



Risk and Ride: Understanding Safety and Security in Jakarta's Motorcycle-based Ride-Sourcing

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Abstract. *The use of motorcycle-based ride-sourcing services for medium-distance travel as a feeder for home-based trips poses higher risk to passenger safety and security during the trip. This study aimed to identify the perception of safety and security of motorcycle-based ride-sourcing users and its influence on the preference for motorcycle-based ride-sourcing as a feeder mode for Jakarta's metro system in home-based trips. The method used to determine user perception was principal component analysis (PCA) and the binomial logit model was estimated to analyze user preferences in choosing motorcycle-based ride-sourcing based on attributes such as travel time, cost, and safety and security features. The findings reveal that female respondents tend to choose motorcycle-based ride-sourcing more than male respondents; users traveling for mandatory trips are more likely to opt for motorcycle-based ride-sourcing; and the frequency of using motorcycle-based ride-sourcing to reach their residence as well as the perception of service management, significantly influence the choice of motorcycle-based ride-sourcing as a feeder mode for Jakarta's metro system. However, individuals with a secondary education level tend to avoid using motorcycle-based ride-sourcing services. The model highlights that, in addition to travel time and cost, safety and security features, along with effective service management in motorcycle-based ride-sourcing, can increase the likelihood of their adoption as a feeder mode for the Jakarta's metro system. Therefore, motorcycle-based ride-sourcing operators are advised to improve the service by developing these features to provide better safety and security for users.*

Keywords. *Motorcycle-based ride-sourcing, safety, security, Jakarta's metro system feeder mode, binomial logit model, principal component analysis*

Introduction

The public transportation system is an inseparable part of urban life, both now and in the future. Public transportation carries commuters from one stop to another. A journey using public transportation typically consists of three stages. In the first and last stages, known as 'first mile' and 'last mile', feeder modes are used, while the middle part is the main journey, using the main mode of transport. The feeder modes connect public transport users from a specific area to the main transportation stop such as a metro station or bus stop. Feeder modes can include walking, cycling, buses, taxis, and online transportation or ride-sourcing services.

Public transportation in Jakarta has experienced significant growth over the past two decades. One of the most notable developments is the introduction of Jakarta's metro

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system called MRT Jakarta, which has been in operation since 2019. Jakarta's metro system is a rail-based public transport system that currently consists of a single corridor spanning approximately 16 kilometers, connecting Lebak Bulus to Bundaran Hotel Indonesia with a total of 13 stations. This mode of transport has become one of the backbones of Jakarta's public transportation network, as evidenced by a 176% increase in ridership in 2022 compared to the previous year and an impressive on-time performance rate of 99.95%. Meanwhile, the lack of integration between different public modes of transportation remains a major obstacle to increasing public transport usage in Jakarta and its surrounding cities, known as Jabodetabek (Jakarta, Bogor, Depok, Tangerang, and Bekasi). This issue is particularly evident in first-mile and last-mile accessibility, as many stations and bus stops are beyond walking distance, while short-distance transport options like *angkot* (public minivans) remain limited and are not always reliable (Sunitiyoso et al., 2022). Therefore, feeder modes are necessary to enhance public transport usage in Jabodetabek.

The emergence of online ride-sourcing services in recent years has helped address this issue. These services have significantly influenced travel behavior (Irawan et al., 2020). Several studies have also shown that online ride-sourcing can complement public transportation services (Irawan et al., 2020; Rizki et al., 2021; Saffan & Rizki, 2018). According to Sunitiyoso et al. (2022), commuters use ride-sourcing to reach stations or continue their journeys from stations to their final destinations. Their ease of access, time flexibility, and relatively affordable fares make them highly appealing to commuters, effectively bridging the gaps in an otherwise poorly integrated public transport system.

While previous studies have primarily emphasized the role of ride-sourcing in improving accessibility and complementing public transport services, considerably less attention has been devoted to users' perception of safety and security when using ride sourcing as a feeder mode. Technology-based transportation services have broader social implications, particularly concerning user safety and security. According to Maurice et al. (2001), safety is normatively defined as a state of protection from physical, psychological, or material harm. Safety can be assessed both objectively and subjectively. Objective assessment relies on measurable parameters, such as fatality rates or injuries resulting from traffic accidents. In contrast, subjective assessment focuses on individual perceptions of safety and security.

Home-based travel refers to trips that begin and end at an individual residence. According to Yagi & Mohammadian (2008), home-based travel exhibits unique characteristics, as it encompasses daily activity-travel patterns, including mandatory trips such as commuting to work and school as well as non-mandatory trips such as shopping, recreation, and social activities. Furthermore, a preliminary survey conducted by the author involving fifteen motorcycle-based ride-sourcing drivers around Jakarta's metro stations indicated that the majority of Jakarta's metro system users opt for motorcycle-based ride-sourcing as a feeder mode for home-based trips, particularly during morning and evening travel periods.

Nevertheless, the role of motorcycle-based ride-sourcing as a feeder mode for home-based trips, especially in the context of metro system services, remains relatively weak

and empirical evidence on this matter is still limited. The integration of ride-sourcing services as a feeder mode for Jakarta's metro system presents new challenges. Using motorcycle-based ride-sourcing for medium-distance travel, in particular, poses a higher risk to passenger safety and security. Therefore, a more in-depth analysis is needed to explore user perceptions of safety and security factors when utilizing motorcycle-based ride-sourcing as a complement to public transport, especially as a feeder mode for home-based trips on the Jakarta's metro system service. Motorcycle-based ride-sourcing have relatively poor safety and security standards. This may be due to the higher likelihood of motorcycle drivers engaging in unsafe riding behaviors, which can pose significant risks to passenger safety (Vlahogianni et al., 2014).

