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MODE CHOICE BEHAVIOR ANALYSIS OF COMMUTER STUDENTS AT UNIVERSITAS INTERNASIONAL BATAM

Antony Hermawan[1], Andri Irfan Rifai[2*], Susanty Handayani[3]
[1,2]Faculty of Civil Engineering and Planning, Universitas Internasional Batam, Indonesia
[3]Trisakti Institute of Transportation and Logistics, Indonesia
** e-correspondence: andri.irfan@uib.ac.id*

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ABSTRACT

University students in many developing countries experience different mode choices in developed countries. This study implements existing influence factors of mode choice towards a university in a developing country by analyzing the characteristics of the student's preferences in choosing the best transportation modes under different circumstances. The primary data is taken through a stated preference survey which is then analyzed using a descriptive statistics approach, and findings are compared with existing studies. Firstly, commuter students show a significant interest in driving-alone mode compared to the other four modes. Secondly, proximity to campus proves to be influential on students' mode choices. Thirdly, most students live within their family residences, which influences their mode choice behavior. Lastly, the results shown are correlated only with evening-period students.

INTRODUCTION

The human population has an unlimited choice of transportation modes, so finding the solution to air pollution caused by conventional vehicles has been the focus recently and will be in years ahead. However, that has not been the case in many developing countries, particularly Southeast Asian countries like Indonesia. Residents of major urban cities in Indonesia have adopted motorcycles as their first choice regarding daily transportation routines. DKI Jakarta is an urban city and the capital of Indonesia and has adopted Governor Instruction Number 66 issued by the government in 2019 to reduce congestion and air pollution. This instruction consists of accentuating the use of public transportation modes such as Light Rail Transit (LRT), Mass Rapid Transit (MRT), Trans Jakarta Bus (TJ), and Electric Train (KRL Commuter Line) following Jakarta's 2018 "Jak Lingko" program. This program is a public transportation integration regime to promote the transition of private to public transportation modes. As a developing country, these efforts to encourage healthier transportation are appraised as new compared to developed countries with current goals of boosting Electric Vehicles (EVs). Nevertheless, electric vehicles can be implemented in Indonesia (Huda, Aziz, & Tokimatsu, 2019). Furthermore, it has been realized with President Instruction No. 7 in the Year 2022 to speed up the transition from gas to gas-electric cars.

With the recent development of public transportation in Jakarta, the same cannot be said with Batam City, which this study case focuses. Public transportation modes offer a lesser choice for the population compared to Jakarta. Trans Batam is the only open government public transportation that implemented the bus rapid transit system in Batam City, almost like that of Trans Jakarta. Trans Batam is an imperfect version of bus rapid transit as it adopts multiple

weaknesses relative to Batam's geographical road disadvantages, such as the lack of busway roads and limited route options. Private transportation modes like motorcycles and cars are the residents' primary mobility tool as it neglects the disadvantages of walking to bus stops or later suffering the risk of congestion. An easy-to-use, on-demand, all-location taxi service with a transparent payment cost—digitally or in cash—is offered by online-based transportation services, especially smartphone-based services. Customers prefer online transportation because it is more convenient, less expensive, and more comfortable and secure. Thus, it is not surprising that many people are converting from traditional transport modes to online transport modes (Azizah & Adawia, 2018).

Many students of the Engineering Faculty of Sultan Ageng Tirtayasa University prefer public transportation services such as buses and trains to private transportation (Budiman, Bethary, & Hilzams, 2022). From the study, no doubt public bus transportation in Cilegon city is superior to that of Batam City "Trans Batam". Students trust public bus services to transport them to their desired places without worrying too much about their cost, time, service, and safety. The opposite can be said with the students of Muslim of Indonesia University in Makassar City. While public transportation has yet to reach the level of Cilegon or Jakarta's advanced public services, thus causes its majority choose private transportation over most options, followed by a close percentage between public and online-based transportation (Alkam & Said, 2019).

