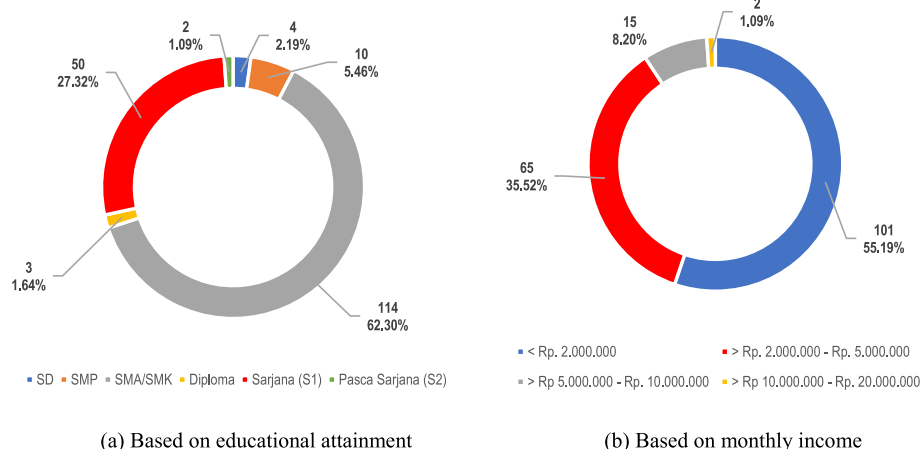

(a) Based on educational attainment

(b) Based on monthly income

Fig. 5. Characteristics of respondents based on (a) educational attainment and (b) monthly income.
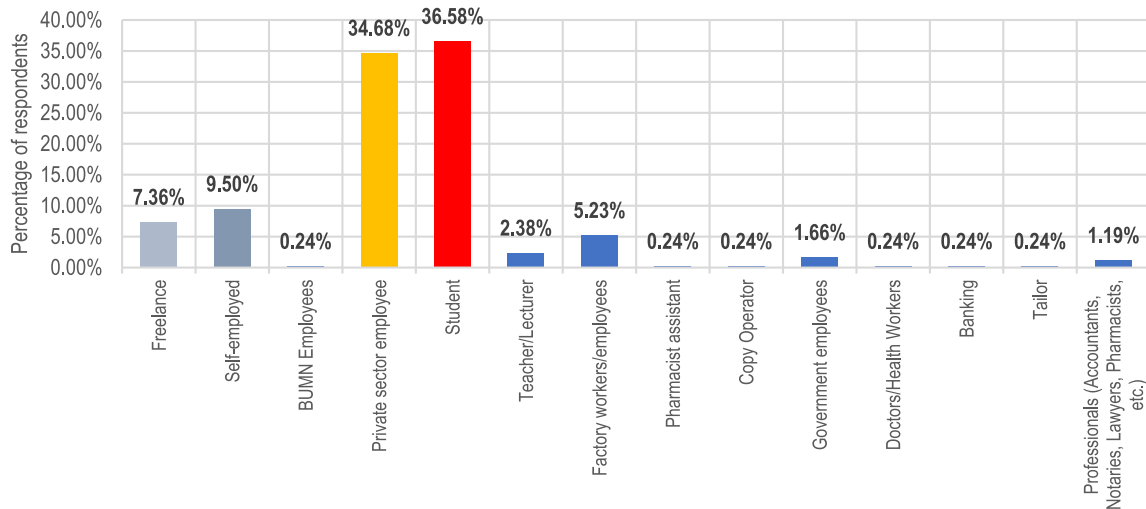
Fig. 6. Characteristics of respondents by occupational categories.

The access to transportation is structured as follows: first, private vehicle ownership; second, the ability to access public transportation. In the context of this study, the ownership of a private vehicle for daily necessities was one variable that must be taken into strong consideration. The results of the questionnaires indicated that the majority of households possessed three motorcycles, as indicated by 33 % of respondents, followed by two motorcycles, reported by 32 % of respondents. Additionally, 65 % of repondents indicated that they did not own a car, while 28 % reported owning only one car. Fig. 7 provides a visual representation of the respondents' transportation characteristics. According to the type of vehicle owned, nearly 92 % of respondents reported a preference for regular travel by motorcycle.

Fig. 8a further elucidates the frequency of transportation mode used for daily commutes, with 92.2 % of respondents opting for motorcycle commuting, 2.48 % opting for car commuting, and the remaining repondents exhibiting varied responses. Furthermore, the data indicate that over 43.62 % of respondents reported never using public transportation as their primary mode of transportation, with 48.94 % indicating that it was uncommon for them to do so (Fig. 8b). These findings suggest that public transportation is not considered a primary mode of transportation for the majority of respondents on a daily basis.

The survey respondents reported varying distances from their residences to workplace or school. The majority of respondents commuted between 5 and 20 km daily (Fig. 9a), with an estimated daily cost

ranging from 7,500 to 20,000 rupiahs (equivalent to approximately USD 0.50 to 1.27) (Fig. 9b). The survey results indicated that the majority of respondents engaged in activities related to commuting, such as going to work or school, during the average period between 6:00 and 9:00 am. Furthermore, the survey results demonstrated that the period with the highest number of commuters was observed to be 7:00 am (Fig. 10).