To address this gap, this study examines users' preferences regarding safety and security attributes of the use of motorcycle-based ride-sourcing services as a feeder mode to Jakarta's metro system. The safety and security attributes included in this study are based on features currently available in several ride-sourcing applications, including an emergency button, trip-sharing functionality, travel insurance, and driver safety training provided by ride-sourcing operators. In addition, this study incorporates geofencing and safety sensors as technological innovations intended to enhance passenger security and safety. Furthermore, this study adopts safety and security variables that capture the distinctive characteristics of application-based ride-sourcing services, particularly data security risk, which is inherent to digital mobility platforms.

Based on the background and issues outlined above, the research questions can be formulated as follows:

- 1) How do Jakarta's metro system users perceive safety and security when choosing motorcycle-based ride-sourcing as a feeder mode for home-based trips?
- 2) What are the preferences of Jakarta's metro system users in selecting motorcycle-based ride-sourcing as a feeder mode for home-based trips to and from Jakarta's metro system stations?

Literature Review

The Role of Ride-Sourcing in Public Transportation Services

Ride-sourcing services can serve as a complementary mode of transport by bridging both spatial and temporal gaps in urban public transport, thereby enhancing accessibility (Jin et al., 2018). Temporally, ride-sourcing can supplement public transport services during nighttime and weekend when transit frequency is lower. Spatially, it can function as a feeder service for public transport addressing first-mile and last-mile challenges. According to Circella & Alemi (2018), ride-sourcing services such as Uber and Lyft have facilitated greater public transport usage by providing access to transit stations for suburban residents in California who live in areas with limited connectivity. Moreover, the integration of ride-sourcing with public transport has been shown to improve service quality and increase ridership in Orlando (Azimi et al., 2021). Additionally, a study by

Babar & Burtch (2020) revealed that ride-sourcing services are associated with a significant rise in commuter rail usage in the United States.

On the other hand, ride-sourcing services also compete with or even replace public transport, particularly in high-density areas (Jin et al., 2018), potentially leading to a decline in public transit ridership as more people opt for ride-sourcing. This is also supported by research from Circella & Alemi (2018), which found that independent millennials in California who use ride-sourcing services tend to drive less but also reduce their reliance on public transit and active modes such as walking. Furthermore, a study covering seven major metropolitan areas in the United States indicates that ride-sourcing services replace approximately 6% and 3% of trips that would have been made via public transit such as buses and light rail (Clewlow & Mishra, 2017). Additionally, Henao (2017) found that 22.2% of passengers would have used public transport if Lyft or Uber were not available as an option.

Several studies have specifically examined the role of ride-sourcing services within Indonesia's public transport system. According to Sunitiyoso et al. (2022), 47.8% of commuters in Jabodetabek incorporate ride-sourcing services into their multimodal journeys, particularly for the first-mile and last-mile segments. Furthermore, commuters tend to use motorbike-based ride-sourcing services more frequently than car-based alternatives. Ride-sourcing also serves as a complementary mode of transport for Transjakarta buses and Jakarta's commuter rail system (Irawan et al., 2020). Jakarta commuter rail users rely on ride-sourcing services for first-mile and last-mile travel due to the poor quality of public transport feeder services and inadequate pedestrian way infrastructure (Saffan & Rizki, 2018). Additionally, ride-sourcing plays a crucial role as a first-mile and last-mile mode for accessing intercity transport hubs, such as intercity bus terminals, railway stations, and airports in Yogyakarta (Widiastuti & Irawan, 2024). However, a study by Aritenang (2024) found that ride-sourcing services can also serve as a substitute for public transport or as an alternative mode, particularly for low-and-middle income commuters in Jabodetabek and the Bandung Metropolitan Area.

Based on the literature, motorcycle-based ride-sourcing can serve as a complement to public transport services by addressing accessibility needs in the first-mile and last-mile segments. This suggests that motorcycle-based ride-sourcing can function as a feeder mode for public transport, specifically for the Jakarta's metro system in this study. Meanwhile, some literature indicates that motorcycle-based ride-sourcing can also act as a substitute for public transport, particularly in high-density areas.

Safety and Security in Ride-Sourcing Services

Safety Aspects

According to Maurice et al. (2001), safety is defined as a state in which hazards and conditions that lead to psychological, material, or physical harm are controlled to protect the health and well-being of individuals and communities. From a systems perspective, safety theory identifies common types of accidents and the critical role of safety management in preventing them (Lower et al., 2018). In the ride-sourcing industry,

passenger safety perceptions improve as a result of the quality of service promised by ride-sourcing companies, including vehicle maintenance and skilled drivers (Quy Nguyen-Phuoc et al., 2021). Safety risks experienced by ride-sourcing users stem from driver behavior, such as reckless driving and the use of mobile phones driving (Acheampong, 2021). Passenger safety perceptions are considered a reflection of the responsible behavior exhibited by ride-sourcing drivers (Askari et al., 2021).

