International Journal on Advanced Science Engineering Information Technology

Vol.15 (2025) No. 3
ISSN: 2088-5334

# Cashless Transit Payments in a Developing City: Yogyakarta's BRT and Technology Integration

Alfin Aghisna [a], Anita Ratnasari Rakhmatulloh [a,*], Diah Intan Kusumo Dewi [a], Hadi Wahyono [a]

[a] *Department of Urban and Regional Planning, Diponegoro University, Semarang, Indonesia*
*Corresponding author: [*]anita.ratnasari.rakhma@gmail.com*

***Abstract*—The implementation of cashless payments for public transportation is an essential component of the development of a sustainable and smart urban transportation system. However, developing countries often face challenges in implementing cashless transactions because of limited infrastructure. In Yogyakarta, a city of students and tourists, public transportation users such as Bus Rapid Transit (BRT) Trans Jogja still tend to prefer cash payments. This study aimed to determine the acceptance of cashless payment technology to support effective public transportation development policies. Digital wallets, such as QRIS and similar applications, enable direct payments via mobile devices. At the same time, prepaid cards require users to pre-load a specific amount of money, resulting in different user experiences. This study explores the factors influencing cashless payment adoption and the preferences of BRT Trans Jogja users. Using utility function analysis, it also examined how socioeconomic characteristics affect travel frequency. The results show that safety and efficiency play a dominant role in increasing Trans Jogja use, while educational efforts and making cashless systems more attractive are needed, especially for younger and less educated users. Perceptions of transaction speed are consistently the most influential factor, highlighting the need to enhance Trans Jogja usage. Improving digital literacy, offering incentives like discounts or loyalty programs, and enhancing infrastructure stability are key to expanding cashless adoption and making the system more accessible to all users. This study provides a foundation for future research on payment strategies, integration with other transportation modes, and ways to enhance the attractiveness of cashless systems.**

***Keywords*— Technology integration; user perception; utility functions; Trans Jogja; cashless payment.**

*Manuscript received 2 Dec. 2024; revised 2 Feb. 2025; accepted 17 May 2025. Date of publication 30 Jun. 2025.*


## I. INTRODUCTION

Cities worldwide are moving toward a cashless society with a focus on optimizing payment systems by applying technology and data-driven solutions [1]–[3]. In the context of public transportation, the implementation of electronic fare payments based on cards and applications provides systemic efficiency and increases operational cost efficiency in line with the Smart City Concept [4]–[6]. The Smart City Concept aims to create a Smart Society and Digital Economy by encouraging technological advancements and opening opportunities for urban innovation [7], [8]. Technologies such as the Internet of Things (IoT) and big data have the potential to enhance resource management and efficiency. One of its main applications is the integration of automatic passenger counting systems that can improve the operational efficiency of public transportation through accurate passenger flow data, which is essential for real-time planning and management [9]. The transition to cashless payment systems in public transport also supports the achievement of Sustainable Development Goal 11 [10], which contributes to building sustainable cities and communities. By emphasizing safety, affordability, accessibility, and sustainability, this goal also underscores the importance of expanding public transportation networks, particularly for vulnerable groups such as women, children, people with disabilities, and the elderly. In addition, reducing reliance on paper-based transactions supports more efficient and environmentally friendly Bus Rapid Transit (BRT) operations because of the reduced need for physical tickets, receipts, and the associated paper production.

However, in developing non-capital cities, this implementation faces challenges such as budget constraints, inadequate infrastructure, and low technological readiness [11]. The fragmentation of authorities and weak governance complicate decision making and resource allocation. Furthermore, shortages of skilled labor and low technological literacy among citizens complicate this process [12]. Increasing access to public transportation, a key element in smart city planning, can change people's mobility patterns

[13]. This shift not only increases economic opportunities but also contributes to sustainable urban growth. Community empowerment, digital literacy programs, and international cooperation can help to bridge this gap and encourage public participation [14].

The management of the Trans Jogja BRT aims to provide seamless integration of comfort, capacity, and speed in the urban public transportation system, which is essential for reducing transportation costs in Yogyakarta. This integration is supported by [15], [16]), which highlights that one of the key comfort features passengers need is easy access to transportation information and payment transactions using BRT services. The public acceptance of public transportation is determined by the economic and psychological aspects of the community and the influence of the surrounding community [17]. The ever-evolving fare collection system has resulted in various payment options [18].

Although widely used because of their simplicity, cash payments pose security challenges, with insufficient measures hindering development goals, especially in the context of rapid urbanization [19]. Therefore, cashless payments are a solution for the lack of cash payments. The public acceptance of public transportation is influenced by the economic and psychological aspects of the community, as well as the surrounding community's impact. According to research in European countries, cash is mainly used for small payments and is the largest part of intermediary payments, whereas payment cards are the main payment instrument for large nominal payments at points of sale [20].

