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Ride-Hailing Preferences for First- and Last-Mile Connectivity at Intercity Transit Hubs

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Abstract: This study aims to fill a research gap by focusing on ride-hailing services (RHSs) as first- and last-mile (FLM) modes linking intercity hubs, which have been explored less than metro hubs. Involving 418 RHS users in the Yogyakarta conurbation, Indonesia, this study applies confirmatory factor analysis to identify the motivations for using RHSs as FLM modes and employs a seemingly unrelated regression model to analyse factors influencing RHS usage and the relationship between first-mile and last-mile use, which remains underexplored. The model's results reveal that the utilization of RHSs for the first mile is mostly seen among younger, educated, and wealthy persons. However, these variables did not impact last-mile-mode use. The model's results also show that in FLM contexts, vehicle ownership did not substantially impact RHS use. In addition, RHSs are less often used for trips to intercity bus terminals compared to airports and railway stations. This study also highlights the significance of user preferences, such as comfort and safety, seamless transaction and service, and cost and time efficiency, in influencing the use of RHSs for FLM modes. Increasing RHS accessibility at transit hubs, expanding e-payment options, simplifying payments, and prioritizing fairness are suggested strategies to improve urban sustainability through RHSs.

Keywords: first mile; frequency; last mile; ride hailing; transit access

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1. Introduction

Ride-hailing services (RHSs), services that dynamically match drivers' availability with customers' demands through online platforms [1], are becoming more widespread worldwide. Studies conclude that implementing effective policies for RHSs could improve not only mobility but also sustainability in urban areas [2–4]. Previous research reveals that RHSs have some positive effects, such as reducing the number of private vehicle owners [5], parking demand [6–8], the risk of drunk driving [9,10], and accident rates [11]. RHSs are also beneficial for transit users as a first- and last-mile (FLM)-mode option to reach transit hubs. For transit use, the first mile refers to the beginning part of an individual's travel or access trip from origin points to transit hubs. In contrast, the last mile refers to the ending part of an individual's travel or egress trips from transit hubs to destination points [12].

Previous studies have shown a wide range of interactions between RHSs and transit, ranging from complementary and competitive to no significant impact [13–16]. However, the focus has predominantly been on urban and metro settings, leaving intercity transit connections less explored. Building on this foundation, this study aims to deepen the understanding of RHS usage within intercity transit contexts. Specifically, it seeks to identify the critical factors driving the use of RHSs as FLM modes at intercity transit hubs, such as bus terminals, railway stations, and airports, thereby addressing a research gap largely neglected by prior studies. Furthermore, this study aims to explore the correlation between RHS use for first-mile (FM) and last-mile (LM) modes, seeking to unveil the interconnected reasons behind these choices. This investigation is essential for a comprehensive understanding of travel behaviour among RHS users, filling the gap left by RHS studies that have not examined the relationship between FM and LM choices [17–20].

This study engaged 418 RHS users in the Yogyakarta conurbation, an Indonesian urban agglomeration with a high demand for RHSs [21] and limited city bus coverage [22,23]. Initially, confirmatory factor analysis was utilized to uncover the motivations behind using RHSs as FLM modes. Subsequently, a seemingly unrelated regression (SUR) model was employed to identify the determinants of RHS use for FLM modes and to examine the relationship between RHS use for FM and LM. This study holds particular interest as, prior to the advent of RHS, Yogyakartans who commuted by train typically preferred to use two motorcycles for their FM and LM needs, avoiding city buses, highlighting a unique urban-mobility dynamic [24].

Using RHSs as an FLM mode contributes to sustainable mobility in the study area in at least three ways. Firstly, as discussed by Suatmadji et al. [2], once intercity travellers prefer to use RHSs as their FLM mode rather than being escorted by their family members or friends using private vehicles, it will reduce the vehicle's number of kilometres travelled, greenhouse gas emissions, and air pollution. Secondly, as shown in Wadud's and Henao and Marshall's findings [6,7], using RHSs as an FLM mode could reduce the parking demand, and therefore, the transit hub operators can accommodate an increasing number of transit passengers and earn monetary benefits without building more parking spaces. Lastly, RHSs could supplement city bus-service coverage in the study area, which also has less reliable arrival times and long travel times due to the slow meandering bus route [22].

The rest of the paper is organized as follows. In the second section, this study reviews previous studies on RHSs acting as an FLM connection to transit hubs. The third section discusses the method and data, including the survey design and data-collection method. The survey findings, including descriptive statistics, and model results are also presented in the next section. The last section outlines the key findings and suggests sustainable transport policies and further studies.

2. Literature Review

2.1. Bridging the Gap between RHSs and Transit

Studies have revealed that RHSs have increased transit demand, especially for commuter rail, in both developing [13] and developed countries [25], since this service can act as an FLM mode. For example, a study in major cities in the U.S. found that RHSs increase commuter rail demand by up to 3% but decrease bus demand by 6% [26]. Panel data from 273 Chinese cities revealed a similar pattern: RHSs boosted commuting-line passengers while reducing bus passengers [27]. Meanwhile, other studies found that integrating RHSs and public transit could significantly attract the demand for both services and effectively solve the FLM problem [28–30]. Another study also revealed that RHSs could supplement transit services where the trips occur outside the operating hours of transit [31,32]. People may, for example, attend evening events using transit but return late at night, utilizing RHSs when transit is unavailable [32]. Thus, RHSs enable previously restricted trips owing to limits on public-transit operating schedules and stimulate transit use that would not be undertaken if RHSs did not exist [33].

Studies focusing on RHSs in Indonesia reveal their dual function in urban transportation: they both supplement and compete with transit systems. Specifically, in the Jakarta Metropolitan Area (JMA)—Indonesia's capital—evidence suggests that RHSs, especially motorcycle RHSs, augment Bus Rapid Transit and metro systems by serving as FLM modes while simultaneously challenging existing micro-transit services [34–36]. Conversely, investigations in other Indonesian urban centres, such as Yogyakarta, Semarang, and Bandung, have delved into how RHSs can act as a substitute for city bus services [37,38]. Despite these findings, a significant gap persists in our comprehension of the underlying factors that guide intercity transit users' preference for RHSs as an FLM solution, alongside strategies for enhancing RHSs' effectiveness in this role. This study aims to bridge this gap by examining the determinants that drive the adoption of RHSs for FLM purposes, particularly at intercity transit hubs. The types of intercity transit hubs, airports, railway stations, or inter-city bus terminals, are also considered independent variables affecting the utilization of RHSs as FLM modes. This inquiry is pivotal, as a specific investigation in Yogyakarta revealed a pronounced reliance on RHSs for trips to transit hubs, as opposed to other destinations such as downtown areas, campuses, shopping centres, social visits, time-sensitive engagements, or peak-hour travel [21]. Nevertheless, that study did not further investigate the trip characteristics leading to transit points, a topic our study seeks to elucidate.