5.2. Motorcycle dependency model

5.2.1. Theory of planned behavior

The TPB, integrated with a structural model analysis tool, was used as an approach to ascertain the level of reliance on primary transportation mode selection. Latent variables—attitudes, subjective norms, perceptions of control behavior and behavioral intentions—were measured by certain manifest variables. In this case, it was hypothesized that mobility values would have a significant influence on the attitude of daily travel mode choice behavior (Kováčiková et al., 2018), such as efficiency, affordability, flexibility, reliability, and convenience. It was also hypothesized that subjective norms in mode selection would be significantly influenced by the perception of the closest environment to the selection made. Furthermore, it was assumed that intention would be influenced by control variables measured by several manifest variables, such as the presence or absence of alternative modes, the affordability of public transport facilities, as well as financial resources
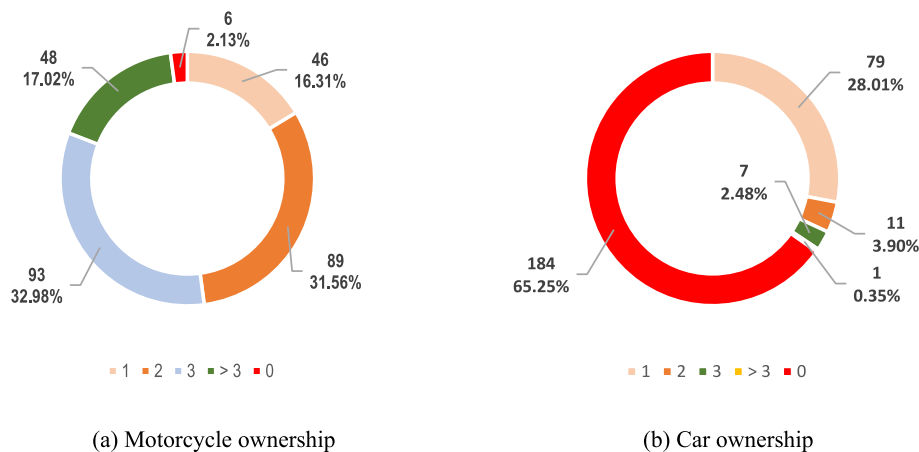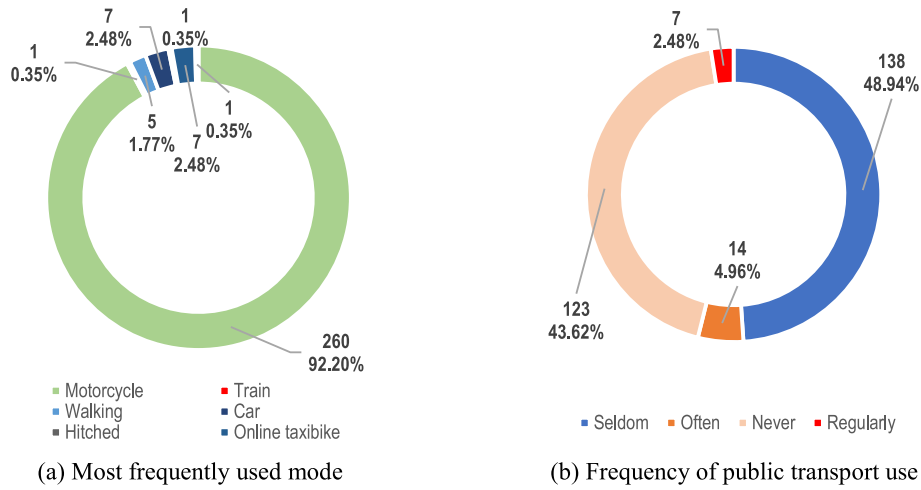

(a) Motorcycle ownership   (b) Car ownership

Fig. 7. Respondent's vehicle ownership.

(a) Most frequently used mode

(b) Frequency of public transport use

Fig. 8. Frequency of use of daily mode and public transportation.
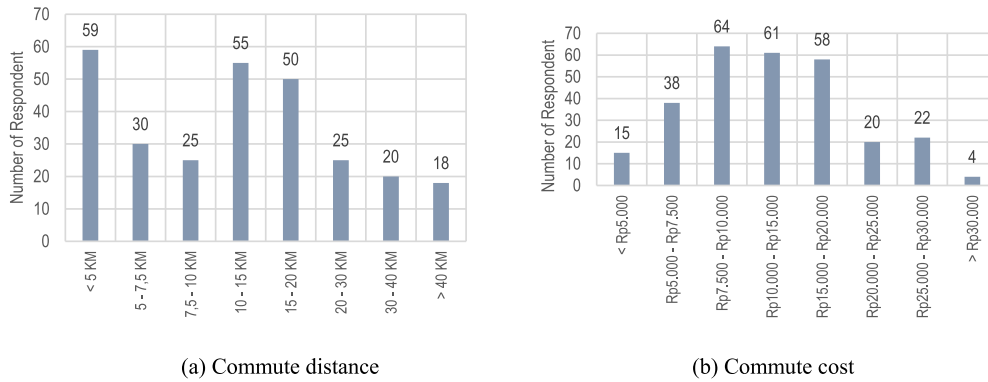