Similarly, in Denpasar, the use of digital wallets for small payments demonstrated their potential to replace cash, showing a shift toward more efficient payment systems [16]. The policy of cashless payments has been implemented in several cities and countries, so that the community is more aware of its various uses and feels safer after implementing cashless payments [20]. However, challenges remain, as seen in Dhaka, Bangladesh, where limited public knowledge about cashless payments has led to lower adoption rates [21]. Users may initially experience fears of additional actions not present with paper tickets, such as ordering and collecting cards or tapping in and out of vehicles [22]. In Malaysia, Many transport users still prefer to use cash for transactions because of their familiarity and trust in physical currency [23]. Additionally, concerns about impulsive purchases triggered by cashless payments, leading to overspending, must also be considered [24].

The Trans Jogja Manager states that cash payments remain dominant on Trans Jogja, preferred by users despite the introduction of cashless alternatives and the substantial gap between cash (135,169 transactions) and cashless (26,134 transactions) payments in February 2024 highlights the persistent preference for cash among Trans Jogja users, underscoring the need to understand user perceptions and readiness for any potential shift to a cashless system [25]. The demand-side mechanism of cash payment services, particularly the perception of users of the cash payment system, is critical for policymakers. Public readiness and demand for payment systems and mechanisms influence the need to provide cash payment services on the Trans Jogja BRT. This study aimed to identify user perceptions of the cashless payment system in Trans Jogja and to determine the acceptance of integrating cashless payment technology.

### *A. Technology Integration*

Technology integration in the context of public transportation aims to improve operational efficiency and user convenience. Through automation, such as cashless payment systems, manual processes, such as ticket purchases, can be eliminated, reducing queue times and speeding up access to transportation [26]. Additionally, technology integration offers opportunities for innovation, such as the development of mobile applications that facilitate easier trip planning or bus arrival monitoring for users. Technology also improves service quality by providing users with better and more accurate access to information, and facilitating connectivity between various modes of transportation to create an integrated and smooth system [27].

### *B. User Perception*

Previous research on the perception of payments has indicated that higher income levels often correlate with a higher willingness to pay for faster and more convenient modes of transport, which can influence the percentage of income spent on transportation [28]. Transportation costs can consume a significant portion of household budgets, especially in urban areas where commuting costs are higher. These preferences are influenced by various factors, including reliability, frequency, and comfort, as well as psychological factors such as perceptions of the station environment or the waiting room.

Studies in Nordic countries have shown that users can be classified into subgroups with different characteristics and preferences [29]. Understanding the use of public transportation, such as the BRT Trans Jogja, can be improved by considering objective variables with individual subjective assessments of the quality of public transportation services [30]. The findings regarding changes in travel behavior can be connected to the sustainability benefits of integrating multiple transportation modes. A well-designed BRT system that facilitates intermodal connections can encourage users to adopt more sustainable travel habits, such as using public transport instead of private vehicles, thereby reducing congestion and environmental impacts [31].

Economic decision-making is a complex process influenced by a myriad of factors beyond the traditional rational choice model. Behavioral and identity economics provide insights into how social, emotional, cognitive, and cultural factors shape individual economic behaviors [17], [32]. In the context of public transport, user behavior reflects how individuals decide to utilize public transportation systems, driven by factors such as social norms, perceived safety, convenience, service quality, and personal attitudes [33]. These decisions are often shaped by the perceived benefits of public transport, societal expectations, and the accessibility and reliability of services. For example, older adults may exhibit different risk perceptions, which in turn influence their transportation choices and broader socio-economic decisions [34].

Perception is the process by which people respond to everything in their environment through their senses. Through individual perceptions, it can be seen that people's responses

to a particular thing or activity are organized and interpreted. One is the perception of the use of payment methods, which currently has various choices and responses. Previous research has focused on the perception of Bus Rapid Transit Performance, where people's responses were positive in terms of user satisfaction and factors that influenced their choice to use BRT, such as convenience, time, and cost. [35]. In short, BRT is an integrated system of facilities, services, and intelligent information systems that improves the speed, reliability, and identity of bus transportation [36].

According to Karakurt, transportation costs can consume a significant portion of household budgets, especially in urban areas where commuting costs are higher by approximately 10-20% of household income, depending on the region and availability of public transport options [37]. BRT is a cost-effective transportation mode for moving a large number of people to large cities in Indonesia. Consumer payment options can be referred to from Consumer Choice Theory, which describes consumer behavior [38]. The basic categories used in this theory are consumers, income, preferences, and utilities. Perception is a vital payment option that reflects consumer preference.

## II. Materials and Method

This study employed a quantitative approach, collecting data through questionnaires using accidental sampling. The number of samples was determined using the Slovin formula with a tolerance limit of 10%, to obtain a sample of 150 respondents. Data collection was carried out for two weeks, from Monday to Sunday. Mondays to Saturdays were chosen because they are the peak days of community activities such as school and work, while Sundays were chosen to capture tourism and social activities.