Based on research conducted by Ricardianto et al. (2024), passengers in Indonesia place significant emphasis on safety when choosing public transport, especially app-based vehicles, as opposed to non-app-based public transport. Similarly, passenger who rarely use ride-sourcing services are particularly concerned about safety factors (Wang et al., 2023). This condition indicates that safety is crucial for retaining and attracting new passengers, as passengers' sensitivity to safety levels can impact satisfaction and loyalty. Furthermore, according to Wang et al. (2023), to enhance passenger safety perceptions, appropriate measures must be taken by transportation network companies and transport agencies.

Security Aspects

According to Acheampong (2021), safety is a means of protecting or preventing individuals from exposure to hazards when using ride-sourcing services. The sense of security perceived by passengers is a complex blend of personal feelings of worry, fear, and anxiety arising from tense situations (Rittichainuwat, 2013). In other words, the perceived sense of safety is a psychological concept that not only encompasses perceptions of external threats but also a subjective evaluation of an individual's ability and capacity to control those threats and mitigate their consequences (Wills-Herrera et al., 2011).

In the context of ride-sourcing services, one factor that influences passenger security is exposure to dangerous and criminal activities (Acheampong, 2021). Although efforts have been made to enhance security through monitoring and tracking by service providers, security risks such as robbery, theft, kidnapping, car hijacking, and sexual harassment continue to be growing concerns among public transport users (Ekwoom Kamais, 2019; Orozco-Fontalvo et al., 2019). Additionally, to improve security in ride-sourcing services, the use of a dashboard camera in vehicles could be considered, as cameras not only monitor risky driving behavior but also suspicious actions by drivers during trips (Ricardianto et al., 2024). A study by Liu et al. (2022) investigated ride-sourcing user safety based on both general security and security concerning specific conditions. General security is influenced by the characteristics of physical security risks, such as sexual violence or other types of physical assault. Meanwhile, specific conditions, such as driving during the day or night, the driver's gender, and whether the passenger is carpooling with a stranger, affect their perception of safety during a particular journey. The study revealed that general security perceptions regarding ride-sourcing services are influenced by two risk factors: perceived likelihood and familiarity with the risk. In contrast, perceptions of security based on specific conditions are more influenced by situational characteristics, including interactions with the driver and vehicle, travel companion, and trip duration.

Measurement of Perception and Preference for Safety and Security in Motorcycle-based Ride-Sourcing

In transportation planning, perception refers to how individuals receive and interpret information about various aspects of different modes of transport. According to the *Kamus Besar Bahasa Indonesia* (KBBI), perception is a direct response or reception of something. Meanwhile, as defined by KBBI, preference is a prioritized choice because it is favored over others. In transportation planning, understanding preferences is essential, as they reflect users' desires, needs, and priorities. A person's preferences can be shaped by various factors, including socioeconomic conditions, personal experiences, cultural values, and interactions with the physical and social environment.

The measurement of user perception in motorcycle-based ride-sourcing services has become an increasingly common research topic in the public transport industry in recent years. A study by Quy Nguyen-Phuoc et al. (2021) examined the impact of perceived risk on user satisfaction, trust, and loyalty in ride-sourcing services in Ho Chi Minh City, Vietnam. To develop a measurement scale model for the study, relevant literature was reviewed to select appropriate measurement items for first-order constructs and to establish formative dimensions contributing to the creation of second-order constructs. Respondents answered questions regarding their level of agreement with each measurement item using a seven-point Likert scale, ranging from strongly disagree (= 1) to strongly agree (= 7). The collected data was analyzed using Partial Least Square–Structural Equation Modeling (PLS–SEM) to validate the proposed model and hypotheses. The measurement items in the study area were as follows:

- 1) Perceived risk related to booking: performance risk, data security risk, and conflict risk.
- 2) Perceived risk related to vehicles and drivers: property security risk, personal security risk, and traffic safety risk.

Another study that utilized PLS-SEM was conducted by Ricardianto et al. (2024), aiming to analyze the influence of service quality and safety perception on passenger satisfaction and attitudinal loyalty in ride-sourcing services across nine major cities in Indonesia (DKI Jakarta, Tangerang, Bekasi, Bandung, Semarang, Yogyakarta, Malang, Surabaya, and Medan). Additionally, a study by Su et al. (2021) also utilized PLS–SEM to develop and validate an integrated framework exploring the direct and indirect relationships among five constructs, that is, service quality, safety, engagement, satisfaction, and passenger loyalty in the context of ride-sourcing services.

Meanwhile, Wang et al. (2023) conducted a study by developing three ordered logit models for different passenger groups to explore factors influencing passenger satisfaction with ride-sourcing services. Another study that utilized a logit model was conducted by Nisa (2018), aiming to gain deeper insight into capturing the dual preferences of on-demand motorbike users as consumers and as citizens when making trade-offs between safety aspects and travel time in Jakarta. The study conducted by Liu et al. (2022) aimed to examine factors influencing passenger safety perceptions of ride-sourcing services in China, both in general and for specific trips, using regression

analysis. The perceived safety of a particular trip was measured using a seven-point Likert scale questionnaire regarding safety from sexual violence or other physical assaults. Subsequently, principal component factor analysis was performed to explore the latent structure of 29 situational characteristics, with varimax rotation applied to obtain a simple and interpretable factor structure. Additionally, the study by Rizki et al. (2020) utilized factor analysis and multiple linear regression analysis to identify safety and security aspects of ride-sourcing services and their relationship with perceived safety and security levels in Bandung. The study focused on young users, such as students, to understand their perspectives.