2.2. Demographics of RHS Users

Over the past decade, extensive effort has been devoted to examining various determinants influencing RHS use, although not specific to their role as an FLM mode. Many investigations have shown that socio-economic characteristics significantly affect the adoption and frequency of RHS use. For example, a study in Iran shows that young people and females tend to use RHSs more [39]. Meanwhile, studies in the U.S. revealed that younger, educated, and more affluent people use online transportation services more frequently [5,10,26,40–43]. A similar pattern of RHS use can be seen in Indonesia, where women, younger and more educated people, and those with lower-middle income dominate RHS use in JMA [34]. However, a different characteristic of ride-hailing users occurs in China, where about 53% of Didi users are not highly educated [44]. Meanwhile, in South Africa, a study found that the majority of ride-hailing users come from low-income households without car ownership [45]. Previous studies also revealed that household characteristics significantly affect RHS use. According to Sikder, Americans who live with children, older adults, or both, and those who live in households with more private vehicles are less likely to utilize RHSs [43]. However, the relationship between private vehicle ownership and the frequency of RHS use is being debated. Conway et al. discovered that, in the U.S., private vehicle ownership is adversely connected to RHS use [40]. Similarly, Alemi et al. also found that people in California who do not own a vehicle use RHSs more often [46]. Furthermore, according to several studies, RHS use is more prevalent in densely populated areas due to the high mobility required in these areas [40,41,46]. Table 1 summarizes previous studies showing that socio-economic variables significantly influence RHS use.

2.3. Motivations behind Utilizing RHSs

The literature also explores the key important reasons for utilizing RHSs. In general, cheaper and transparent fees [47–51], being cashless [35,52], having predictable and short travel times including waiting times [51,53], comfort [14,47], security [54–56], and safety [57,58] are key determinates for RHS use. For example, a study revealed that RHSs employ pricing tactics like surge pricing and incentive bonuses to manage the equilibrium between supply and demand, thus guaranteeing transparent fee structures [48,49]. Meanwhile, another study found that RHS offers more economical transportation while maintaining service quality, rendering it a financially prudent option for travel [59,60]. Additionally, a study investigated reasons for travellers in JMA to use RHSs as their FLM mode connecting commuter lines, bus rapid transit, and mass rail transit, including the convenience of switching to an RHS, the clarity of the pickup location, and the integration of payment methods [35]. Meanwhile, a study concluded that people who own bank accounts and smartphones are more likely to use RHSs for their FLM mode among Los Angeles metro passengers [20]. Furthermore, He et al. stated that strict restrictions for arrival times, heavy luggage, and a guarantee that passengers' desired arrival and travel times may be met despite fluctuations in travel times became three main factors affecting FLM-mode options connecting intercity transit hubs [61]. At the same time, in their systematic review of the empirical literature, Lu et al. concluded that three main components influence the choice of travel mode for FLM. The first component is conventional factors, such as fares and the diversity of land use for the ride-sharing choice as an FLM mode. The next component is exogenous factors, including safety, security, connectivity, weather and temperature, and the ease of accessing FLM modes. The last factor is special considerations associated with newly developed transportation and informal public transport. That study also revealed that for a motorcycle-based RHS choice, these factors include land-use characteristics, stop amenities, public perception of safety, and accessibility to all major destinations [62]. Table 1 presents a summary of prior studies outlining the motivations behind the utilization of RHSs.

Table 1. Determinants of RHS use for FLM and hypothesis development.

Variables	Prior Studies	Hypothesis
H1. Socio-economic variables		
Age	[10,26,40–43]	Negative correlation
Gender (female)	[5,41,42]	Negative correlation
Area of living *	[40,41,46,62]	Negative correlation
Monthly income	[5,10,26,40,42,43]	Positive correlation
Education	[10,41–43]	Positive correlation
Private vehicle ownership	[40,46]	Negative correlation
H2. Frequency of RHS use for all trip purposes	Self-developed	Positive correlation
H3. Type of intercity transit hubs predominantly reached by RHS **	Self-developed	Negative correlation
H4. Reasons for RHS use for FLM		
Flexibility	[35]	Positive correlation
Easy handling of hefty luggage	[61]	Positive correlation
Convenience	[14,47]	Positive correlation
Secure and safety	[54–58,62]	Positive correlation
Cashless	[35,52]	Positive correlation
Simple ordering process	[35]	Positive correlation
Door-to-door service	[62]	Positive correlation
Clarity of pickup location	[35]	Positive correlation
Cheaper and transparent fee	[47–51]	Positive correlation
Short waiting time	[51,53]	Positive correlation
Reliable travel time	[53,61]	Positive correlation
H5. RHS use for FM affects LM	Self-developed	Positive correlation

* Yogyakarta city and ** airport as a reference category.

2.4. Integration Programs of RHSs with Transit in Indonesia and Hypothesis Development

In Indonesian cities, to support the complementary effect of RHSs on existing public transport, since 2022, RHS companies have collaborated with the local government and public transport operators, integrated their payment systems, and built ride-hailing shelters surrounding metro stations and intercity transport hubs. However, to date, only Jakarta and Yogyakarta have implemented this integrated system between RHSs and public transit, and this study has also been conducted in Yogyakarta. On another note, Gojek, the biggest RHS company in Indonesia, remains the sole provider offering this service through its GoTransit feature, which assists public transport users in finding the quickest, most cost-effective, and efficient multimodal routes from their starting point to their destination. Furthermore, Gojek has introduced a unified payment system that is applicable across various platforms, including public transport. This move by Gojek is attributed to their claim that one out of every two users of RHSs, especially motorcycle-based RHSs, employs the service for FLM travel needs [63]. In contrast, other RHS companies operating in Indonesia, such as Grab, Maxim, inDrive, Anterin, and AsiaTrans, have not yet implemented this integrated system.

Furthermore, stemming from the literature review outlined above, five primary hypotheses, where the detailed hypotheses for each variable are presented in Table 1, have been formulated as follows.

Hypotheses 1 (H1): socio-economic characteristics, including age, gender, income, and education level, significantly affect the frequency of RHS use for FLM.

Hypotheses 2 (H2): RHS-use frequency for all trip purposes positively and significantly affects the frequency of RHS use for FLM.

Hypotheses 3 (H3): people travelling to airports have a lower (negative) propensity to use RHSs for FLM compared to people travelling to intercity bus terminals and railway stations.