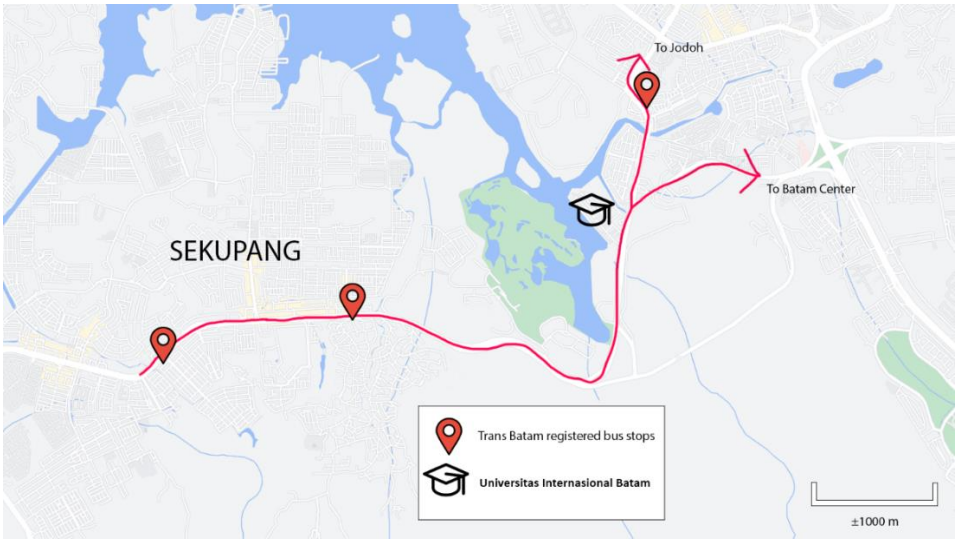


Figure 1. Trans Batam bus stops near campus (Moovit, 2022)

The population of Batam City is presented with a few choices of transportation modes. Private transportation includes motorcycles and 4-wheel vehicles, public transportation modes such as conventional taxi services(non-application-based) and Trans Batam, and online-based transportation service modes. However, some options stated above are only available to some students of Universitas Internasional Batam. Trans Batam has eight bus routes with 23 bus stops—Sekupang to Batam Center, Tanjung Uncang to Batam Center, Sekupang to Jodoh, Tanjung Uncang to Sekupang, Tanjung Piayu to Batam Center, Punggur to Jodoh, and Nongsa to Punggur (Moovit, 2022). Universitas Internasional Batam is in Baloi, Tiban, exactly in-between the route from Sekupang to Batam Center or Sekupang to Jodoh, as shown in Figure 1, with all possible Trans Batam bus stops. From the diagram, Trans Batam does not have the option to stop near the

campus. Additionally, judging from the routes stated, Trans Batam is a long-trip transportation mode with specific bus stops.

This study aims to analyze the characteristics of students' preferences in choosing the best transportation modes under different circumstances. Factors that determine why students prefer one mode over the others. Whether it is due to the unavailability of public transportation such as Trans Batam or simply because one does not own private vehicles, which left students to utilize online-based transportation services. Students may prefer private vehicles over public or online-based transportation as it offers an immediate home-to-campus journey. There are many possible deciding factors on students' behavior leading to their preferred transportation modes, which can be studied.

LITERATURE REVIEW

Mode Choice

Transportation portrays a significant part in the development of the socioeconomic aspects of countries around the world. With good transportation, a nation or region can achieve the maximum use of its natural resources and the maximum productivity of its people (Elmansouri, Almhroog, & Badi, 2020). Good transportation determines the development of an area because it can facilitate the movement of people, goods, services, and information from one area to another (Taufanudin, Isradi, & Rifai, 2021). Each country adopts a particular supply chain management system to maintain a stable distribution across the nation, even though many developing countries suffer numerous transportation system problems. In logistics transporting, both the route and the vehicle itself have a dependent relationship with each other. Logistics efficiency has been recognized as a significant global issue in rapidly changing global environments. The changes include industrialization, urbanization, and economic growth (Song, Seo, & Lee, 2022).