(a) Commute distance

(b) Commute cost

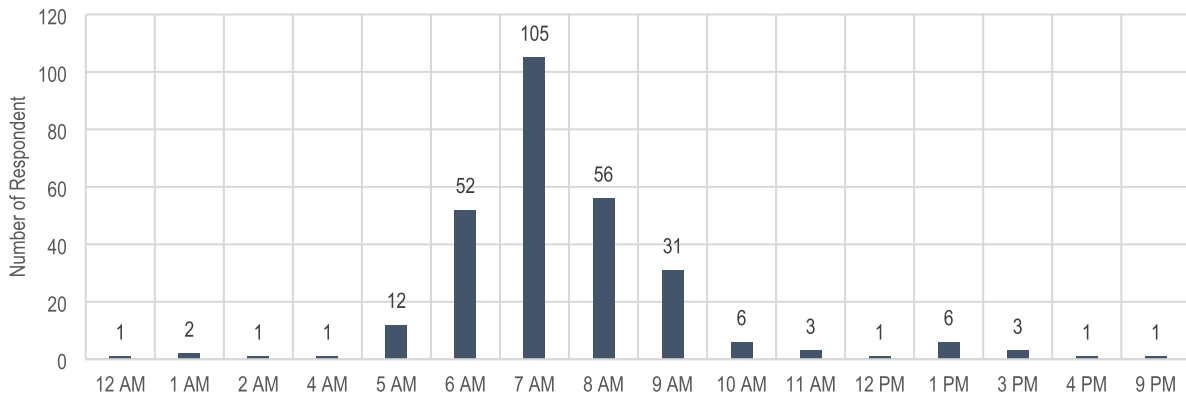**Fig. 9.** Distance and cost of respondents' daily commutes.

Fig. 10. Distribution of the times of respondents' commutes to work or their daily activities.

(Fig. 11).

The results of the SEM analysis yielded 334 filtered data points from 430 respondents. The relationship between the attitude variable, subjective norm, and PBC was found to be significant for the intention variable, as indicated by a T-statistic greater than 1.96 and a p-value less than 0.05. The SEM analysis of the effect of behavior on the intention to use a motorcycle, as depicted in Fig. 12, elucidates that the influence of the surrounding environment and close relatives prevails over behavioral dependence, as evidenced by the path-coefficient of 0.531 on the

relationship between subjective norms and intentions.