Hypotheses 4 (H4): user preferences for RHSs positively and significantly affect the frequency of RHS use for FLM.

Hypotheses 5 (H5): an increase in RHS-use frequency for the FM significantly increases the frequency of RHS use for the LM, and vice versa.

3. Method and Data

3.1. Seemingly Unrelated Regression (SUR)

SUR is one of the econometric methods that has been widely used in applied research [64]. Wang and Kockelman stated that many studies in the transportation field encounter situations where similar factors arise and exhibit correlated disturbances that influence the variables of interest [65]. In some studies, SUR was employed to gain insights into how explanatory variables affect response variables in the context of travel-behaviour analysis and public transport choice [64,66–69]. For instance, Fu's study [66] investigates the impact of socio-economic variables on individuals' allocation of time to various activities, including maintenance and leisure, across five cities in China. Utilizing the SUR method, the study elucidates determinants of time allocation on various activities and the correlations among different activities across cities. Meanwhile, a study conducted in the United States examines the interplay between multi-level urban form and commuting modes, such as automobile, transit, and walking/biking, within the vicinity of rail-station areas. The application of SUR in this context facilitates a comprehensive analysis, revealing factors influencing travel-mode choice and the complex relationship between the three available modes [64].

In this study, employing SUR allows for understanding factors influencing the frequency of RHS use for the FM and LM and for exploring a relationship between the frequency of RHS use for FM and LM modes. SUR enables us to estimate coefficients more effectively. The basic equation of SUR, as initiated by Zellner [70], can be written as shown in Equation (1), where Y means the dependent variable, X represents the explanatory variable, β is a coefficient, u is unexplained error terms, and N is the number of equations.

$$\begin{pmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_N \end{pmatrix} = \begin{pmatrix} X_1 & 0 & \dots & 0 \\ 0 & X_2 & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & X_N \end{pmatrix} \begin{pmatrix} \beta_1 \\ \beta_2 \\ \vdots \\ \beta_N \end{pmatrix} + \begin{pmatrix} u_1 \\ u_2 \\ \vdots \\ u_N \end{pmatrix}, \tag{1}$$

There were two dependent variables (Y). Y_1 represents the frequency of RHS use for the FM mode, and Y_2 represents the frequency of RHS use for the LM mode. Meanwhile, the explanatory variables (X) consist of socio-economic variables (gender, age, education, income, area of living, and private vehicle ownership), frequency of RHS use for all trip purposes, and intercity transit hubs that RHSs predominantly reach. This study also attempted to include latent variables of psychological factors into the explanatory variables. The latent variables were represented by the endogenous factors related to reasons for choosing RHS and were run separately from the SUR model.

Factor scores were computed to analyse latent variables separately from the SUR model to characterize the factors of endogenous variables, a step included in the subsequent confirmatory factor analysis (CFA), as proposed by Hair et al. [71]. These scores are composite values formed by the interaction of the weight factor and the original values of various observed variables with an average of zero. Factor scores were preferred over simple averages or mean values, as they apply different weights to the observed variables compared to the latent variables. Equation (2) illustrates the calculation of the factor score value ($\hat{F}_i$), involving the product of the factor loading matrix (Λ') from the CFA, the inverse of the covariance matrix (Σ^{-1}), and the observed variables (X_i).

$$\hat{F}_i = \Lambda' \sum\nolimits^{-1} X_i \tag{2}$$

In this study, the SUR function within the systemfit package in R-Studio was utilized to conduct the SUR model analysis, while SPSS was employed to conduct factor analysis and calculate factor scores.

3.2. Data Collection

The survey of this study was carried out between December 2022 and January 2023 in the Yogyakarta conurbation, including (1) Yogyakarta city, an urban area with high density and many intercity transit hubs and an accessible public transport service, (2) the Sleman suburban area, a rapidly developing suburban area with a few intercity transit hubs, and (3) the Bantul suburban area, a suburban area without intercity transit hub and a poor public transport-coverage area [72,73]. Figure 1 displays the study area, including the location of intercity transit hubs, and the sample size in each zone within the study area.

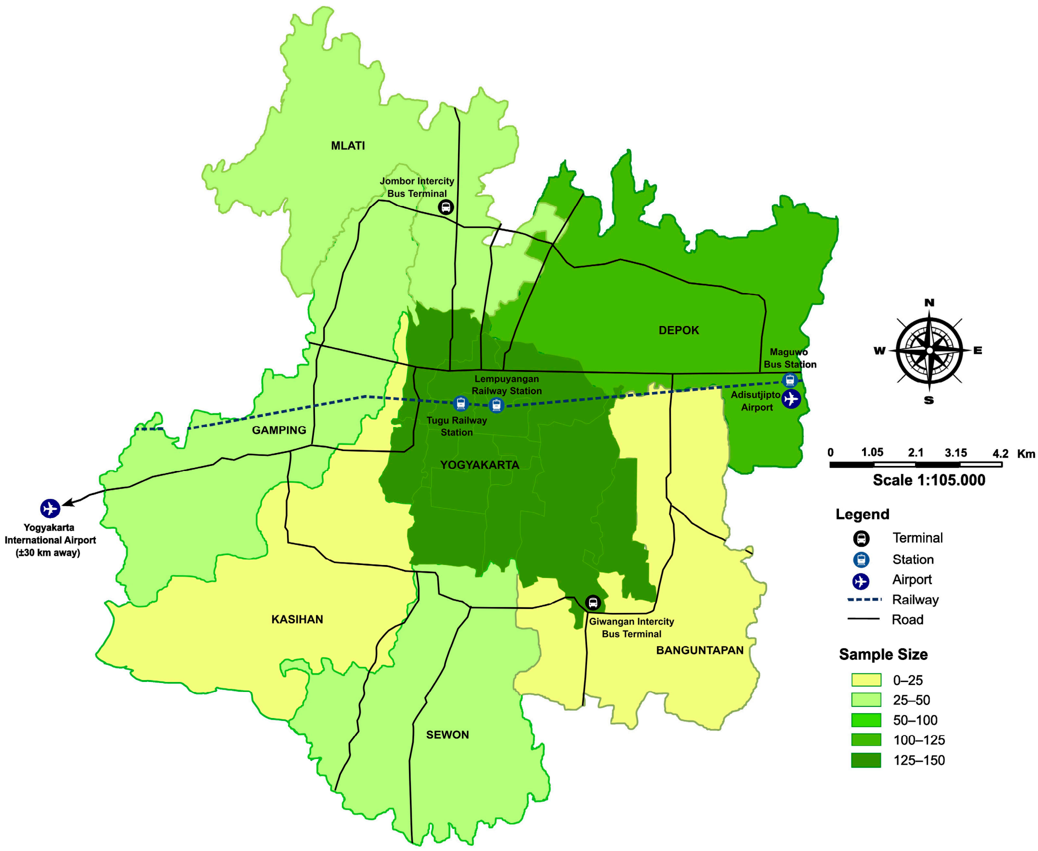

Figure 1. Study area and respondent distribution (modified from [72,74]).