Thus, based on the discussion above, this study selected variables that possess unique characteristics, such as data security risk, which is an integral part of any application-based service, and were hypothesized to address predefined research objectives. The author applied factors influencing safety and security in online motorcycle taxi services to identify user perceptions of these two aspects, drawing from previous studies. The indicators used to measure security were categorized into data security risk, property security risk, individual security risk, and information security. Meanwhile, safety was assessed based on traffic-related safety risks and conflict risks. The statements used to measure these indicators are presented in the following table.

Table 1. Measurement of safety and security variables in motorcycle-based ride-sourcing

Variables	Indicators	Indicator statement	Code
Security	Data security risk	I feel that my personal information is safe and protected when using online transportation services	SE1
		I believe my ride-sourcing app account is secure from hackers who may want to misuse it	SE2
		I feel that the money in my e-wallet connected to the ride-sourcing platform is safe from theft	SE3
		The monitoring measures on the app provide adequate security for passengers	SE4
	Property security risk	I feel safe when carrying valuable belongings while using motorcycle-based ride-sourcing	SE5
		I feel that my belongings are safe from theft	SE6
		I feel safe if I accidentally leave my belongings behind, as the driver will return them	SE7
	Individual security risk	I feel safe from sexual harassment when using motorcycle-based ride-sourcing	SE8
		I feel safe from violence (assault) when using motorcycle-based ride-sourcing	SE9
		I feel safe from kidnapping (or similar incidents) when using motorcycle-based ride-sourcing	SE10
		I feel I can prevent myself from being attacked by a ride-sourcing driver	SE11
		I understand the risks of physical assault that may	SE12

Variables	Indicators	Indicator statement	Code
		be carried out by a ride-sourcing driver	
		I feel that the driver will not commit a physical assault that would have a significant impact on my life and work	SE13
	Information	The media pays a lot of attention to incidents that occur in motorcycle-based ride-sourcing	SE14
		People around me provide positive comments about motorcycle-based ride-sourcing services	SE15
		The ride-sourcing platform responds promptly to my inquiries when I file a complaint	SE16
		The information about the driver and vehicle is always consistent with the information available on the app	SE17
		The existing regulations regarding ride-sourcing services in Indonesia ensure customer security	SE18
		Overall, I feel safe using motorcycle-based ride-sourcing services	SE19
Safety	Traffic-related safety risk	I feel that I will be protected from traffic accident risks when using motorcycle-based ride-sourcing services	SA1
		I feel that I will be protected from being injured in a collision with another vehicle when using motorcycle-based ride-sourcing services	SA2
		I feel that the driver complies with traffic regulations and drives safely	SA3
		I have never experienced an accident when using motorcycle-based ride-sourcing services	SA4
	Conflict risk	The ride-sourcing service operator can provide me with an appropriate conflict resolution process in the event of a traffic accident	SA5
		The existing regulations regarding ride-sourcing services in Indonesia ensure customer safety	SA6

The measurement of preferences in this study was modelled and evaluated using econometric methods that employ data collected through a stated preference (SP) survey. This study combines four main attributes in the stated preference, namely travel time, travel cost, safety features, and security features, to understand the preferences of online motorcycle taxi service users, which are further explained in the next chapter. The attributes of travel time and travel cost have shown significant results in previous studies (Nisa, 2018), but this study also incorporates safety features and security features, which may offer new insights into this research topic.

The safety and security features used as attribute levels were based on features already available in several ride-sourcing apps, such as an emergency button, the ability to share trip details, travel insurance, and training provided by the ride-sourcing operator to offer

traffic safety training to drivers. Additionally, this study also used geofencing and safety sensors as technological innovations to enhance security and safety in motorcycle ride-sourcing services. Geofencing is a strategy that involves a virtual perimeter around a real-world geographical area, created to direct or prohibit vehicles and passengers from entering or exiting the area (Luis & León, 2022). An alarm will sound if the driver directs the passenger to the wrong route. Meanwhile, safety sensors act as warning devices if the driver exceeds the maximum speed limit to minimize traffic accidents. The choice scenarios that were offered to participants in the questionnaire were as shown in the following table. They were offered two alternative modes with unlabelled alternatives: RHS A and RHS B, where 'RHS' stands for ride-sourcing service.

Table 2. The choice scenarios in the main survey

Scenario	RHS A			
	Cost (rupiah)	Travel time (mins)	Security features	Safety features
1	17,500	15	Share trip details	Safety sensor
2	15,000	45	Emergency button	Travel insurance
3	12,500	15	Dash camera	Safety sensor
4	17,500	35	Share trip details	Driver training
5	20,000	25	Geofencing alert	Driver rest time reminder
6	20,000	25	Dash camera	Driver rest time reminder
7	15,000	35	Geofencing alert	Driver training
8	12,500	45	Emergency button	Travel insurance
Scenario	RHS B			
	Cost (rupiah)	Travel time (mins)	Security features	Safety features
1	12,500	25	Dash camera	Travel insurance
2	17,500	15	Geofencing alert	Driver rest time reminder
3	20,000	25	Geofencing alert	Driver training
4	15,000	15	Dash camera	Safety sensor
5	12,500	45	Emergency button	Travel insurance
6	15,000	35	Share trip details	Safety sensor
7	17,500	45	Emergency button	Driver rest time reminder
8	20,000	35	Share trip details	Driver training