The results of the SEM analysis have corroborated the study by Herwangi (2018), which examined the factors contributing to motorcycle dependency, especially among low-income residents, in the urban area of DIY. The study identified spatial and socio-economic factors as significant contributors to motorcycle dependency among low-income residents. Furthermore, the study highlighted that limited public transportation services and urban forms cause high dependence on motorcycles (Fevriera et al., 2021). However, the study by Herwangi did
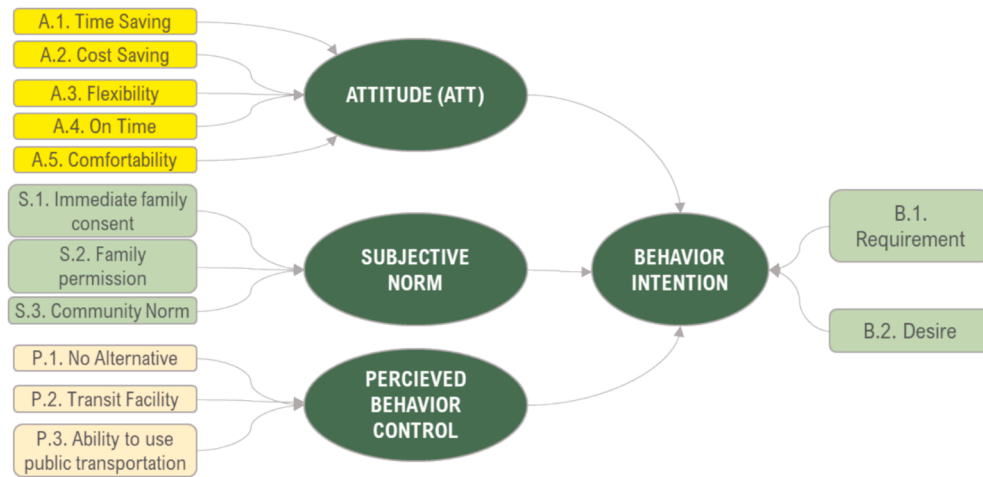
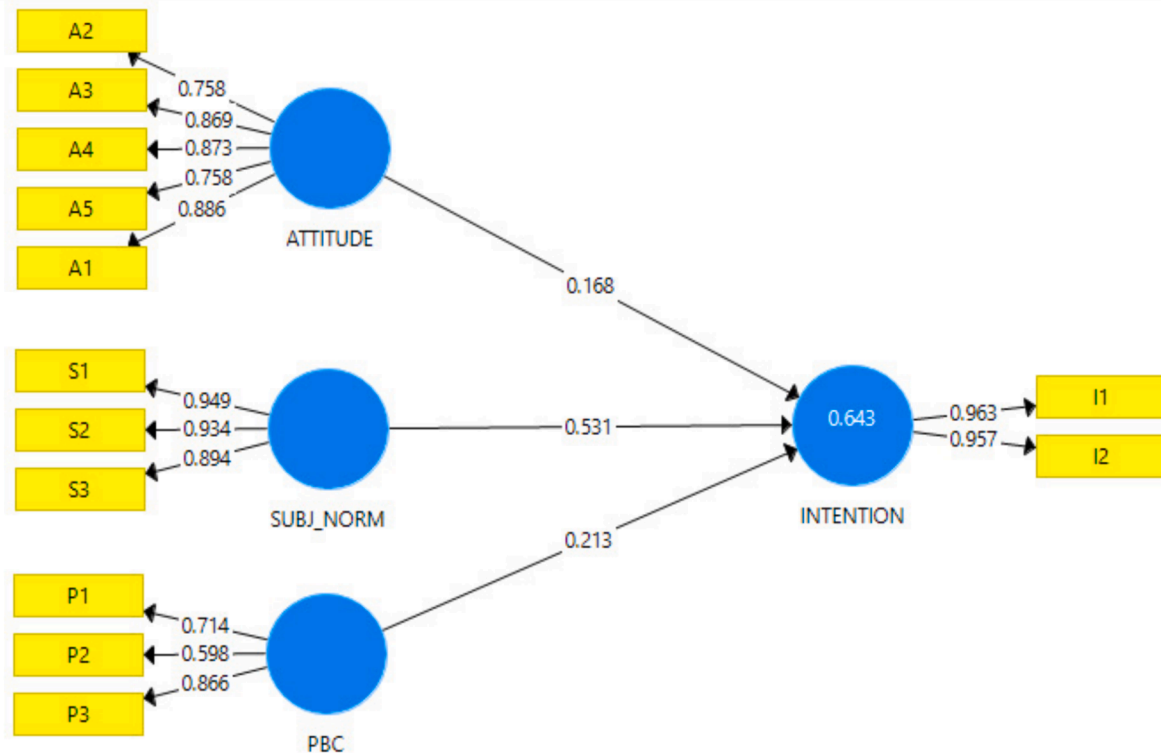**Fig. 11.** Structural model proposed for society mode dependency.

Fig. 12. Results of the SEM analysis of the dependence behavior of motorcycle use among commuters.

not incorporate behavioral variables and social influences.

Another study, which focused on factory workers in Sukabumi Regency, a region with predominantly low-income population, revealed that the dearth of adequate public transportation options and the necessity for cost-effective mobility solutions compelled workers to rely on motorcycles for their daily commutes. This reliance was further influenced by the affordability and flexibility offered by motorcycles in comparison to alternative modes of transportation (Hadi & Yoshida, 2018). Furthermore, research conducted in the in DIY revealed that that urban sprawl and inadequate public transportation infrastructure contribute to increased motorcycle usage among low-income residents (Fevriera et al., 2021; Herwangi et al., 2017).

5.2.2. Descriptive data

In order to gain a better understanding of travel movement patterns,

it is imperative to explore the reasons behind respondents' regular choice of transportation modes, particularly the motorcycle. The predominant rationales identified pertained to financial considerations, such as cost saving, and to aspects of flexibility and the absence of alternative transportation options. The descriptive questionnaire findings are illustrated in Fig. 13.

1. With respect to travel expenditures, 62.41 % of respondents concurred that the selected mode was chosen due to its significantly lower cost, as indicated by 24.47 % of respondent selecting the "strongly agree" descriptor. This finding underscores the significance of travel expenses as an essential factor in mode selection.
2. Another issue pertained to mode flexibility, with a resounding 93.26 % of respondents expressing strong agreement (38.30 %) or somewhat agreement (54.96 %) that the mode used must be flexible.
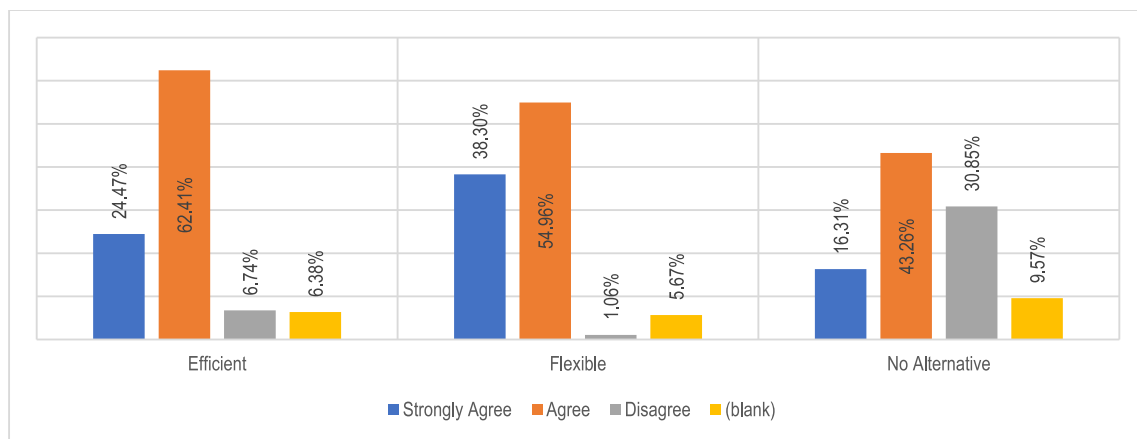
Fig. 13. Reasons underlying the utilization of current modes for commuting to work and other daily activities.