Before conducting the main survey, a pilot study was conducted involving a sample of thirty students. This preliminary study aimed to assess the clarity of the language and the relevance of the questions presented in the questionnaire. The original content of the questionnaire, which drew on variables identified in previous studies as discussed in the literature review, was evaluated during this pilot phase. Additionally, two experts reviewed the content, providing insights and adjustments to enhance its validity. The data collected from this pilot study were rigorously analysed to ensure both validity and reliability. Based on the feedback obtained from the respondents in the pilot study, the questionnaire was refined and finalized for use in the main survey.

The main survey involved ten undergraduate students as surveyors. Each surveyor was provided with training and monitored by researchers. For example, when surveyors ask the motivations behind RHS use for FLM to the respondents, where responses are measured on a 5-point Likert scale ranging from "strongly disagree" to "strongly agree", surveyors are taught how to systematically ask about these variables. Moreover, surveyors are trained to maintain a neutral tone to avoid influencing the respondents' answers. During the survey, the surveyor also communicated with the researcher via WhatsApp if there were any questions related to the survey. This study employed a random sampling method to conduct surveys in public places such as commercial areas and intercity transit hubs, including bus terminals, airports, and railway stations. The surveyors randomly select and intercept individuals who appear to be approachable and comfortable with participating in the survey. Of the 480 respondents who participated, 418 valid answers were collected. The survey achieved an impressive response rate of 87.08% because the surveyor directly explained all questions on the questionnaire form to the respondents. The invalid survey data were identified by recognizing patterns that indicate non-genuine responses, such as uniform answers to consecutive questions, especially answers related to the motivations behind RHS use for FLM, and suspicious entries, particularly in sensitive questions like that concerning income. This can be carried out by comparing income-related answers with those related to the ownership of private vehicles. Completing the interview required an approximate 20 min duration, and respondents who completed the questionnaire received IDR 20,000 (USD 1.34).

The questionnaire is structured into five distinct sections, each focusing on the behaviour of RHS passengers during their FLM trips at integrated transit hubs. The initial section probes the frequency of using RHSs for all trip purposes. The respondents' responses are defined on a seven-point scale from the lowest to the highest (1: Once a year or less, 2: Several times per year, 3: Once a month, 4: Several times a month, 5: Once a week, 6: Several times a week, and 7: Almost every day). After that, the respondents were asked about their RHS use for FM and LM modes, separately, to and from intercity transit hubs. In this question, the respondents are faced with a 5-point Likert scale answer, ranging from 1 for never to 5 for always. If a respondent only uses RHSs for FM, he/she will answer with "always". In contrast, if a respondent uses RHSs for all trip purposes except trips from intercity transit hubs to his/her home (RHS use for the LM mode), he/she will answer with "never".

The next question investigates the predominant intercity transit hub destination when RHSs are employed for FLM, with the question, "Which intercity transport hub do you often use MHS for your FM and LM modes?" In this part, respondents have three choices: railway stations, airports, and intercity bus terminals. The fourth section delves into the reasons behind users choosing RHSs for an FLM mode to intercity transit hubs. The main variables within this section encompass flexibility, the easy handling of hefty luggage, convenience, security and safety, being cashless, having a simple ordering process, door-to-door service, the clarity of the pickup location, having cheaper and transparent tariffs, short waiting times, and reliable travel times. Respondents are given a 5-point Likert scale to indicate their level of agreement with each factor, ranging from 1 for "strongly disagree" to 5 for "strongly agree." The last section delves into the respondents' socio-economic profiles, examining variables such as age, place of residence, educational attainment, and motorized vehicle ownership. Details of the survey questions, along with their answers, can be found in Appendix A.

4. Results and Discussion

4.1. Respondents' Characteristics and Preferences

Table 2 shows that from 418 valid answers, the respondents' ages ranged between 16 and 66 years old, with an average age of 24.72 and a standard deviation of 6.53. This implies that RHS users for FLM modes are dominated by Gen Zers, who are more than 16 years old, and Millennials. Meanwhile, there were more female respondents than males, with the percentage of female respondents being 58%. The higher number of female respondents and respondents in those generations is similar to an MBRH study in Yogyakarta [75]. Furthermore, looking into the respondents' residence deployment, nearly half of them (45.45%) live in Yogyakarta city, more than one-third (36.60%) live in the Bantul suburban area, and the rest (17.94%) live in the Sleman suburban area. For respondents' income, about half of RHS users (49.04%) had an income of less than IDR 1975 thousand (USD 129.77), followed by an income between IDR 1975 and IDR 3950 thousand (USD 129.77–259.60), accounting for 36.6%. Meanwhile, around 5% of respondents earn between IDR 3950 and IDR 5925 thousand (USD 259.60–389.39), a similar portion earn 5925 to 7900 thousand IDR (USD 389.39–519.23), and only 3.59% have incomes greater than 7900 thousand IDR (USD 519.23). This shows that the majority of RHS users are people with low incomes. Regarding educational level, most respondents were pursuing a bachelor's degree or higher, accounting for 78.95%. The survey data also recorded that 53.11% and 1.67% of RHS users were motorcycle and car owners, respectively, while 34.45% had both a motorcycle and a car. The rest (10.77%) were without motorcycle or car ownerships, meaning private vehicle owners dominate RHS users for FLM to intercity transit hubs.

Table 2 also shows the frequency of RHS use for FLM to intercity transit hubs. It can be seen that RHSs are not commonly used for routine trips, indicating that RHSs are not the primary mode of travel for daily trips. For these non-routine trips, most of the respondents occasionally use RHSs for their FLM mode to intercity transit hubs, accounting for around 40% for both FM and LM modes. Interestingly, 9.33% and 7.18% of respondents exclusively use RHSs for their FM and LM mode, respectively. Also, among the respondents who opted for RHSs for their FLM mode, more than half used RHSs for intercity train station trips, while 26.32% and 15.55% used RHSs for airport and intercity bus terminals, respectively. This percentage can be attributed to the high travel cost to the airport due to the long distance, while intercity bus passengers tend to consider low-cost travel options, and their travel costs significantly increase once they opt for RHSs, compared to city buses, for their FLM mode.