Sampling was carried out at 26 bus stops, including transit and bus stops located in trade, service, and tourism areas. These locations are considered strategic because they are located around offices, tourist attractions, and trade centers. A total of 150 responses were collected based on the survey.

The steps of this methodology align with the research objectives and context of the study on technology acceptance in the Smart City concept, as illustrated in Fig. 1.

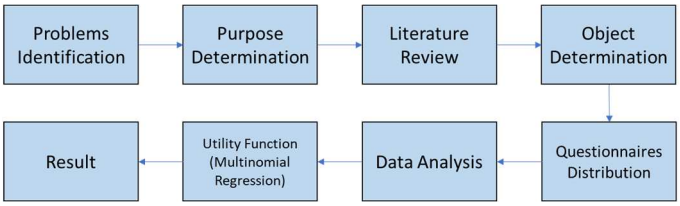


Fig. 1 Methodology

In this study, several vital variables were analyzed to understand the characteristics of BRT Trans Jogja users and their perceptions of the cashless payment system. The variables analyzed included the following:

TABLE I
Variables and Attributes

| Variables | Attributes | Results |
|---|---|---|
| Socio-demographic characteristics | 1. Age<br>2. Gender<br>3. Educational level<br>4. Occupation | - Percentage and frequency of socio-demographic<br>- Distribution of BRT users based on social demographic characteristics |
| Travel characteristics | 1. Frequency of use Trans Jogja<br>2. Purpose of using Trans Jogja | - Percentage and frequency of Trans Jogja usage |
| Perspective of cashless payment | 1. Reasons to use cashless payment<br>2. Cashless payment users by method<br>3. Secure<br>4. Shorten the time<br>5. More desirable<br>6. Simplify<br>7. Always used when transacting | - Likert Scale<br>- Utility function |
| The preference for cash payment | 1. It is necessary to have a means of payment at every bus stop and bus<br>2. Availability of terms and costs that are relatively easy to purchase BRT tickets<br>3. Easy of making cash payments at every bus stop or bus<br>4. The existence of a payment system integration with other public transportation | Implementations of preferences into potential locations for infrastructure |

The collected data were analyzed using a quantitative approach, including numerical data analyzed using descriptive statistics such as frequency distribution to identify the dominant characteristics. The Likert scale was used to analyze public perceptions of the payment system, whereas the utility function was used to measure user perceptions of benefits. According to [39], the Likert scale consists of five levels of answers that indicate respondents' agreement with the statements given. The index was calculated on a Likert scale using the following formula:

Index value = ((F1x1) + (F2x2) + (F3x3) + (F4x4) + (F5x5) / Ftotal x 5)

Where:

F1 is the frequency of respondents answering 1 (Strongly Disagree)

F2 is the frequency of respondents answering 2 (Disagree)

F3 is the frequency of respondents answering 3 (Neutral)

F4 is the frequency of respondents answering 4 (Agree)

F5 is the frequency of respondents answering 5 (Strongly Agree)

The utility function is a statistical analysis technique used to model the relationship between a categorical dependent variable with more than two categories and one or more independent variables. The method employed in this study is multinomial regression, which is an extension of binary logistic regression. This method is particularly suitable for modeling the decision-making process regarding the frequency of Trans Jogja use, where the outcome variable has multiple categories (e.g., 1 time per week, 2-3 times per week, 4-6 times per week, and more than seven times per week). Multinomial regression allowed us to model the relationship between multiple outcome categories and independent variables, providing insights into how various factors influence user behavior. Based on prior studies [18], [40], this method has been effectively used to identify the most significant factors influencing project success and to understand how different factors influence users decision-making.

The development of the utility function began with the identification of relevant independent variables based on prior studies and theoretical frameworks. Socioeconomic variables such as age, gender, and educational level were included as key predictors in the model, as they are commonly found to influence public transportation behavior. Additionally, user perception variables, measured using a Likert scale, were incorporated to capture behavioral tendencies toward a cashless payment system and the frequency of public transport use.

The utility function is expressed as follows:

$Yi=\alpha+\beta_n x_n+ \beta_{n.j} x_{n.j}$

Where :

$\alpha$: Intercept

$x_n$: Factors (e.g., secure, shorten time, more desirable, simplify, always used when transacting).

$x_{n.j}$: Factors in covariates, representing categorical variables such as age, gender, and education level, with $n$ indicating the group (e.g., age, gender, or education), and $j$ representing specific categories within the group.

Yi: reference category (frequency of use Trans Jogja)

Xi: independent variable

The decision not to use the purpose of using Trans Jogja and occupation characteristics variables in the utility function that has been created is based on the results of the likelihood ratio test, which shows that variables do not significantly influence the frequency of Trans Jogja use. These variables do not have a sufficiently strong relationship with the dependent variable category, so they cannot provide a relevant contribution to the model.