3. The final consideration pertained to the availability of alternative modes. In this case, respondents indicated a strong agreement (16.31 %) and a somewhat agreement (43.26 %) that they lacked access to other modes of transportation in their area, thereby becoming captive users. However, 30.85 % of respondents noted the presence of alternative options (beyond private vehicle usage).

5.2.3. Policy insights and actionable recommendations

The findings of this study offer valuable insights into addressing the dire transportation challenges faced by low-income communities in the Special Region of Yogyakarta, namely the high dependency on motorcycles. The results of the present study are in line with those of previous studies, including those by Herwangi (2018) and Herwangi et al. (2017). It is imperative that policymakers acknowledge the intertwined influence of economic, social, and infrastructural factors that perpetuate this dependency. The realization that cost savings and time efficiency are critical factors in the decision to use motorcycles underscores the necessity for public transportation solutions to prioritize affordability, accessibility, and reliability in order to effectively serve these communities (Chiu, 2023; Jou & Chen, 2014).

One key policy implication of this analysis is the urgent need to enhance public transportation infrastructure, particularly in suburban and rural areas with high-concentrations of low-income populations (Bondemark et al., 2021). The expansion of accessible transit networks, featuring more frequent schedules and convenient routes, has the potential to encourage individuals to opt for public transportation as a viable alternative to motorcycles. Furthermore, the integration of last-mile connectivity options, such as feeder buses or shared bicycles (Kosmidis & Müller-Eie, 2024), may help address accessibility gaps and reduce the reliance on private vehicles.

In addition to infrastructural improvements, the implementation of targeted campaigns and incentives has the potential to complement the aforementioned efforts aimed at inducing behavior change. Awareness programs that highlight the environmental and safety benefits associated with the utilization of public transportation may influence attitudes and norms while the provision of subsidies or discounted fares for low-income commuters has the potential to alleviate financial impediments (Arranz et al., 2022; Fearnley & Aarhaug, 2019). Additionally, the formulation of policies that support sustainable transport modes, such as electric motorcycles or shared mobility services, can further align with the overarching objective of sustainable mobility goals.

Finally, collaboration among relevant stakeholders is essential to ensure the long-term success of these initiatives. Governments, transportation planners, and community organizations must collaborate to design and implement inclusive transportation strategies that reflect the unique needs of low-income communities. By addressing the systemic causes of motorcycle dependency and providing practical alternatives,

these policy recommendations can pioneer a more equitable and sustainable transportation system in the region.

6. Conclusions

The present study has demonstrated that the low-income commuter group exhibits a high degeree of dependence on motorcycles, as evidenced by the descriptive data. The utilization of motorcycles is primarily driven by their efficiency and affordability and the absence of viable alternatives. This dependence is further substantiated by the co-efficient value of the manifest variable on the endogenous latent variable, which approaches 1, particularly in measuring the desire and obligation to use the mode. This finding suggests that the intention to use a specific mode is influenced by the balance between intention and needs. Nonetheless, mode usage dependence is predominantly driven by the influence of the surrounding environment, such as family and close relatives, rather than attitudes or perceived behavioral control.

This study, employing the TPB as its analytical framework, has confirmed that cost savings, time efficiency, and community influence are the most significant factors driving high motorcycle reliance among low-income communities. Among these factors, community influence, represented by subjective norms, has the most substantial influence, with a path coefficient of 0.531. This finding indicates that approval and preference from close social circles strongly shape behavioral intentions. Furthermore, cost savings and time efficiency, which are associated with attitudes, play significant roles in shaping positive perceptions toward motorcycle use. This is evidenced by the respective coefficients, which indicated their substantial contributions in this regard. These findings underscore the interconnection between economic and social factors in influencing transportation choices, further reinforcing motorcycles as the primary travel option in these communities.

Geographical disadvantage has been demonstrated to have a significant impact on the financial burdes of daily transportation expenses for low-income communities, which often exceeds that of moderate and higher-income communities. This disparity persists due to the limited affordability of housing in central activity or hub area, compounded by the inadequate accessibility of public transportation infrastructure.