Method

Study Area

The study area for this research were Jakarta's metro system stations along the Lebak Bulus – Bundaran Hotel Indonesia service line, also known as Phase 1, which is entirely within the Province of DKI Jakarta. Jakarta's metro system stations on this line are distributed across the administrative regions of South Jakarta and Central Jakarta. South Jakarta covers an area of approximately 144.942 km², consisting of 10 districts and 65

sub-districts. The population of South Jakarta was recorded at 2,235,606 people in 2023 (Badan Pusat Statistik, 2024). The Jakarta's metro system stations located within South Jakarta are Lebak Bulus Station, Fatmawati Station, Cipete Raya Station, Haji Nawi Station, Blok A Station, Blok M Station, ASEAN Station, Senayan Station, Istora Station, and Bendungan Hilir Station. Meanwhile, Central Jakarta has an area of approximately 47.565 km², consisting of 8 districts and 44 sub-districts. The population of Central Jakarta in 2023 was recorded at 1,049,314 people (Badan Pusat Statistik, 2024). Jakarta's metro system stations located within Central Jakarta are Setiabudi Station, Dukuh Atas Station, and Bundaran HI Station.

Phase 1 of Jakarta's metro system has been in operation since 2019. According to the 2023 annual report of Jakarta's metro system, there has been a steady increase in the number of passengers per year over the past three years, following the impact of the COVID-19 pandemic in 2020 and 2021. In 2023, the total number of passengers reached 33,496,540, with a daily ridership of 91,771. This represents a 69.38% increase from the previous year, when 19,776,064 passengers annually were recorded (PT MRT Jakarta, 2024). The trend of annual passenger numbers since Jakarta's metro system began operation in 2019 is illustrated in the following graph.

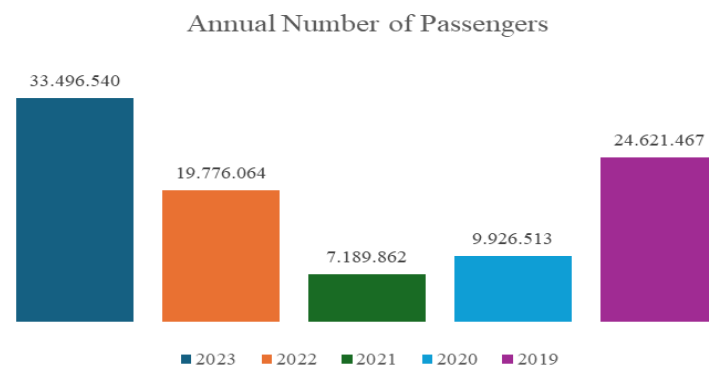


Figure 1. Annual number of passengers of Jakarta's metro system.

Integration of Jakarta's Metro System with Motorcycle-based Ride-Sourcing Services

A study conducted by Bosker et al. (2023) investigated the role of motorcycle-based ride-sourcing services in public transportation, specifically in Jakarta's metro system, and found that the opening of Jakarta's metro system stations led to a significant increase in motorcycle-based ride-sourcing activity around the stations. This finding aligns with the idea that motorcycle-based ride-sourcing services complement public transportation by providing first-mile and last-mile connectivity to the newly established mass rapid transit system.

One of the efforts to integrate Jakarta's metro system services with motorcycle-based ride-sourcing services is the establishment of designated stopping points for motorcycle-based ride-sourcing, serving as pick-up and drop-off locations around Jakarta's metro stations. Designated motorcycle-based ride-sourcing stopping points are available at Fatmawati

Indomaret Station and Cipete Raya Station.

Study Sample and Data Collection

The primary data in this study was collected through field surveys using a questionnaire distribution method. The platform used for this study was Google Forms. The questionnaire was designed for users of Jakarta's metro system who also use motorcycle-based ride-sourcing services as a feeder mode. The target characteristics of Jakarta's metro system users selected as the unit of analysis in this study were those who use online motorcycle taxi services for home-based trips to and from Jakarta's metro stations. Based on the survey, conducted from October 1 to October 27, 2024, a total of 744 responses were collected. However, after a selection and screening process to ensure the questionnaire results aligned with the study's characteristics and requirements, 718 respondents were deemed suitable for further analysis. These respondents met the criteria of having used Jakarta's metro system and having used motorcycle-based ride-sourcing services as a feeder mode for home-based trips.

In this study, factor analysis was used to process variables related to the perception of security and safety in motorcycle-based ride-sourcing services, as represented by statements in the questionnaire. The security variable consisted of data security risk, property security risk, individual security risk, and information risk. Meanwhile, the safety variable consisted of traffic-related safety risks and conflict-related risks. Furthermore, a binomial logit model was used since two alternative modes were being considered with unlabelled alternatives: RHS A and RHS B. The mode choice preference analysis was conducted using Pandas Biogeme (Bierlaire, 2023). The underlying concept of the discrete choice model is the random utility theory, which suggests that individuals make choices based on the utility they perceive from each available alternative (Ben-Akiva & Lerman, 1985). Each individual makes decisions rationally by considering which alternative offers the greatest benefit. The probability of choosing one alternative over the other is expressed in a logit function, which accounts for systematic utility and random disturbances. Mathematically, the probability P that an individual chooses alternative 1 over alternative 2 is given by:

$$P = \frac{e^{V_1}}{e^{V_1} + e^{V_2}} \quad (1)$$

where,

P : probability,

v_1, v_2 : the systematic utility perceived by each individual for each given choice.