On the other hand, the user perception variables —age, gender, and level of education —were retained because they met the significance criteria based on the results of statistical testing. These variables are considered more relevant for describing user behavior and can enhance the model's accuracy. By retaining only significant and relevant variables, the developed model can more accurately represent the factors that influence user decisions regarding the frequency of Trans Jogja service use, while providing more specific insights into perceptions of the non-cash payment system.

## III. Results and Discussion

### A. Descriptive Results

The following descriptive table presents the demographic profile of respondents who participated in the survey on the use of cashless payments in Trans Jogja transportation. The majority of respondents were in 16-30 years age range, 73% (110 people), indicating that Trans Jogja users were dominated by young people. Respondents aged 31-50 years comprised 15% (22 people) of the sample, while respondents aged ⩽15 years comprised only 3% (5 people). The 50-64 years age group reached 7% (11 people), and the ⩾65 years age group was the smallest with only 1% (2 people). Trans Jogja users were mainly female, 57% (85 people), while males numbered 43% (65 people). Most of the respondents had a relatively high level of education. As many as 49% (73 people) had completed college, while 40% (60 people) had completed high school education. Respondents with lower education levels, such as junior high school (9%, 14 people), elementary school (1%, 2 people), and kindergarten (1%, 1 person), were fewer in number. In terms of frequency of use, respondents who rarely (1 time) and often use Trans Jogja (3-6 times) each account for 28% of the total respondents (42 people). Respondents who occasionally use (2-3 times) accounted for 27% (41 people), while very frequent users (>7 times) accounted for only 17% (25 people), which is the smallest group.

TABLE II
DESCRIPTIVE STATISTICS OF SOCIAL DEMOGRAPHIC AND TRAVEL CHARACTERISTICS

| Variables | Description of Variable | Number of Respondents | % |
|---|---|---|---|
| **Age** | ≤ 15 years old | 5 | 3% |
| | 16-30 years old | 110 | 73% |
| | 31-50 years old | 22 | 15% |
| | 50-64 years old | 11 | 7% |
| | ≥ 65 years old | 2 | 1% |
| **Gender** | Male | 65 | 43% |
| | Female | 85 | 57% |
| **Educational Level** | Kindergarten | 1 | 1% |
| | Elementary School | 2 | 1% |
| | Middle School | 14 | 9% |
| | High School | 60 | 40% |
| | College | 73 | 49% |
| **Frequency of using Trans Jogja (per week)** | Rarely (1 time) | 42 | 28% |
| | Occasionally (2-3 times) | 41 | 27% |
| | Frequently (3-6 times) | 42 | 28% |
| | Always (>7 times) | 25 | 17% |

(Questionnaire Processed, 2023)

The data show that Trans Jogja is primarily used for work and school purposes, making it a crucial mode of transportation for workers and students in Yogyakarta as indicated in Fig. 2. Tourism is also an important destination, especially for users who rarely use Trans Jogja for routine activities. Use for worship or socializing is relatively low, indicating that this transportation is more often used for routine and productive needs, such as work and education.

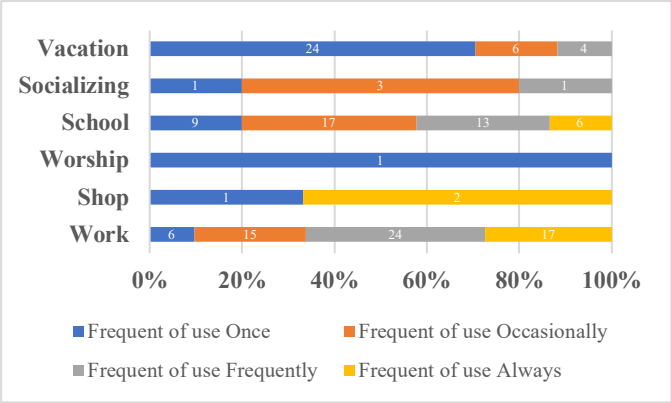


Fig. 2 Purpose of Using Trans Jogja

These results support the findings by [39], which showed that regular users have a higher level of familiarity with routes, schedules, and how to use the bus, thereby reducing uncertainty and increasing comfort. In addition, individuals with busy lifestyles and those seeking efficiency tend to choose cashless payments because they are faster and more practical [27]. The frequency of cashless use varies depending on the occupation, as shown in Fig. 3. Students and private employees tended to use cashless payments more often, while housewives and entrepreneurs tended to use them less. This indicates that differences in the accessibility and convenience of payment technologies affect the frequency of use [27].