The TPB framework illuminates how Yogyakarta citizens' decision-making mindset is significantly influenced by the presence of role models, which curtails individual autonomy. These role models tend to encourage the use of motorcycle for daily activities and perpetuate the stereotype that public transportation is less flexible and efficient.

CRediT authorship contribution statement

Nindyo Cahyo Kresnanto: Conceptualization, Formal analysis, Funding acquisition, Methodology, Visualization, Writing – original

draft, Writing – review & editing. **Wika Harisa Putri:** Conceptualization, Formal analysis, Writing – original draft. **Rini Raharti:** Data curation, Project administration, Resources.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Nindyo Cahyo Kresnanto reports administrative support, article publishing charges, and writing assistance were provided by Janabadra University. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

References

Aditjandra, P.T., Mulley, C., Cao, X.J., 2016. Exploring changes in public transport use and walking following residential relocation: a British case study. *J. Transp. Land Use* 9 (3), 77–95. https://doi.org/10.5198/jtlu.2015.588.

Aditya, M.H., Yuniaristanto, Sutopo, W., 2024. Exploring the factors accelerating the electric motorcycle adoptions: insights from theory of planned behavior and travel behavior. *Automotive Exp.* 7 (1), 171–188. https://doi.org/10.31603/AE.11044.

Ajzen, I., 1985. From Intentions to Actions: A Theory of Planned Behavior. In J. Kuhl & J. Beckmann (Eds.), *Action Control: From Cognition to Behavior* (p. Springer-Verlag). Springer-Verlag.

Ajzen, I., 1991a. The theory of planned behavior. *Organ. Behav. Hum. Decis. Process.* 50, 179–211. https://doi.org/10.1922/CDH_2120VandenBroucke08.

Ajzen, I., 1991b. The theory of planned behavior. *Disability, CBR and Inclusive Development* 50 (1), 179–211. https://doi.org/10.47985/dcidj.475.

Ajzen, I., 2011. The theory of planned behaviour: reactions and reflections. *Psychol. Health* 26 (9), 1113–1127. https://doi.org/10.1080/08870446.2011.613995.

Ansori, N., Sutarto, A.P., Widyanti, A., Trapsilawati, F., Rifai, A.P., Woodman, R., 2023. The road to acceptance: a theory of planned behavior analysis of indonesian public intentions towards autonomous vehicles. In: *2023 14th International Conference on Information & Communication Technology and System (ICTS)*, pp. 193–198. https://doi.org/10.1109/ICTS58770.2023.10330866.

Arranz, J. M., Burguillo, M., Rubio, J., 2022. Are public transport policies influencing the transport behaviour of older people and economic equity? A case study of the Madrid Region. *Research in Transportation Economics*, 95(November 2021). https://doi.org/10.1016/j.retrec.2022.101218.

Ashraf Javid, M., Abdullah, M., Ali, N., Dias, C., 2021. Structural equation modeling of public transport use with COVID-19 precautions: An extension of the norm activation model. *Transp. Res. Interdiscip. Perspect.* 12, 100474. https://doi.org/10.1016/J.TRIP.2021.100474.

Bandyopadhyaya, V., Bandyopadhyaya, R., 2022. Case Studies on Transport Policy Understanding public transport use intention post Covid-19 outbreak using modified theory of planned behavior : Case study from developing country perspective. *Case Stud. Transport Policy* 10 (4), 2044–2052. https://doi.org/10.1016/j.cstp.2022.09.002.

Bartik, T.J., Hershbein, B., 2018. Degrees of poverty: the relationship between family income background and the returns to education. *SSRN Electron. J.* 18. https://doi.org/10.2139/ssrn.3141213.

Bastos, S.Q.A., Gama, F., de Paula Assis, T., Milosz, M., 2020. Is there a relationship between the use of motorcycles and the level of development of countries? *Bull. Geogr.. Socio-Econ. Series* 50 (50), 43–53. https://doi.org/10.2478/bog-2020-0031.

Bertazzo, À. B. S., Jacques, M. A. P., Neto, I. L. (2020). *Beliefs underlying modal choice in school trips : A case study in Brazil.* 69, 187–205. https://doi.org/10.1016/j.trf.2020.01.008.

Bondemark, A., Andersson, H., Wretstrand, A., Brundell-Freij, K., 2021. Is it expensive to be poor? Public Transport in Sweden. *Transportation* 48 (5), 2709–2734. https://doi.org/10.1007/s11116-020-10145-5.

Bosnjak, M., Ajzen, I., Schmidt, P., 2020. The Theory of Planned Behavior: Selected Recent Advances and Applications. *Europe's J. Psychol.* 16 (3), 352. https://doi.org/10.5964/EJOP.V16I3.3107.

Carrasco, J. L. (2010). Structural Equation Model. *Encyclopedia of Biopharmaceutical Statistics*, 8(3), 1300–1305. https://doi.org/10.3109/9781439822463.209.

Chiu, B.Y., 2023. Does mass rapid transit reduce motorcycle travel? evidence from Taipei, Taiwan. *Transport. Res. Part d: Transp. Environ.* 121, 103844. https://doi.org/10.1016/J.TRD.2023.103844.