Furthermore, Figure 2 highlights the key reason users opt for RHSs for their FLM mode to intercity transit hubs. Factors of being cashless, having a simple ordering process, and door-to-door service became the most agreed-upon factor, commanding the highest combined percentage of “Agree” and “Strongly Agree’ responses, accounting for more than 90%. In contrast, the cheaper-and-more-transparent-fee factor received the lowest percentages of “Agree” and “Strongly Agree” responses. This represents that RHS users are more inclined to prioritize seamless transactions and service quality over cost savings in their FLM-mode choice. Interestingly, flexibility and travel-time factors, including reliable travel times and short waiting times, also did not become the most dominant reasons for respondents who chose to use RHSs for their FLM mode.

Table 2. Respondents' characteristics and frequency of RHS use.

Variable	n	%	Mean	St. Dev.
Age			24.72	6.53
Gender (female)			0.58	0.49
Area of living				
Yogyakarta City	190	45.45%		
Sleman	75	17.94%		
Bantul	153	36.60%		
Monthly income (in thousand IDR)				
Less than 1975 (USD 129.77)	205	49.04%		
1975–3950 (USD 129.77–259.60)	153	36.60%		
3950–5925 (USD 259.60–389.39)	23	5.50%		
5925–7900 (USD 389.39–519.23)	22	5.26%		
More than 7900 (USD 519.23)	15	3.59%		
Education				
Without a bachelor's degree	88	21.05%		
With a bachelor's degree or higher	330	78.95%		
Private vehicle Ownership				
With no private vehicle	45	10.77%		
Motorcycle ownership	222	53.11%		
Car ownership	7	1.67%		
Motorcycle and car ownership	144	34.45%		
RHS-use frequency for all trip purposes				
Once a year or less	15	3.59%		
Several times per year	122	29.19%		
Once a month	39	9.33%		
Several times a month	128	30.62%		
Once a week	33	7.89%		
Several times a week	65	15.55%		
Almost every day	16	3.83%		
RHS use for FM mode				
Never	18	4.31%		
Rarely	110	26.32%		
Sometimes	167	39.95%		
Often	84	20.10%		
Always	39	9.33%		
RHS use for LM mode				
Never	20	4.78%		
Rarely	117	27.99%		
Sometimes	168	40.19%		
Often	83	19.86%		
Always	30	7.18%		
Type of intercity transit hubs predominantly reached by RHSs				
Airport	110	26.32%		
Railway station	225	53.83%		
Intercity bus terminal	65	15.55%		
Never use RHSs for FM or LM	18	4.30%		

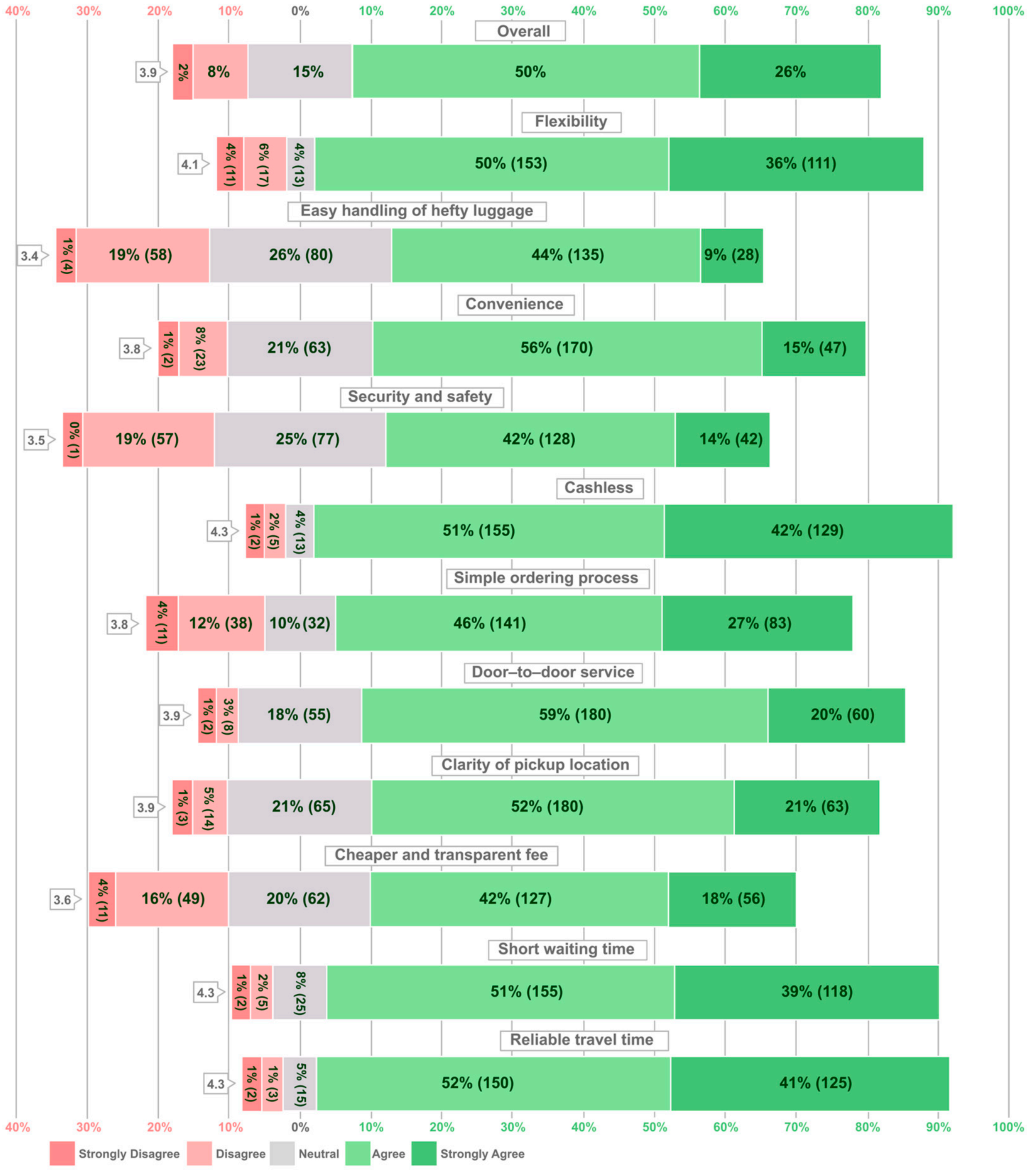

Figure 2. The reasons for opting for RHSs as a FLM mode.