In this study, V_1 represents the alternative mode 1, which is RHS A, and V_2 represents the choice mode 2, which is RHS B. The systematic utility is typically calculated as:

$$V_{RHS A} = \beta_0 + \beta_{1 RHS A} X_{i1 RHS A} + \beta_{2 RHS A} X_{i2 RHS A} + \dots + \beta_{k RHS A} X_{ik RHS A} \quad (2)$$

$$V_{RHS B} = \beta_0 + \beta_{1 RHS B} X_{i1 RHS B} + \beta_{2 RHS B} X_{i2 RHS B} + \dots + \beta_{k RHS B} X_{ik RHS B}$$

Result And Discussion

Summary Statistic Descriptives and Sample Characteristics

Socio-economic characteristics are a set of factors that describe the social and economic status of an individual within society. Socio-economic data is typically used to understand the demographic profile and the economic or financial situation of respondents in a study. According to the survey results from the 718 selected respondents, the majority were female, comprising 59%, with 427 respondents. Meanwhile, male respondents accounted for 41%, with 291 respondents. The age distribution of the respondents shows that the majority were between 24 and 29 years old, totalling 243 individuals. The median age of the respondents was 25 years and the frequency of respondents of age 25 was highest, with 70 respondents out of a total 718. This indicates that the respondents who use motorcycle-based ride-sourcing services as a feeder mode for Jakarta's metro system, for home-based trips, belonged to the productive age group. In terms of educational background, the majority of respondents (66.43% or 477 respondents) had a bachelor's degree or equivalent. Most respondents were employed as civil servants, employees of state-owned enterprises (BUMN), private sector employees, or honorary staff, with a total of 425 respondents, making up 59.19% of the sample. This suggests that most of Jakarta's metro system users who use motorcycle-based ride-sourcing as a feeder mode are individuals with formal employment in various institutions. The survey results further revealed that most respondents had a middle-income level, with 410 respondents earning between IDR 5,000,000 and IDR 15,000,000. Based on the data, 200 respondents did not own private vehicles, either motorcycles or cars. These respondents were classified as captive users. A captive mode user is described as an individual who has no other available transportation options, such as someone who does not have a driver's license or does not own a personal vehicle (Beimborn et al., 2003). Therefore, these respondents were reliant on public transportation for their daily mobility.

Based on the survey results, most respondents resided in South Jakarta, with a total of 287 respondents. The fewest respondents lived in Bogor Regency, with 6 respondents, and Tangerang Regency, with 5 respondents. Most of Jakarta's metro system users who also use ride-sourcing services as a feeder mode of transport live in the Jakarta Capital Region (DKI Jakarta), with a total of 490 respondents, accounting for 68.25% of the total 718 respondents. The most frequently traveled route was from Dukuh Atas Station to Blok M Station, with 38 trips recorded. The area surrounding Blok M Station is characterized by a bustling activity hub, including shopping malls and parks that are popular for recreation. The next most common route was from Lebak Bulus Station to Bundaran HI Station, with 34 respondents. Bundaran HI Station is surrounded by office buildings and shopping centers. Additionally, the Lebak Bulus – Bundaran HI route was one of the most popular routes in 2023 (PT MRT Jakarta, 2024). This aligns with the travel purposes, showing a balanced mix of mandatory trips such as commuting to work and non-mandatory trips such as leisure or shopping. Furthermore, according to the survey results, respondents used Jakarta's metro system during various times of the day, with the highest frequency in the afternoon (from 3:00 PM to 7:00 PM), with 419

respondents, or 34.26%. This is influenced by the combination of mandatory and non-mandatory travel purposes that can be carried out during that time. The frequency of using motorcycle-based ride-sourcing to travel to Jakarta's metro stations from home is consistent with the frequency of using motorcycle-based ride-sourcing to travel from Jakarta's metro stations to home. The majority of respondents used motorcycle-based ride-sourcing one to two times a week for both trips, with 429 respondents for the former and 430 respondents for the latter. Based on the survey results, the majority of respondents used Jakarta's metro system and motorcycle-based ride-sourcing as their primary modes of transportation, with 503 respondents for Jakarta's metro system and 402 respondents for motorcycle-based ride-sourcing. This data aligns with the objectives of this study, which focused on both Jakarta's metro system and motorcycle-based ride-sourcing users. This means that the respondents were representative of the actual population. Additionally, the majority of respondents used motorcycle-based ride-sourcing to access stations or the initial stops of their daily public transportation, with 451 respondents.

Furthermore, the majority of respondents, 92.76% or 666 respondents, had never experienced a traffic accident while using motorcycle-based ride-sourcing services. Meanwhile, 52 respondents, or approximately 7.24% of the total 718 respondents, had experienced a traffic accident while using motorcycle-based ride-sourcing services. In general, respondents tended to have similar perceptions across all indicators, meaning that motorcycle-based ride-sourcing services provide a sense of safety with the various statement indicators provided. These statement indicators include risks related to traffic safety and the risk of conflict as well as security variables such as data security risk, property security risk, individual security risk, and information security risk. However, for indicators SE7 and SE17, the respondents tended to show a higher level of disagreement compared to other indicators. This suggests that users are concerned about the honesty of drivers with indicator SE7. Additionally, indicator SE17 indicates that users encounter inconsistencies between the driver and vehicle information available on the motorcycle-based ride-sourcing app.