To bring maximum efficiency in transporting goods, we must implement green logistics processes (also known as eco-logistics). Four scientific standpoint points can be used to analyze the word "green logistics": as a concept for the development of sustainable logistics systems at various levels; as a tool for the circular economy; as a part of business corporate social responsibility; and as a sort of walking activity (Dzwigol, Trushkina, Kvilinskyi, & Kvilinskyi, 2021). The focus is on autonomous transportation in logistics, with a deeper examination of its use throughout various supply chain components (Díaz, Lin, & Molinera, 2021). The autonomous vehicle concept has found its way into the logistics transportation sector, not just private commercial transportation. This technology also means strengthening the concept of green logistics to minimize the environmental impact caused by transport and delivery.

An autonomous and electric vehicle or a combination of both is recognized as the future of zero-carbon transportation modes. It is human's next step in fighting one of many environmental issues. This innovation has been implemented in public transportation modes of many developed and developing countries around the globe. For example, many European cities have adopted the electrification of public bus services. With more European towns seeing electric buses to decarbonize and reduce local air pollution, the recently developed Li-ion battery technologies for electric bus fleets align with recent and future advancements in clean public transportation in European cities (Carrilero, et al., 2018). In addition to the bus transit system, Stockholm City was the first to build an electric highway that uses a catenary system.

Integrating urban transport systems such as metro, light rail, and tram systems is another public transportation choice in European cities categorized as an electrified rapid transit train system. These are some differences in public transportation modes between developed and developing countries. Although, it is only partially relevant in Indonesia's Capital, the Metropolitan City of Jakarta. Jakarta promotes public transportation by adopting the rapid transit system. However, not all urban and rural cities in Indonesia meet the level of the advance of Jakarta. Therefore, Internet of things (IoT) technologies is developed to improve the quality of public transportation services in urban and rural areas, such as integrating transport systems (Porru, Misso, Pani, & Repetto, 2020).

Mode Choice for Students

The multinomial logit model methods are used to identify factors that affect students' preferred transport, such as gender, studying class, and distance to school (Chaudhry & Elumalai, 2020). Safety and security factors may determine male and female students' personal transport choices over public ones. We must ensure that public transportation is secure and open to all to promote its use and further development (Friman, Lättman, & Olsson, 2020). A sustainable public transport system means a reduction in environmental impact and not overlooking its users' safety and comfort. These factors correlate to the three major transport mobility features (Safety, Comfort, and Sustainability).

Distance and the availability of parking lots are the key factors influencing students' decisions to use private modes (Cattaneo, Malighetti, Morlotti, & Paleari, 2018). Distance and parking lot availability can be categorized as Sustainability features. Both are defined as the road's ability to sustainable transport and vehicle parking capacity, which in many cases refer to private transport modes. Many students who live more than 2.4 kilometers from the school's grounds depend on private transportation, while those who live farther than 5 kilometers from the grounds choose public transportation (Chaudhry & Elumalai, 2020). Based on studies discussed, distance to educational institutes is a crucial variable in determining students' behavior on transport modes preference.

The three transport mobility features (Safety, Comfort, and Sustainability) can be adopted as references to estimate the stated preferences for students, which then be analyzed with the multinomial logit model to bridge the features with the transport mode choice. With the set above, the result shows the students of the University of Bergamo prefer to travel via a comfortable than a sustainable transport mode, thus corresponding to the 5-point Likert scale used in the questionnaires between Comfort and Sustainability (Cattaneo, Malighetti, Morlotti, & Paleari, 2018). Zhou, Wang, and Wu elaborate transport modes available for students at Iowa State University (ISU) into five alternatives: driving alone, carpooling, public transit, biking, and walking. The study shows that 77% of ISU students use non-driving-alone transport modes, which include walking and public transit, with the highest choosing majority (Zhou, Wang, & Wu, 2018).