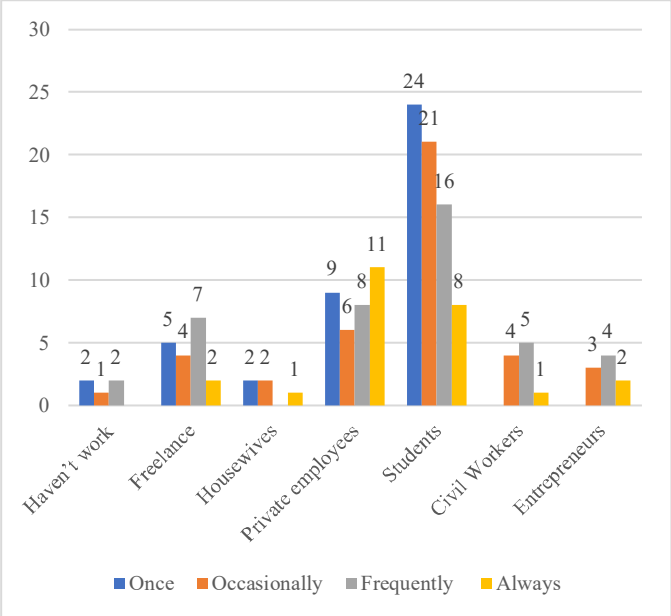


Fig. 3 Cashless Users Based on Occupation

Prepaid card usage was more prevalent than digital wallet usage, with notable differences between males and females. Of the 65 participants, 16 (11%) used digital wallets and 49 (33%) used prepaid cards. Of the 85 females, 18 (12%) used digital wallets and 67 (45%) used prepaid cards. Digital wallets, such as QRIS and other similar applications, allow users to make payments directly from their mobile devices without the need for a physical card. By contrast, prepaid cards require users to transfer a specific amount of money to the card before it can be used, which may create an additional step in the payment process. The use of digital wallets is lower than that of prepaid cards; however, this could be an opportunity to promote the adoption of digital wallets among users by offering more effective promotional and educational strategies. For further details, see Fig. 4.

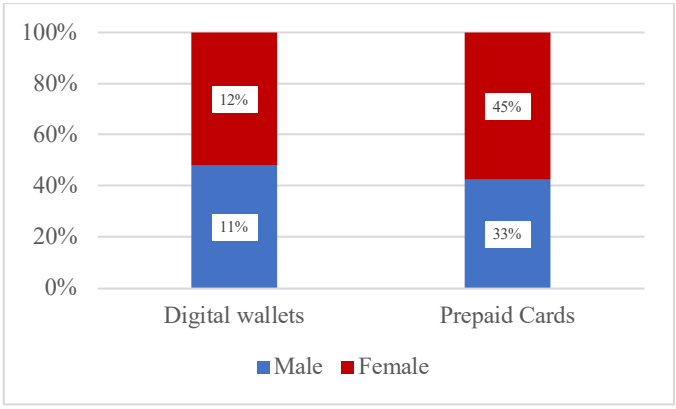


Fig. 4 Cashless Users Based on Payment Method

The main reason users choose cashless payments is convenience, with 49% of the respondents stating that this method is easier and less complicated (see Fig. 5). Other reasons included cheaper prices (22%), efficiency (10%), and habit (8%). A total of 5% of the respondents used cashless payments for health and safety reasons, and 3% chose it because it is safer. Cheaper ticket prices with prepaid cards and digital wallets are an incentive for Trans Jogja users to switch to cashless payment methods, which can speed up transactions and improve operational efficiency.

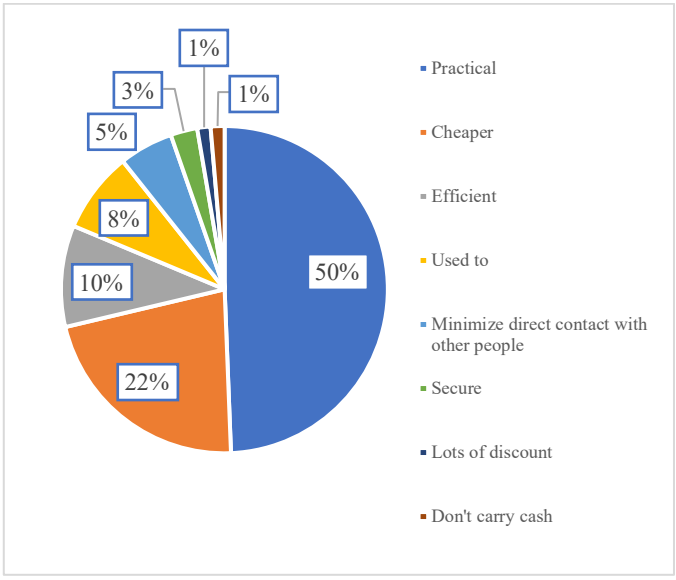


Fig. 5 Reasons for Using Cashless

### *B. Perception of Trans Jogja Cashless Payment*

The perceptions of Trans Jogja users regarding the cashless payment system are evaluated based on several key indicators. The indicators are security, time saving, usage preference, convenience, and frequency of use of the cashless method (see Fig. 6). The evaluation was conducted using a Likert scale to understand how well the system met user expectations and encouraged wider adoption.