Civelek, M.E., 2018. Essentials of Structural Equation Modeling. In *Zea Books* (Issue March). https://doi.org/10.13014/k2sj1hr5.

Dash, G., Paul, J., 2021. CB-SEM vs PLS-SEM methods for research in social sciences and technology forecasting. *Technol. Forecast. Soc. Chang.* 173, 121092. https://doi.org/10.1016/J.TECHFORE.2021.121092.

Ehteshamrad, S., Saffarzadeh, M., Mamdoohi, A., Nordfjærn, T., 2022. Case Studies on Transport Policy Behavior of parents and children in the way they use public transport . A case study of Iranian households. *Case Stud. Transp. Policy* 10 (1), 454–462. https://doi.org/10.1016/j.cstp.2022.01.006.

Fearnley, N., Aarhaug, J., 2019. Subsidising urban and sub-urban transport – distributional impacts. *Eur. Transp. Res. Rev.* 11 (1), 1–10. https://doi.org/10.1186/S12544-019-0386-0/FIGURES/7.

Ferdinand, A., 2006. *Structural Equation Modeling dalam Penelitian*, 4th ed. BP UNDIP.

Fevriera, S., de Groot, H.L.F., Mulder, P., 2021. Does urban form affect motorcycle use? evidence from Yogyakarta, Indonesia. *Bull. Indonesian Econ. Stud.* 57 (2), 203–232. https://doi.org/10.1080/00074918.2020.1747595.

Forward, S. (2004). The prediction of travel behaviour using the theory of planned behaviour. *Traffic & Transport Psychol.*, *2004*, 481–492. https://doi.org/10.1016/b978-008043925-9/50045-1.

Golob, T. F., Golob, T., 2001. *Structural Equation Modeling for Travel Behavior Research.*

Hadi, R.P., Yoshida, T., 2018. Study on motorcycle dependency of factory workers in low-income cities: case study of Sukabumi Regency, Indonesia. *Policy Sci.* 25 (1), 1–18.

Hair, J. F., Hult, G. T. M., Ringle, C. M., Sarstedt, M., Danks, N. P., Ray, S., 2021. *An Introduction to Structural Equation Modeling.* 1–29. https://doi.org/10.1007/978-3-030-80519-7_1.

Heath, Y., Gifford, R., 2002. Extending the theory of planned behavior: Predicting the use of public transportation. *J. Appl. Soc. Psychol.* 32 (10), 2154–2189. https://doi.org/10.1111/j.1559-1816.2002.tb02068.x.

Herwangi, Y., 2018. Motorcycle dependency in low-income people: modeling spatial and socio-economic factors in urbanized area of Yogyakarta. *Jurnal Plano Madani* 7 (2), 196–208.

Herwangi, Y., Pradono, P., Syabri, I., Kustiwan, I., 2017. Transport affordability and motorcycle ownership in low-income households: case of yogyakarta urbanised area , Indonesia. *Proc. Eastern Asia Soc. Transport. Studies* 11 (2016), 14.

Herwangi, Y., Syabri, I., Kustiwan, I., 2015. Peran dan Pola Penggunaan Sepeda Motor Pada Masyarakat Berpendapatan Rendah di Kawasan Perkotaan Yogyakarta. *Jurnal Perencanaan Wilayah Dan Kota* 26 (3), 166–176. https://doi.org/10.5614/jpwk.2015.26.3.2.

Hou, L., Wang, Y., Zheng, Y., Zhang, A., 2022. The impact of vehicle ownership on carbon emissions in the transportation sector. *Sustainability (switzerland)* 14 (19). https://doi.org/10.3390/su141912657.

Ibrahim, A.N.H., Borhan, M.N., Rahmat, R.A.O.K., 2020. Understanding users' intention to use park-and-ride facilities in malaysia: The role of trust as a novel construct in the theory of planned behaviour. *Sustainability (switzerland)* 12 (6). https://doi.org/10.3390/su12062484.

Irtema, H.I.M., Ismail, A., Borhan, M.N., Das, A.M., Alshetwi, A.B.Z., 2018. Case study of the behavioural intentions of public transportation passengers in Kuala Lumpur. *Case Stud. Transport Policy* 6 (4), 462–474. https://doi.org/10.1016/j.cstp.2018.05.007.

Jou, R.C., Chen, T.Y., 2014. Factors affecting public transportation, car, and motorcycle usage. *Transp. Res. A Policy Pract.* 61, 186–198. https://doi.org/10.1016/J.TRA.2014.02.011.

Kahachi, H.A.H., Brown, A., 2021. Low-income housing provision: between governmental interventions and informal settlements. *Iraqi J. Architect. Plann.* 19 (2), 39–50. https://doi.org/10.36041/iqjap.v19i2.522.

Knoke, D., 2004. Structural equation models. *encyclopedia of social measurement. Three-Volume Set* 3. https://doi.org/10.1016/B0-12-369398-5/00392-3. V3–689-V3-695.