Stated Preference

Data on stated preferences can be beneficial for determining how people value products traded on the market or not yet on the market (Michaels-Igbokwe, MacDonald, & Currie, 2017). There are two common variants of stated preferences (SP) which are called discrete choice experiment (DCE or CE) and discrete choice contingent valuation (CV). Discrete choice contingent valuation (CV), a popular strategy, involves asking respondents whether they would support a proposed change at a given price (Johnston, et al., 2017). Respondents can make relatively simple decisions thanks to the CE presentation format, and attributes and their levels can

be customized so that they are realistic for respondents (i.e., reflecting specific conditions they face) (Holmes, Adamowicz, & Carlsson, 2017). In other words, respondents' data collected using CV is used to estimate future market based on a hypothetical set of questionnaires asked to that market audience. Meanwhile, CE does not include hypothetical questions but rather is based on the audience's current situations.

Data collected from stated preference surveys are then analyzed with the logit model. This model can be implemented to study the mode choice behavior of a population. In travel mode choice modeling, based on a set of given attributes, the objective is to model the choice processes and behaviors of travelers faced with several travel mode alternatives (Lee, Derrible, & Pereira, 2018). The "traditional" multinomial logit model (MNL) is commonly used in much travel-behavior research. The nested logit model and, more recently, the mixed logit model are significant additions to the MNL model that address some of the constraints that the MNL model has (Zhao, Yan, Yu, & Van Hentenryck, 2018). However, its primary drawback is the stringent statistical assumptions, like the independence of irrelevant alternatives (IIA), which frequently necessitates rigorous model formulation and well-formatted data structures (Wang & Ross, 2018).

Stated preferences and logit model are a harmonized combination in mode choice modeling by determining possible influence variables leading to the mode choice behavior. Moniruzzaman and Farber adopted the MNL models to examine the mode choice behavior of students from four universities in the Greater Toronto Area with variables as follows: student's socioeconomic characteristics, travel cost, travel demand management measures (TDM), residential self-selection, and built environment around place of residence (Moniruzzaman & Farber, 2018). Furthermore, Zhou, Wang, and Wu conducted a comparative study using MNL and nested logit model (NLM) to estimate the mode choice behavior at Iowa State University with variables as follows: physical environment, mode-specific service factors, personal attributes, trip characteristics, TDM measures, and psychological factors (Zhou, Wang, & Wu, 2018). From the following literature reviews, relevant variables can be determined for the mode choice behavior research of Universitas Internasional Batam students.

Table 1. Mode Choice of urban university students

Influence Factors	Urban University
1. Physical environment	Students living on or around campus are significantly more likely to walk/bike and less likely to drive (Wang, Khattak, & Son, 2012). Dependency on public transit over private vehicles increases when the distance to school premises increases (Chaudhry & Elumalai, 2020). Perceived and actual distances have different magnitudes of effects on travel mode choice (Emond & Handy, 2012). Personal motor vehicles (PMVs) are more frequently used for both short and long travels by urban populations (Saigal, Vaish, & Rao, 2022).
2. Mode-specific or service factors	Mode-specific costs influence mode selection, travel distance/time, bus accessibility, and environmental consciousness (Collins & Chambers, 2005). Transit access increases transit usage among university students (Zhan, Yan, Zhu, & Wang, 2016). The transportation, sociological, and

Influence Factors	Urban University
	environmental effects of students traveling to and from university campuses are significant (Ribeiro & Fonseca, 2022).
3. Personal attributes	Age, gender, income level, travel time, and employment status influence mode choice (Das, et al., 2021) (Zhan, Yan, Zhu, & Wang, 2016). Travel aspects are affected by student status, faculty, level of study, and first language (Glover, 2011). In exchange for affordable rent, proximity to buses, and a quick commute, university students are more inclined to share a residence (Zhou J., 2014)
4. Trip characteristics	Mode choice tends not to be related to the time of travel (Zhou J., 2012). Times of travel are not significant for modes other than public transport during peak hours (Crotti, Grechi, & Maggi, 2022)
5. Psychological factors	Environmental awareness, together with mode-specific costs and travel distance/time, jointly influence mode choice (Klöckner & Friedrichsmeier, 2011); The social-cognitive features and socioeconomic traits of the travelers are considered to be internal factors because they affect their decision-making when traveling (Javid et al., 2022)