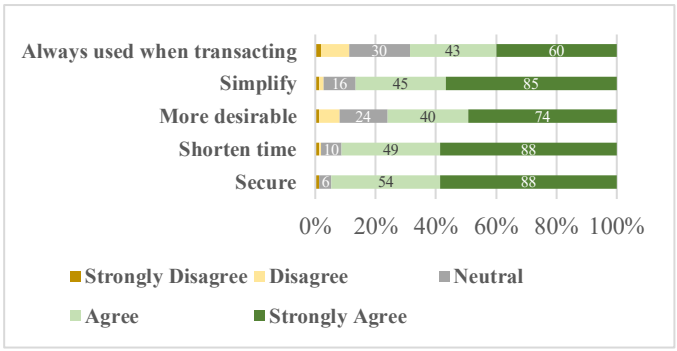


Fig. 6 Perception Of Trans Jogja Cashless Payment

Based on the Likert scale values ranging from 0.79 to 0.90, respondents generally showed a positive perception of cashless payments. However, in the aspect of "always used during transactions," the score tended to be lower (0.79), indicating that full adoption of this method has not occurred. Some respondents were still neutral or disagreed with aspects such as "more desirable" and "ease", indicating that there are still challenges in meeting user needs.

### *C. Perspective of Cashless Influence Frequency in Using the Trans Jogja*

Based on the analysis of user perception and socio-demographic profiles using the Likert scale, a utility function analysis was conducted. The test results showed that this model is suitable for use with a Pearson value of 0.17 (P-value > α; 0.17 > 0.05) (See Table 3). The R-squared coefficient of 0.370 indicates that the independent variable can explain 37% of the variability of the dependent variable, while other factors outside the model explain the rest.

TABLE III
LIKELIHOOD RATIO TESTS

| | Model Fitting Criteria | Likelihood Ratio Tests | | |
|---|---|---|---|---|
| Effect | -2 Log Likelihood of Reduced Model | Chi-Square | df | Sig. |
| Intercept | 175.095[a] | .000 | 0 | . |
| Secure $x$ 1 | 176.139 | 1.043 | 3 | .791 |
| Shorten time $x$ 2 | 184.821 | 9.725 | 3 | .021 |
| More desirable $x$ 3 | 176.605 | 1.509 | 3 | .680 |
| Simplify $x$ 4 | 176.838 | 1.742 | 3 | .628 |
| Always used when transacting $x$ 5 | 177.573 | 2.478 | 3 | .479 |
| Age $x$ 6 | 198.520 | 23.424 | 12 | .024 |
| Gender $x$ 7 | 175.872 | .776 | 3 | .855 |
| Educational $x$ 8 | 191.524 | 16.429 | 12 | .172 |

Notes:
The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

The Likelihood Ratio Test results show that only two variables are significant in influencing the frequency of BRT use, namely perception of transaction speed ($x2$) and age ($x6$). The faster users experience BRT services, and the older they are, the greater the influence on the frequency of use. In contrast, perceptions of security, preference, simplicity, frequency of cashless use, gender, and education level did not show a significant influence. The utility function model related to the frequency of use of Trans Jogja services was designed based on the results of parameter estimates. The model was obtained through an analysis of various social and economic factors, as well as user perceptions of the cashless payment system. The utility function formed from this model serves as an essential analytical tool in evaluating the relationship between perception variables toward payment and demographic factors such as age and education level [39], [41].

The perception factors influencing the Trans Jogja frequency usage model were identified. For occasional frequency, perception of transaction speed (Shorten Time, $x2$) has the most significant influence with a coefficient of 4.039 (positive influence). Conversely, the most negative factor is the simplicity of payment (Simplify, $x4$) with a coefficient of -1.168. In terms of socio-economics, the level of basic education (Elementary School, $x8.2$) contributes the most with a coefficient of 27.127 (positive influence), while age under 15 years (Age <15, $x6.1$) has the most significant negative influence, with a coefficient of -23.240. For the frequency of frequent use, the most dominant perception factor is transaction speed (Shorten Time, $x2$) with a coefficient of 1.064 (positive influence), while the factor that has the greatest negative influence is always using cashless methods (Always Used When Transacting, $x5$) with a coefficient of -0.819. In terms of socio-economics, secondary education (Middle School, $x8.3$) contributes the most with a coefficient of 14.780, and age under 15 years (Age <15, $x6.1$) is the largest negative factor, with a coefficient of -9.673. In the very frequent use frequency model, the perception of security (Secure, $x1$) is the most dominant factor with a coefficient of 12.666 (positive influence) (See Table 4 for the details).