4.2. Model Results

4.2.1. CFA Model Results

As previously mentioned, this study adopted a SUR framework incorporating latent variables derived from eleven observed reasons for selecting RHSs as an FLM option. Due to this, a CFA was performed to construct the latent variables and compute the factor score from the observed variables related to the rationale behind opting for RHSs as the preferred FLM mode. The CFA results identified three major reason patterns, with all observed variables' loading factors being higher than 0.5, as shown in Table 3. A study suggests that only observed variables with a loading factor of 0.5 or higher can be included in calculating the factor score of latent variables [76]. Meanwhile, the CFA results also reveal that the value of Kaiser–Meyer–Olkin was 0.67, higher than the minimum threshold of 0.5 [71], with Bartlett's test of sphericity signified at 0.00.

The CFA results indicated that the first latent variable was constructed from four observed variables: flexibility, the easy handling of hefty luggage, convenience, and security and safety. The second latent variable was constructed from four observed variables: being cashless, the simple ordering process, door-to-door service, and the clarity of the pickup location. The last latent variable was constructed from three observed variables:

cheaper and transparent fees, short waiting times, and reliable travel times. The three latent variables can be titled "Comfort and Safety" for the first, "Seamless Transaction and Services" for the second, and "Cost and Time Efficiency" for the third. Furthermore, checking the value of Cronbach's Alpha for each latent variable, which must be higher than the minimum threshold of 0.6 [71], the results show that the values of Cronbach's Alpha were 0.698, 0.720, and 0.819 for the first to the third latent variable, respectively.

Table 3. CFA model results.

Observed Variable	Loading Factors	Factor Scores of Latent Variables	Cronbach's Alpha
Flexibility	0.651	Comfort and safety (0.00; −3.95; 3.36)	0.698
Easy handling of hefty luggage	0.559		
Convenience	0.739		
Security and safety	0.717		
Cashless	0.742	Seamless transaction and services (0.00; −6.23; 2.21)	0.720
Simple ordering process	0.701		
Door-to-door service	0.695		
Clarity of pickup location	0.681		
Cheaper and transparent fee	0.726	Cost and time efficiency (0.00; −3.45; 2.03)	0.819
Short waiting time	0.775		
Reliable travel time	0.730		
Extraction method: principal component analysis; rotation method: Varimax with Kaiser normalisation statistics			
Kaiser–Meyer–Olkin		0.67	
Bartlett's test of sphericity [$\chi 2$; df; *p*-value]		[1451.596; 55; 0.000]	

Values in parentheses are the estimated factor scores, which show the factor's mean, minimum, and maximum value.

Table 3 shows that a short waiting time, with the highest loading factor, stands out as the most significant reason for individuals choosing RHSs for FLM modes. In contrast, the easy handling of hefty luggage appears to be less critical than the other reasons for choosing RHSs for FLM modes. In the latent variable of comfort and safety, convenience dominates as the most important factor, highlighting RHS users' priority for comfort. Meanwhile, although relevant, the easy handling of hefty luggage has the least impact on individual reasons related to comfort and safety when choosing RHS use for FLM modes. In the context of the latent variable of seamless transaction and service, seamless transactions, including cashless and simple ordering processes, become a more significant reason for choosing RHSs for FLM modes than seamless integration, such as door-to-door service and the clarity of the pickup location. This emphasizes the importance of the convenience of simple and non-cash transactions for RHS users in their FLM trips. Meanwhile, for the latent variable of cost and time efficiency, the value of loading factors displays that travel time, including in-vehicle travel time and waiting time, is higher than travel cost (i.e., cheaper and transparent fees), suggesting that on their FLM trips, intercity travellers place a higher value on their travel and waiting time than on seeking the cheapest option. This finding is consistent with a previous study concluding that reliable and predictable travel time is the most important factor for multimodal transportation when using RHSs for FM or LM modes [35].

4.2.2. SUR Model Results

After the three latent variables were constructed, each latent variable's factor score was calculated and included as independent variables in the SUR model, together with socio-economic variables, the frequency of RHS use for all trip purposes, and the type of intercity transit hubs predominantly reached by RHSs. Meanwhile, the frequency of RHS use for FLM was considered the dependent variable.

Table 4 shows the results of the SUR model. The results indicate that age negatively affected the frequency of RHS utilization, meaning that younger individuals are more likely to use these services. Conversely, a higher level of education correlated positively with RHS usage, suggesting that individuals with higher educational attainment are more inclined to use RHSs for FM trips. This trend may be attributed to the familiarity and comfort level of younger and more educated demographics with technological advancements and digital platforms, as supported by evidence from prior studies [10,41]. Meanwhile, for RHS use in LM trips to intercity transit hubs, contrary to our hypothesis, both age and education had an insignificant impact on the frequency of RHS use. This indicates that for LM trips, the decision to use RHSs is not affected by age and education factors, as it is in FM trips. This disparity may be attributed to the fact that LM trips are generally perceived as less useful compared to FM trips, particularly due to the time constraints associated with connecting to intercity transit. This assertion is reinforced by a study indicating that there is a significant relationship between sociodemographic factors and the perceived usefulness and ease of use of RHSs [77]. Furthermore, out of our hypotheses, the gender factor did not significantly affect the frequency of RHS use for FM and LM modes. This result is also inconsistent with previous studies on RHS use for all trip purposes, showing that women use RHSs more frequently than men [75,78].

Table 4. SUR model results.

Variable	Frequency of RHS Use for FM Mode		Frequency of RHS Use for LM Mode	
	Coeff.	***p*-Value**	**Coeff.**	***p*-Value**
Gender (female)	−0.093	0.334	−0.067	0.469
Age	−0.019	0.018 **	−0.008	0.305
Education	0.275	0.024 **	0.176	0.135
Monthly income (less than 1975 thousand IDR (USD 129.77) as a reference category)				
1975–3950 thousand IDR (USD 129.77–259.60)	0.189	0.079 *	0.200	0.055 *
3950–5925 thousand IDR (USD 259.60–389.39)	0.500	0.020 **	0.458	0.027 **
5925–7900 thousand IDR (USD 389.39–519.23)	0.331	0.149	0.508	0.022 **
More than 7900 thousand IDR (USD 519.23)	0.579	0.042 **	0.542	0.048 **
Private vehicle ownership (having no private vehicle as a reference category)				
Motorcycle ownership	−0.171	0.298	0.087	0.817
Car ownership	−0.054	0.889	−0.020	0.902
Motorcycle and car ownership	−0.220	0.196	−0.155	0.346
Area of Living (Yogyakarta as a reference category)				
Sleman	0.136	0.199	0.048	0.636
Bantul	−0.079	0.577	−0.183	0.182
Latent variables				
Comfort and safety	0.121	0.011 **	0.091	0.047 **
Seamless transaction and service	0.114	0.018 **	0.166	0.000 ***
Cost and time efficiency	0.154	0.001 ***	0.127	0.005 ***
Frequency of RHS use for all trip purposes	0.093	0.003 ***	0.097	0.001 ***
Intercity transit hubs RHSs predominantly reach (airport as a reference category)				
Train Station	−0.036	0.791	−0.071	0.592
Intercity Bus Terminal	–0.321	0.038 **	–0.450	0.003 ***