METHOD

The study site is Universitas Internasional Batam (UIB), located in Batam City, Riau Islands Province. Classes are divided into two periods: morning-afternoon and evening classes. The earliest class may start at 9 am, while the last class ends at 4 am for the morning-afternoon period. Meanwhile, the evening class starts at 6 pm and ends at approximately 10 pm. Different times might give exciting insights into students' preferred mode, as road performance from 5 pm to 6 is the highest. Questionnaires are given to both morning-afternoon and evening students. UIB does not implement the TDM measures. Therefore, suitable influence variables on mode choices are divided into dependent and independent variables. The target of the survey is commuter students. Meaning students who live outside the premises need to travel through Gajah Mada Road with different modes of choice. Gajah Mada Road is the road on which Universitas Internasional Batam resides. Dependent variables include primary mode choice: self-driving (private vehicle), carpooling (including motorcycle), online application-based transport (car and motorcycle), biking, and walking. This study aims to analyze the characteristics of the student's preferences in choosing the best transportation modes under different circumstances. A research paper's systematic process must start with identifying the problem (Rifai, Hadiwardoyo, Correia, & Pereira, 2016). Students might have multimodal travel behaviors. To ensure a centered and direct

survey, the survey asked about the primary mode choice by answering stated reasons. Stated reasons or independent variables are the influencing factors: physical environment, mode-specific or service factors, personal attributes, trip characteristics, and psychological factors.

The questionnaire is designed with the stated preference approach of CE using the abovementioned variables. In addition, we conducted an additional CV survey of a hypothetical set of questionnaires regarding Trans Batam. The additional survey is separated from the primary CE survey. The CV survey will discuss students' perspectives on the current state of Trans Batam. The survey asks if they would consider Trans Batam as one of their choices if changes are proposed, like better mobility features, better access to bus stops, or an official route to the university. When choosing their mode of transportation, respondents are heavily influenced by factors including trip expenses, travel time, and waiting for departure (Rifai, Putra, Isradi, Mufhidin, & Prasetijo, 2022).

RESULT AND DISCUSSION

Findings

The questionnaire data is collected from 100 respondents consisting of 52% male and 48% female respondents. 89% of the total respondents are aged from 18 to 20 years old, 9% are aged from 21 to 23 years old, and 2% are younger than 18 years old. The summarized questionnaire data is in Table 2, including the five groups of influencing factors and the primary mode choice of commuter students. In addition, we include results from the additional CE survey regarding students' perspectives on Trans Batam, which is further discussed in the mode choice and service factors section.

Table 2. Variables, Description, and Values

Variables		Description	Values
Dependent Variables			
Driving alone (private vehicle)		The primary mode is driving alone	46%
Escorted by related (private vehicle)		The primary mode is escorted (by a family member, chauffeur, or partner).	26%
Carpooling (car or motorcycle)		The primary mode is carpooling with friends from campus.	9%
Online transportation service		The primary mode is an online transportation service.	11%
Walking		The primary mode is walking.	8%
Independent Variables			
1 Physical environment	Commute distance	Network-based distance between campus and residence	Mean: 7.34 km
	Perceived commute time	Less than 10 min; 10-20 min; 20-40 min; 40-60; more than 60 min	Median: 10-20 min