TABLE IV
UTILITY FUNCTION BASED ON FREQUENT USE OF TRANS JOGJA

| Frequent use of Trans Jogja | Utility Function |
|---|---|
| Occasionally (2-3 times) | 6.779 - 0.448 $x1$ + 4.039 $x2$ - 0.680 $x3$ - 1.168 $x4$ - 0.838 $x5$ - 23.240 $x$ 6.1 - 10.396 $x6.2$ - 7.252 $x6.3$ - 9.711 $x6.4$ + 0.299 $x7.1$ + 12.885 $x8.1$ + 27.127 $x8.2$ + 13.728 $x8.3$ + 0.077 $x8.4$ |
| Frequently (3-6 times) | -3.445 - 0.175 $x1$ + 1.064 $x2$ - 0.746 $x3$ - 0.063 $x4$ - 0.819 $x5$ - 9.673 $x6.1$ + 5.282 $x6.2$ + 7.714 $x6.3$ + 4.849 $x6.4$ - 0.133 $x7.1$ + 14.516 $x8.1$ + 11.013 $x8.2$ + 14.780 $x8.3$ - 0.300 $x8.4$ |
| Always (>7 times) | -29.628 + 12.666 $x1$ + 2.494 $x2$ - 1.095 $x3$ - 0.546 $x4$ - 0.224 $x5$ - 38.557 $x6.1$ - 11.437 $x6.2$ - 8.350 $x6.3$ - 9.574 $x6.4$ - 0.017 $x7.1$ + 46.573 $x8.1$ + 11.519 $x8.2$ + 14.189 $x8.3$ - 0.078 $x8.4$ |

This shows that users who feel the cashless system is safe use BRT more often. Conversely, the perception of payment attractiveness (More Desirable, $x3$) has the most significant negative influence with a coefficient of -1.095. In terms of socio-economics, kindergarten education (Kindergarten, $x8.1$) has the largest positive influence with a coefficient of 46.573, while age under 15 years (Age <15, $x6.1$) is again the largest negative factor with a coefficient of -38.557.

The perception of transaction speed plays a crucial role in all usage frequencies (occasionally, frequently, and very often). Therefore, speeding up the cashless transaction process at bus stops and buses, for example, through QR

codes or NFC-based payments, will increase BRT use. However, the perception of payment attractiveness (More Desirable), which has a negative influence, indicates the need for efforts to improve the attractiveness of cashless systems through education, promotions, or incentives such as discounts and cashbacks.

The age group under 15 years has a negative influence in all models, indicating that this group rarely uses BRT, possibly due to limited access or inconvenience in using cashless systems. This finding is consistent with [41] and [38], who stated that children and adolescents have limited access to cashless payment systems. Therefore, education and ease of access for young users need to be improved, for example, through special rates or child-friendly payment instruments.

In addition, low education levels (Kindergarten and Elementary School) have a positive effect on the frequency of BRT use, in contrast to the findings by [42], who stated that users with low education have more difficulty using cashless systems. Therefore, educational programs regarding the benefits of digital payment systems, especially for people with low education, must be optimized using a more practical and easy-to-understand approach. Groups of students and private workers, who are busy and prioritize ease of transactions, tend to prefer digital payments [27]. This model shows that perceptions of transaction speed have a significantly positive effect on the decision to use BRT.

### *D. User Expectations of the Payment System*

To improve the BRT Trans Jogja payment system, several key aspects must be considered to enhance the user experience. The following Likert survey data in Figure. 7 provides an overview of public perceptions and expectations of payment technology integration solutions to improve the efficiency and convenience for BRT Trans Jogja users.

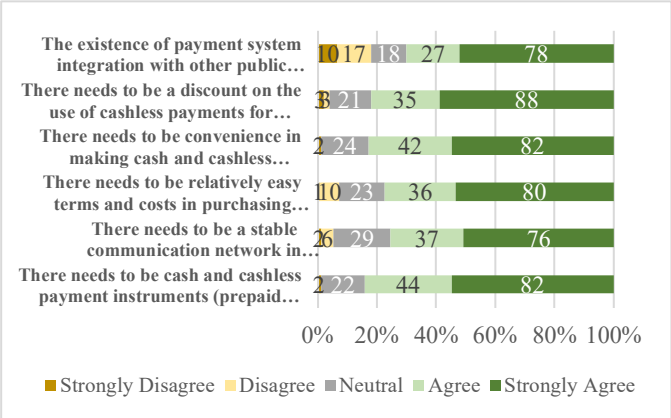


Fig. 7 User Expectations of The Payment System in Trans Jogja

The highest score (0.87) was related to the availability of cash and cashless payment methods at every bus stop and on the bus, as well as ease of payment. This demonstrates significant user support for the flexibility of payment methods. The availability of payment methods at bus stops and on buses should be the top priority. The stability of the communication network was also important, with a score of 0.84. This indicates that although the network infrastructure needs improvement, the primary priority is ensuring the availability of payment methods. A score of 0.87 for discounts on cashless payments suggests that incentives, such as discounts, can encourage more users to adopt cashless payments. This is crucial for attracting users who are not yet familiar with this method.