Factor Analysis of Safety and Security Perception

Factor analysis was used to reduce independent variables into a set of factors based on correlations between variables, reflecting respondents' perceptions of the safety and security factors of ride-sourcing services. This process grouped 24 indicators from the independent variables on safety and security perception into simpler new factors, which effectively represented the variables formed in the safety and security perceptions, while considering the relationships between the variables. The data used in this analysis were primary data obtained from a questionnaire with a Likert scale, ranging from strongly disagree, disagree, neutral, agree, to strongly agree. Based on the values in Table 3, it can be seen that five factors were formed, originating from eigenvalues greater than 1. The number of factors formed is also shown in Figure 2, where five points have values greater than 1. According to the total variance explained in Table 2, Factor 1 explained 43.182% of the variance, Factor 2 explained 7.186%, Factor 3 explained 6.542%, Factor 4 explained 5.106%, and Factor 5 explained 4.933%. Cumulatively, the five factors formed explained 66.949% of the total variance. In other words, 33.051% of the variance remained unexplained by these factors.

Table 3. Total variance explained

Initial Eigenvalues			Extraction of Squared Loadings			Rotation Sums of Squared Loadings		
Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
10.364	43.182	43.182	10.364	43.182	43.182	3.963	16.512	16.512
1.725	7.186	50.368	1.725	7.186	50.368	3.504	14.601	31.113
1.570	6.542	56.910	1.570	6.542	56.910	3.167	13.196	44.309
1.225	5.106	62.016	1.225	5.106	62.016	2.971	12.381	56.690
1.184	4.933	66.949	1.184	4.933	66.949	2.462	10.259	66.949

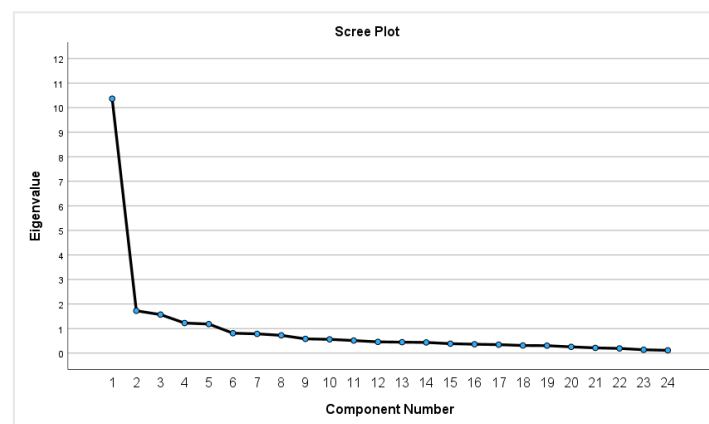


Figure 2. Scree plot eigen values graphic.

Based on the results of the principal component analysis (PCA), the names of the factors formed were determined based on the highest loading factor values, considering the significant variables associated with each factor (Hair Jr et al., 2010). Factor 1 could be categorized as the perception of property and individual security, Factor 2 as the perception of service management, Factor 3 as the perception of data security, Factor 4 as the perception of traffic accident risk, and Factor 5 as the perception of physical security.

The results revealed that users of motorcycle-based ride-sourcing as feeder mode for Jakarta's metro system currently prioritize property and individual security. This factor accounts for 43.182% of the total variance. The emphasis on property and individual security may stem from the increasing prevalence of criminal incidents and sexual harassment targeting motorcycle-based ride-sourcing passengers in Indonesia. This finding aligns with research conducted by Quy Nguyen-Phuoc et al. (2021), which highlights that various types of criminal activities pose threats to both user and drivers of motorcycle-based ride-sourcing services.

Model of the Influence of Safety and Security Aspects of Motorcycle-based Ride-Sourcing as a Feeder Mode for Jakarta's Metro System

In this section, a model estimation is carried out to determine the preferences of Jakarta's metro system users in selecting ride-sourcing services as a feeder mode for home-based

travel, with respect to safety and security aspects. The amount of data processed in the model estimation is the product of the number of respondents obtained and the number of scenarios provided, that is, 718 respondents x 8 scenarios = 5744 observations. The data conditions for each variable are explained in the descriptive statistics presented in Table 4. The binomial logit model analysis was performed using the Biogeme application. The modelling was divided into two parts: the first model was the base model, consisting of attribute variables in the choice scenarios. The second model estimated the attribute variables, the socio-economic variables of the respondents, and the factors formed from the factor analysis results.

Table 4. Model estimation results

Variables	Affected Alternative	Base Model		Socioeconomic Significant Model	
		Value	Rob t-test	Value	Rob t-test
Constant	RHS B	0.244*	4.849	0.175*	4.359
Cost	RHS B	-0.176*	-14.259	-0.184*	-13.644
Travel time	RHS A	-0.076*	-17.450	-0.073*	-17.724
Travel insurance	RHS B	0.125*	2.657	-	-
Driver training	RHS A	-0.170*	-3.552	-0.171*	-3.58
Driver rest time reminder	RHS B	-0.453*	-5.676	-0.472*	-5.971
Safety sensor	RHS A	0.096*	2.696	0.088*	2.505
Share ride details	RHS A	-0.570*	-12.113	-0.511*	-12.243
Geofencing alert	RHS A	0.275*	10.259	0.29*	10.714
Dash camera	RHS A	-0.383*	-4.121	-0.298*	-3.702
Emergency button	RHS B	-0.275*	-10.259	-0.29*	-10.714
Female	RHS B	-	-	0.147*	2.534
Secondary education	RHS A	-	-	-0.128*	-3.4
Mandatory trips	RHS B	-	-	0.19*	2.839
Frequency RHS to home (1-2 times a week)	RHS B	-	-	0.223*	3.296
Perception of service management	RHS A	-	-	5.1e-16*	2.218
Observations		5744		5744	
Final log-likelihood		-3575.94		-3566.12	
Rho-squared		0.102		0.104	
Akaike Information Criterion		7173.881		7168.245	
Bayesian Information Criterion		7247.096		7288.052	

- Not relevant; * Significant at 5% level.