***, **, * indicate that the coefficient is statistically significant at the levels of 1%, 5%, and 10%, respectively.

The SUR model results also indicate that income played an important role in influencing RHS user preferences for FM and LM modes, except for the RHS use for the FM mode for those with a 5925–7900 thousand IDR monthly income. The results show that RHS users with less than a 1975 thousand IDR monthly income were less likely to use RHSs for FM and LM modes than their counterparts. Meanwhile, there was no significant difference in using RHSs for the FM for those with 1975 and 5925–7900 thousand IDR monthly incomes. This income-based result indicates that wealthier individuals had a higher frequency of RHS use for FM and LM modes. Meanwhile, the variations in the impact of income on RHS use, especially noted among individuals with monthly incomes between 5925 and 7900 thousand IDR, underscore the distinct needs associated with FM and LM trips. In this income segment, the perceived reliability of RHSs appears to be a decisive factor in determining RHS use. This reason is supported by prior research indicating a significant association between income level and the reliability of RHSs [77]. Additionally, separate studies have shown that, particularly for the LM mode, RHSs are considered reliable and could significantly boost the demand for public transit, reflecting their potential to complement transit systems effectively [79,80].

Regarding private vehicle ownership, the findings indicate that car and motorcycle ownership insignificantly influence the frequency of RHS use for FM and LM modes. In other words, owning motorcycles, cars, and both (i.e., motorcycles and cars) is not a primary hindrance in choosing RHSs as FM and LM modes for trips to intercity transit hubs. This aligns with the findings of Nugroho et al., who also demonstrated that in two Indonesian cities (i.e., Semarang and Bandung), having multiple motorized vehicles did not substantially impact the frequency of using MBRH services [38]. Meanwhile, residing in the city centre characterized by numerous intercity transit hubs and accessible public transport (Yogyakarta), as well as living in a fast-growing suburban region with some intercity transit hubs (Sleman), and in a suburban area lacking intercity transit hubs and with limited public transport (Bantul), did not significantly impact the frequency of RHS use for FM and LM modes. This finding contradicts the study's hypothesis and a previous study concerning RHSs linking metro hubs as an FLM mode. For example, a study in Shenzhen City, China, shows that RHSs replace the metro in the city centre but enhance the ease of reaching metro stations in the peripheral areas [81]. The insignificant effect of private vehicle ownership and area of living on the frequency of RHS use for FM and LM modes, which does not align with this study's hypotheses, reflects a broader trend in urban mobility, where the availability and perceived benefits of RHS use are becoming more influential than the conventional variables, including private vehicle ownership and proximity to transit hubs. This reason was strengthened by the model results showing that all latent variables of individual preferences, including comfort and safety, seamless transaction and services, and cost and time efficiency, play a significant role in determining the frequency of RHS use for FM and LM modes. Those three latent variables had positive signs, meaning that the more individuals value comfort and safety, seamless transactions and services, and cost and time efficiency, the more likely they are to use RHSs for both FM and LM modes.

Meanwhile, as shown by positive signs, the frequency of RHS use for all trip purposes also significantly affects the frequency of RHS use for FM and LM modes. This suggests that individuals who regularly opt for RHSs for all trip purposes are more inclined to consistently choose these services for trips to and from intercity transit hubs. Finally, by setting an airport as a reference category for a variable of intercity transit hubs that are predominantly reached by RHSs, a negative and significant impact occurs for intercity bus terminals, while no significant effect was found in the frequency of RHS use for train stations. This indicates that RHSs are used less frequently for trips to intercity bus terminals than airports, while its usage for reaching train stations does not significantly differ from that for airports. This finding is consistent with a previous study showing that the demand for RHSs for FLM differs depending on transit mode [82]. The preference for using buses might influence the distinction in RHS-use patterns between these transit hubs. Individuals accustomed to using intercity buses tend to perceive fewer difficulties in using city buses than those who use trains and airplanes for their intercity trips. Sunitiyoso et al. also showed that bus rapid transit users in Jakarta tend to use microbuses for their FM and LM modes compared to mass rail-transit users, who are more inclined to use MBRH services and personal motorcycles for their FM and LM [35]. This finding is also correlated with the income of RHS users. The model results show that the higher the RHS user's income, the higher the probability of using MBRH for FM and LM modes. Intercity trips using buses tend to be cheaper than using trains and aeroplanes. Consequently, those who travel outside the city by bus tend to use RHSs as FLM mode less often than those who travel outside the city by trains and aeroplanes. This reason aligns with Ren et al.'s findings that RHSs for FLM modes in China are still relatively exclusive to low-income groups [83].

For the second contribution of this study, as shown in Table 5, the SUR model results display the correlation between the frequency of RHS use for FM and LM modes. It can be seen that a strong and positive correlation coefficient existed between the frequency of RHS use for FM and LM modes, as hypothesized. It represents that individuals who frequently opt for RHSs for their FM mode are more likely to opt for RHSs for their LM mode, and vice versa. This finding highlights a consistent preference for RHSs across different intercity trip stages.

Table 5. Correlation between the frequency of RHS use for FM and LM modes.

	RHS Use for FM Mode (Y1)	RHS Use for LM Mode (Y2)
Y1	1.000	0.726
Y2	0.726	1.000

5. Conclusions and Recommendations

This study explored the factors influencing the frequency of RHS use to connect intercity transit hubs, including intercity bus terminals, railway stations, and airports in the Yogyakarta conurbation, Indonesia. Applying a seemingly unrelated regression (SUR), it can be concluded that the frequency of RHS use for the FM and LM displays similar patterns in both cases. The SUR model results reveal that, consistent with previous RHS studies, the consumers of RHSs for the FM tend to be younger, well-educated, and wealthier. In contrast, factors of age and education insignificantly impacted RHS use for the LM. Meanwhile, the frequency of RHS use for FM and LM modes is strongly correlated, indicating that those who choose RHSs for all trip purposes are likely to choose RHSs for both the FM and LM. The main difference between RHS users for the FLM and RHS users for all purposes, as found in previous studies, is that the ownership of motorcycles, cars, or both does not significantly influence the choice of RHSs for the FLM. Furthermore, when comparing the use of RHSs for accessing various intercity transport hubs, it is found that RHSs are less often used for reaching intercity bus terminals than airports. However, the frequency of RHS use for reaching both airports and intercity train stations is identical. This study also found that RHS customers' preferences, including comfort and safety, seamless transaction and service, and cost and time efficiency, play a significant role in determining RHS-use frequency for both FM and LM modes. Lastly, this study concluded that customers who frequently use RHSs for their FM mode are also more likely to use it for their LM mode, suggesting a consistent pattern in RHS preferences across different stages of their journey.