Variables		Description	Values
	Residential type	A family residence (family member's, partner, or rental residence)	74%
		An owned residence (independent)	3%
		A rental shared with other students or friends	20%
		A homestay with an unrelated family	2%
		None of the above (open answer)	1%
2 Mode-specific or service factors	Trans Batam perspectives	Most commuter students have never used Trans Batam as a transport mode; 43.75% of commuter students would consider Trans Batam as a mode choice if there are changes to some transport features	70% never used Trans Batam
	Driving and carpooling	Students who reported driving as a commuting choice drive 3 to 6 times a week	
3 Personal Attributes	The primary reason for choosing the current residence	Proximity to campus	14%
		Rent affordability	6%
		Community amenities (safety, comfortable, green space, proximity to shops, restaurants, etc.)	13%
		Friends network (with friends or classmates living nearby)	3%
		Family member residence (living with family member/s	63%
		None of the above (open answer)	1%
	Gender	Male	52%
		Female	48%
	Age	<18, 18-20, 21-23, 24-26, or >26	Median: 18-20
	Annual Income	Rp2.000.000 and below.	21%
		Rp2.000.000−Rp4.000.000.	23%

Variables		Description	Values
		Rp4.000.000−Rp6.000.000.	18%
		Rp6.000.000−Rp10.000.000.	3%
		Rp10.000.000 and above.	0%
		I don't work.	35%
4 Trip characteristics	Time of Travel	Morning classes	7%
		Evening classes	93%
5 Psychological factors	Friends or partners influence	Based on residence type	20%
Trans Batam	Students' perspectives	Students have never used Trans Batam as a transport mode	70%
		Students would not choose Trans Batam when the cost is reduced	33%
		Students would not choose Trans Batam when the transit line passes the residence	32%
		Students would not walk to a Trans Batam bus stop	42%
		Students would not wait on a scheduled Trans Batam time	44%

Discussion

In this research, we provide a descriptive analysis using the factors that influence commuter students' mode choice. Although Batam has not yet offered public transportation service other than Trans Batam, we were able to implement the five groups of influencing factors onto the currently available mode choices for UIB students. Regarding the primary mode choice, our prefatory analysis shows that 54% of students use non-driving-alone for their commuting choice to campus, which is moderate compared to other urban universities shares such as 54% at Virginia Commonwealth University (VCU) (Khattak, Wang, Son, & Agnello, 2011), 42% at the Old Dominion University (ODU) (Zhou, Wang, & Wu, 2018), 66% at the University of Western Australia (UWA) (Shannon, et al., 2006), 27% at Ohio State University (OSU) (Akar, Fischer, & Namgung, 2013), and 77% at the Iowa State University (ISU) (Zhou, Wang, & Wu, 2018). Furthermore, in the non-driving-alone modes, 26% of students are escorted to the campus by their family member, chauffeur, or partner. Notably, online-based transport service is the third preferred commuting mode choice with 11%. Meanwhile, carpooling and walking hold a close share of 9% and 8% respectively. In this discussion section, we adopted a descriptive analysis approach to the survey data to explain the relationship between the student's primary mode choice and the five groups of influence factors.

1. Mode Choice and Physical Environment

   This study explores the three physical environment factors— perceived commute time, distance, and the residential type. For UIB students, proximity to campus proves to be influential on students' mode choices. 8 out of 13 students with a commuting distance of less

than 2 km would choose to walk to campus, while the rest (n = 5) prefer driving alone, carpooling, or online-based transport service (Table 3). Students' dependency on driving alone mode increases when commuting distance increases. Long commuting distance attracts a specific mode choice—14 out of 17 students who reside more than 10 km from campus prefer driving alone. Additionally, three students who reside more than 10 km do not own driving licenses and therefore are escorted by their relatives.

Table 3. Mode choice and commute distance

Commute distance *d* (km)	**<2**		**2 < *d* ≤ 6**		**6 < *d* ≤ 10**		**>10**	
	n	**%**	***n***	**%**	***n***	**%**	***n***	**%**
Driving alone	3	23.1	11	44.0	20	44.4	14	82.4
Escorted	0	0.0	6	24.0	16	35.6	3	17.6
Carpooling	1	7.7	3	12.0	4	9.0	0	0.0
Online based	1	7.7	5	20.0	5	11.0	0	0.0
Walking	8	61.5	0	0.0	0	0.0	0	0.0
All	13	100	25	100	45	100	17	100

The correlation between students' residence type and mode choice is worth noticing—especially "a family residence" being most of the students' stated answers (Table 4). Students living within a family residence prefer to drive alone and be escorted to campus than students living in a non-family residence.