Kosmidis, I., Müller-Eie, D., 2024. The synergy of bicycles and public transport: a systematic literature review. *Transp. Rev.* 44 (1), 34–68. https://doi.org/10.1080/01441647.2023.2222911.

Kováčiková, T., Lugano, G., Pourhashem, G., 2018. From travel time and cost savings to value of mobility. *Lecture Notes Networks Syst.*, *36*(January 2019), 35–43. https://doi.org/10.1007/978-3-319-74454-4_3.

Kresnanto, N.C., Wicaksono, B.K., 2021. The impact of growth in vehicle ownership on commuter travel time. *Lecture Notes Civil Eng.* 132 (July), 749–755. https://doi.org/10.1007/978-981-33-6311-3_85.

Litman, T., 2014. Transportation Affordability. Victoria Transport Policy Institute, pp. 1–15.

Lucas, K., 2012. Transport and social exclusion: Where are we now? *Transp. Policy* 20, 105–113. https://doi.org/10.1016/j.tranpol.2012.01.013.

Lucas, K., Mattioli, G., Verlinghieri, E., Guzman, A., 2016. Transport poverty and its adverse social consequences. *Proc. Inst. Civ. Eng. Transp.* 169 (6), 353–365. https://doi.org/10.1680/JTRAN.15.00073/ASSET/IMAGES/SMALL/JTRAN.15.00073-F3.GIF.

Nurlaela, S., 2018. Structural equation model for the relationship between property value and public transport accessibility. *Jurnal Penataan Ruang* 13 (1), 13. https://doi.org/10.12962/j2716179x.v13i1.7062.

Parkany, E., Gallagher, R., Viveiros, P., 2004. Are attitudes important in travel choice? *Transp. Res. Rec.* 1894, 127–139. https://doi.org/10.3141/1894-14.

Pojani, D., Stead, D., 2015. Sustainable urban transport in the developing world: beyond megacities. *Sustainability* 7 (6), 7784–7805. https://doi.org/10.3390/su7067784.

Pojani, E., Van Acker, V., Pojani, D., 2018. Cars as a status symbol: Youth attitudes toward sustainable transport in a post-socialist city. *Transport. Res. F: Traffic Psychol. Behav.* 58, 210–227. https://doi.org/10.1016/j.trf.2018.06.003.

Rahmadaniyati, D., Faqih, M., Hayati, A., 2016. Housing Preference for Low-Income People in Indonesia. *Proceeding "Enhancing Academic Collaboration Through ASEA-UNINET Scientific.*, 1–12.

Ru, X., Qin, H., Wang, S., 2019. Young people's behaviour intentions towards reducing PM2.5 in China: Extending the theory of planned behaviour. *Resour. Conserv. Recycl.* 141, 99–108. https://doi.org/10.1016/j.resconrec.2018.10.019.

Sharghi, A., Nourtaghani, A., Ramzanpour, M., Gorji, R.B., 2021. Low-income housing location based on affordable criteria using AHP Model and GIS Technique (Case Study: Babolsar City). *Environ. Dev. Sustain.*. https://doi.org/10.1007/s10668-021-01870-7.

Stryzhak, O., 2020. The relationship between education, income, economic freedom and happiness. *SHS Web of Conferences* 75, 03004. https://doi.org/10.1051/shsconf/20207503004.

Susanti, A., Soemitro, R.A.A., Suprayitno, H., Ratnasari, V., 2019. Searching the appropriate minimum sample size calculation method for commuter train passenger travel behavior survey. *J. Infrastruct. Facility Asset Manage.* 1 (1), 47–60. https://doi.org/10.12962/jifam.v1i1.5232.

Titheridge, H., Christie, N., Mackett, R., Hernández, D. O., & Ye, R. (2014). *Transport and Poverty*. *July*, 1–43. https://www.ucl.ac.uk/transport-institute/pdfs/transport-poverty.

Wassmer, R.W., Baass, M.C., 2006. Does a more centralized urban form raise housing prices? *J. Policy Anal. Manage.* 25 (2), 439–462. https://doi.org/10.1002/PAM.20180/ABSTRACT.

Zheng, Y., Chai, Y., Le, Y., Lu, H., 2023. Study on Green Transportation Behaviors in Beijing, Tokyo, and Klang Valley based on Theory of Planned Behavior. *International Conferences on Intelligent Transportation Engineering*, 255–260. https://doi.org/10.1109/ICITE59717.2023.10733810.

Zhou, J., Guo, Y., Dong, S., Zhao, L., Yang, R., 2016. Structural equation modeling for pedestrians' perception in integrated transport hubs. *Procedia Eng.* 137, 817–826. https://doi.org/10.1016/j.proeng.2016.01.321.

Zudhy, M., Simanjuntak, N.I.M., Fawzan, F., Dwitasari, R., 2020. Predicting the impact of Trans Java Toll Roads on demand for intercity air travel in Indonesia. *J. Air Transp. Manag.* 87 (June), 101848. https://doi.org/10.1016/j.jairtraman.2020.101848.