This study brings crucial insights to transportation planning and the formulation of effective policies. Firstly, since the latent variables of comfort and safety, seamless transaction and service, and cost and time efficiency were identified as significant variables in choosing RHSs for FM and LM modes, RHS companies should focus on maintaining and enhancing their service arrangements. This will enable more intercity travellers to experience the advantages provided by RHSs. Effective measures to improve RHS passenger drop-offs and pickups might include establishing supplementary waiting areas at intercity transit hubs, designating parking spaces near transit hubs specifically for RHS vehicles to facilitate seamless transitions, providing more e-wallet options to customers for RHS payments, and simplifying payment methods by integrating RHSs and intercity-travel mode payment. These are important recommendations since, as shown in Table 4, indicators constructing latent variables of seamless transactions and services, including being cashless, having a simple ordering process, door-to-door service, and the clarity of the pickup location, are the main reasons for customers to use RHSs for their FLM compared to other indicators that construct latent variables of comfort and safety (i.e., flexibility, easy handling of hefty luggage, convenience, and security and safety) and cost and time efficiency (i.e., cheaper and transparent fees, short waiting times, and reliable travel times).

It should be noted that, although since 2022, ride-hailing companies have collaborated with the local government and public transit operators to integrate their payment systems and build ride-hailing shelters surrounding metro stations and intercity transport hubs [84], not all intercity transit hubs have such facilities. Only one RHS company (i.e., Gojek) has an integrated payment-system feature. Additionally, the ride-hailing shelters at the intercity transit hub areas can only be used for specific ride-hailing companies. Therefore, the government must encourage broader integration and collaboration between ride-hailing companies and public transit operators. This effort would involve extending the availability of advanced and integrated payment systems and shared ride-hailing shelters to more intercity transit hubs and ensuring that these facilities are accessible to multiple ride-hailing services rather than being exclusive to a single RHS company. Through these strategies, RHS companies will not only deal with important customer preferences but also promote sustainable transport by means of better integration with public transit systems.

Furthermore, this study reveals that using RHSs for FLM modes is comparatively less prevalent among those with lower income levels. The SUR model suggests that intercity travellers with lower incomes tend to use RHSs less often for both FM and LM modes. This finding emphasizes the need to tackle equality concerns in using RHSs for FLM modes. RHS companies could consider providing targeted discounts or subsidies to certain low-income demographics, such as the retired elderly, in order to improve the accessibility of their services as a means of transportation to and from intercity transit hubs, catering to a wider array of socio-economic groups. A study remarked that low-income individuals may not benefit as much from the integration of RHSs with public transit unless subsidized fare reductions are implemented to address affordability issues [85]. Implementing these actions could ensure that RHS use for the FLM mode is available to and affordable for people from different socio-economic backgrounds, thereby contributing to wider sustainable transport objectives.

Despite uncovering intriguing findings, this study has certain limitations. Firstly, the limited scope of this study, whether it pertains to the number of respondents or geographical coverage, may restrict the generalizability of its results. Future studies should broaden their geographical scope to enhance the findings' applicability and relevance across diverse settings. Also, implementing household-based interview surveys can be carried out for future studies to provide a more accurate and representative RHS users. Secondly, this study found that vehicle ownership has an insignificant effect on using RHSs for the FLM. Future research could further investigate the underlying factors that may influence this relationship, such as the effect of intra-household interaction on FLM modes to intercity transit hubs. The literature shows that there is a strong correlation between intra-household interaction, vehicle ownership, and mode choice [86–89]. Additionally, employing structural equation modelling to treat vehicle ownership as a mediating variable could offer deeper insights into the indirect effects of vehicle ownership on the RHS use for FM and LM modes to intercity transit hubs. Lastly, this study found the varying patterns of RHS use for the FLM mode in different intercity transport hubs, where the use of RHSs for trips to intercity bus terminals was less often compared to airports and railway stations. Further investigation is required to examine more the underlying factors contributing to these disparities, such as the presence of alternative transportation options at these transit hubs, the geographical proximity of the transit hubs to urban centres, the length of travel from origin points (i.e., home) to intercity transit hubs, or the socio-economic attributes of individuals who favour distinct intercity transportation modes.

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Appendix A. List of Questions in the Survey

Respondents' Characteristics

1. Age: . . .. . . years old
2. Gender:
   (a) Male
   (b) Female
3. Area of living:
   (a) Yogyakarta Cit
   (b) Sleman
   (c) Bantul
4. Monthly income (in a thousand IDR):
   (a) Less than 1975
   (b) 1975–3950
   (c) 3950–5925
   (d) 5925–7900
   (e) More than 7900
5. Education:
   (a) Without a bachelor's degree
   (b) With a bachelor's degree or higher
6. Private vehicle Ownership:
   (a) With no private vehicle
   (b) Motorcycle ownership
   (c) Car ownership
   (d) Motorcycle and car ownership
7. RHS-use frequency for all trip purposes:
   (a) Once a year or less
   (b) Several times per year
   (c) Once a month
   (d) Several times a month
   (e) Once a week
   (f) Several times a week
   (g) Almost every day
8. RHS use for FM mode:
   (a) Never
   (b) Rarely
   (c) Sometimes
   (d) Often
   (e) Always
9. RHS use for LM mode:
   (a) Never

(b) Rarely
(c) Sometimes
(d) Often
(e) Always

10. Type of intercity transit hubs predominantly reached by RHSs
(a) Airport
(b) Railway station
(c) Intercity bus terminal
(d) Never use RHS for FM or LM mode

Please rate your motivations in using RHSs for FLM trips to intercity transit hubs (railway stations/airports/intercity bus terminals) using a scale of 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), and 5 (strongly agree).

I use RHSs for FLM mode to or from intercity transit hubs because …	1	2	3	4	5
Easy handling of hefty luggage					
Convenience					
Security and safety					
Cashless					
Simple ordering process					
Door-to-door service					
Clarity of pickup location					
Cheaper and transparent fees					
Short waiting time					
Reliable travel time					

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