The t-test values for the attributes of travel time and cost are high in the model estimation results are high, meaning that these parameters were estimated with greater accuracy. The travel time parameter has a value of -0.073, which indicates that for every 1-minute increase in travel time, utility will decrease by 0.073. Additionally, the cost parameter has

a value of -0.184, indicating that for every 1,000 IDR increase in cost, the utility will decrease by 0.184. Both factors suggest that respondents prefer motorcycle-based ride-sourcing because they offer fast travel times and low transportation costs. This is consistent with previous research by Nisa (2018) and Raco et al. (2018).

Furthermore, several socio-economic variables were found to be significant in the choice of motorcycle-based ride-sourcing as a feeder mode for Jakarta's metro system on home-based journeys. Female users tended to choose motorcycle-based ride-sourcing services over males. This aligns with previous research by Irawan et al. (2022) and Sabogal-Cardona et al. (2021), which found that women tend to rely more on ride-sourcing services. Women tend to have more diverse travel chains compared to men and the flexibility of motorcycle-based ride-sourcing can facilitate women's mobility. The purpose of the trip, particularly mandatory trips such as commuting to work, school, or university, also influence the preference for motorcycle-based ride-sourcing services. The interaction between the considered modes for mandatory trips and their attributes, such as travel time reliability, stress levels, and fare transparency, affects online transport choices (Devaraj et al., 2020). A study by Bhaduri & Goswami (2023) revealed that students exhibit the highest tendency to use ride-sourcing services, followed by working individuals, and that respondents who are employed have more resources, knowledge, and control over online transport systems, reflecting their need for regular travel, especially for mandatory trips. Furthermore, individuals who use motorcycle-based ride-sourcing services from Jakarta's metro system stations to their homes with a frequency of 1 to 2 times a week are more likely to choose motorcycle-based ride-sourcing services as their feeder mode.

On the other hand, individuals with only secondary education, including elementary, middle, and high school levels, tend to not choose motorcycle-based ride-sourcing services as their feeder mode for Jakarta's metro system. Previous studies have indicated that the increased use of ride-sourcing services correlates with individuals having higher education (Gomez et al., 2021; Grahn et al., 2020; Lim & Fernandez, 2022), rather than those with only secondary education.

The latent variable formed from the factor analysis, which represents individuals' perceptions of safety and security, significantly affects the choice of motorcycle-based ride-sourcing services as a feeder mode for Jakarta's metro system. This was particularly evident in the perception of service management. This factor reflects respondents' perceptions of operators' responsiveness to complaints, the consistency of driver information in the app, regulations related to customer safety and security, and perceptions of available media information and overall security. Respondents had a positive view of service management, indicating that the variables included in this factor influenced their positive decision regarding their willingness to use ride-sourcing services as a feeder mode for Jakarta's metro system on home-based trips.

Conclusion and Future Study

The development of ride-sourcing services over the past decade in Indonesia has reflected

changes in urban mobility. These services have become not only a complement to public transportation but, for some, a replacement for traditional public transport. Along with the growth of this technology-based service, new problems and challenges have emerged, particularly regarding the safety and security of its users. Respondents using motorcycle-based ride-sourcing services as a feeder mode for Jakarta's metro system now prioritize the safety of property and individuals. Furthermore, factors such as service management, data security, traffic accident risks, and physical safety have also become significant considerations for the public.

Individual preferences in choosing motorcycle-based ride-sourcing services are influenced by various variables. In addition to travel time and cost, the features available in the motorcycle-based ride-sourcing services also impact preferences. Features that positively influence the choice of motorcycle-based ride-sourcing include safety sensors that provide warnings when the driver accelerates too quickly and geofencing alerts that notify users when a driver deviates from the intended route to their destination. Socio-economic characteristics and travel characteristics that influence the choice of motorcycle-based ride-sourcing include respondents who are female, the purpose of the trip being mandatory (such as work or school), and the frequency of using motorcycle-based ride-sourcing services from Jakarta's metro system stations to home 1-2 times a week. The perception of safety and security factors that affect individual preferences for choosing motorcycle-based ride-sourcing is primarily related to service management.

Therefore, motorcycle-based ride-sourcing services have the potential to serve as a feeder mode for Jakarta's metro system. This potential must be supported by improving safety and security measures for passengers. Safety features that could be added include safety sensors, while security features that need to be incorporated include geofencing alerts. Additionally, motorcycle-based ride-sourcing service operators must improve their responsiveness to complaints and ensure consistency in the driver information provided on the app.

This study had several limitations that should be considered to ensure that the findings are interpreted within the appropriate context as follows: this study only considered the availability of safety and security features in the attributes of the scenarios without providing a broader depiction of security and safety risk, such as traffic accident rates, fatality rates, crime rates, and weather conditions. This study only provided motorcycle-based ride-sourcing service as an alternative to feeder mode; future research could explore alternative feeder modes, such as minibuses, electric bicycles, and others, to examine user preferences for these modes while considering safety and security aspects specific to each mode of transport. Furthermore, the model estimation results indicate that, in this study, the independent variables only explained 10.4% of the variation in the dependent variable. The remaining variation was influenced by other independent variables that were not included in this study. This suggests that additional variables may better explain user preferences related to this topic.

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