Table 4. Mode choice and residence type

Residence type	**A family residence**		**Non-family residence**	
	n	**%**	***n***	**%**
Driving alone	36	48.6	8	30.8
Escorted	22	29.7	5	19.2
Others	16	21.6	13	50.0
All	74	100	26	100

2. Mode Choice and Mode-Specific or Service Factors

Due to the unavailability of Trans Batam as a capable transit mode choice for students, we instead ask for students' perspectives on Trans Batam. According to Table 2., the result shows that a surprising 70% (n = 70) of students have never used Trans Batam. As discussed in previous literature, we promote better changes to Trans Batam transport attributes—cost, transit line, schedule, and walking distance to bus stops. If public transport cannot meet these needs, then there is a possibility that passengers will not use this mode (Rifai A. I., 2021). Even when changes are considered, the number of students who would not try Trans Batam is relatively high. For instance, 42% (n = 42) of students would not walk above 500 m to a Trans Batam bus stop. Also, as many as 44% of students would not wait for a scheduled Trans Batam.

The effectiveness of the other mode choices may cause this. For example, students would not have to wait to drive their vehicles. Fortunately, 66% of students would consider Trans Batam regarding its cost.

3. Mode Choice and Personal Attributes

The four personal attributes—the primary reason for residence choice, age, gender, and income- influence the students' preferred commuting mode choice. In particular, the correlation between the respondents' age majority—18 to 20 years old (n = 89) and the primary reason for choosing residence choice—family member residence (n = 63). Therefore, 32% of (n = 63) chose escorted by related as the primary mode choice, while 54% of (n = 63) chose driving alone mode choice. This shows how family members within a family residence provide necessary mode assistance such as vehicle and the help of escorting students. The study finds that students who prioritize rent affordability as the primary reason have mixed mode choice answers. 50% of students who chose rent affordability prefer to drive alone. 33% of students prefer carpooling, and only 17% prefer online-based transport services.

4. Trip Characteristics

The results in Table 2 show that many students in UIB study during the evening period. Evening period classes start at approximately 6 pm and end at 10 pm. Time travel only correlates with commuting distance to campus. The findings suggest that the farther the commute distance, the earlier the travel time. For instance, students who walk to campus start their travel time above 5.30 pm. Meanwhile, students who reside more than 10 km commute early, up to 4.00 pm. The difference between morning and evening classes can only be studied as the difference is too big.

5. Mode Choice and Psychological Factors

Students show psychological impacts towards other students, which may cause significant decisions on mode choice. Social-cognitive and socioeconomic aspects influence decision-making regarding mode choice (Javid et al., 2022). In this case, the study focuses on the correlation between psychological factors and residence type—rental shared with friends. As many as 20% of students chose rental residences and are partly affected by their colleagues.

CONCLUSION

Commuter students show a significant interest in driving-alone mode compared to the other four modes for commuting to campus. Notably, all five influence factors contribute to mode choice behavior. However, TDM measures are not implemented in the current study due to the unavailability of the service in UIB. Much of the existing literature put TDM measures as one of the key influencing factors in determining mode choice behavior. For further studies, this research should be improved in four means. First, future studies should combine the logit model with descriptive statistics to correctly estimate the effects of influence factors (independent variables) on mode choice. Second, upcoming studies should elaborate on factors not present in this study, such as off-campus jobs, vehicle ownership, and financial situation. This should clarify the mode preferences of UIB students and university students. Third, this study only analyzes the correlation between psychological factors and residence type, which is an indirect analysis of the independent variables and influence factors. Lastly, future studies must be oriented under the same circumstances as UIB—especially the unavailability of TDM measures and Trans Batam.

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