The integration of the payment system with other transportation modes received a lower score (0.79), indicating an interest in simplifying the payment process across transportation modes as a long-term solution. Several aspects such as network stability and system integration showed a higher level of disagreement, indicating technical or operational constraints. The main solutions are to provide a flexible payment system at every bus stop and bus stop, implement discounts to encourage the adoption of cashless payments, and ensure a reliable communication network. Developing a system integrated with other modes of transportation could also be an innovation to increase comfort and the number of users in the future.

### *E. Discussion*

The implementation of cashless payments in Indonesia is growing rapidly, resulting in both positive and negative effects [16]. The main obstacle is the digital infrastructure, which is not evenly distributed in this study and was also found in previous studies in several regions such as Lagos, Bangladesh, and Malaysia [10], [21], [23]. Flexible and easy-to-use payment methods, supported by adequate infrastructure, are essential for expanding the implementation of cashless payments. Although the stability of the communication network is also essential, the primary focus remains on ease of payment access.

This study showed that social, cognitive, and emotional factors influence users' perceptions of cashless payments. Busy users who prioritize efficiency prefer cashless payments because they are fast and practical, which is in line with [27], behavioral economics theory, which emphasizes that economic decisions are not only rational but also driven by convenience and emotional preferences. Cashless payment automation increases operational effectiveness, expedites transit access, and shortens wait times [26]. Consequently, to enhance the Trans Jogja BRT user experience, operators must prioritize the integration and adaptability of the payment systems.

User preferences, educational background, and profession also affect the selection of the payment method. Individuals with higher education levels and private sector employees are more inclined to choose cashless transactions. Nevertheless, many travelers demand the availability of both cash and cashless payment alternatives at bus stops and on buses. This suggests that social identity affects the selection of payment methods, particularly among children and teenagers who are less experienced with cashless technology. This is in contrast to the idea of [38], where global trends indicate that younger users are more likely to adopt new technologies. This insight contrasts with the argument that individuals who have recently used public transport are more likely to continue using it, suggesting that early and consistent use can shape future behavior [33]. This is particularly relevant in contexts in which public transport improvements are made.

In the context of developing non-capital cities, where technology readiness and digital literacy are limited, these programs could facilitate the transition from traditional to digital payment systems, thereby promoting broader adoption.

Infrastructure improvement should prioritize high-traffic zones and underserved locations to ensure equal access to cashless payment systems. Enhancing network stability and communication infrastructure at bus stops or terminals can reduce disruptions and elevate user satisfaction [14], [43].

Moreover, incentives such as loyalty programs or cashback programs can be targeted at first-time or infrequent users to promote habit formation and sustained adoption. These incentives are crucial for enhancing user engagement and mitigating the behavioral inertia of infrequent users, as indicated by the study results. By employing these tactics, public transportation systems can advance the objectives of promoting more inclusive and sustainable urban mobility solutions through the Smart City Concept and the Sustainable Development Goals (SDG 11) [10].

## IV. Conclusion

To enhance the convenience and efficiency of Trans Jogja BRT services, it is crucial to integrate payment systems with other modes of transportation and to develop digital infrastructure. To minimize disruptions to the cashless payment system, especially in areas with limited internet connections, it is essential to prioritize the stability of Internet connections and communication networks at bus stops, terminals, and BRT cars.

Providing a flexible and integrated payment system, such as payment via e-wallets, cards, or cash at bus stops and buses, can accommodate the needs of all users, including those who are less familiar with digital technology. Additionally, increasing digital literacy through educational programs at bus stops or terminals, such as distributing brochures or offering short training sessions, can help the community understand and adapt to the cashless payment system.

Promoting the broader implementation of incentives through discounts, cash back, or loyalty programs can appeal to both adolescent and adult customers, while a hybrid payment system that integrates cash and cashless means can ensure accessibility for all demographics. These implementation procedures enhance the adoption of cashless payments, improve user experience, augment the operational efficiency of public transportation, and facilitate the development of more integrated and appealing BRT services for diverse demographics. This study lays the groundwork for future research on payment schemes, integrating transportation modes, and initiatives to enhance the appeal of cashless systems.

## Acknowledgment

This research is supported by the Faculty of Diponegoro University, Indonesia, through the Strategic Research Grant 2024, No. 204/S/PWK/18/UN7.F3/PP/III/2024.

## References

[1] G. K. S. Tan, "Citizens go digital: A discursive examination of digital payments in Singapore's Smart Nation project," *Urban Stud.*, vol. 59, no. 12, pp. 2582-2598, 2022, doi: 10.1177/00420980211039407.

[2] A. H. Shalihah et al., "An empirical investigation of factors affecting personal information's disclosure on mobile payment (e-wallet) platforms," *Int. J. Adv. Sci. Eng. Inf. Technol.*, vol. 13, no. 3, pp. 1031-1040, 2023, doi: 10.18517/ijaseit.13.3.18054.

[3] M. M. Hakim, A. N. Afifah, and G. Aryotejo, "The analysis of factors affecting behavioral intention and behavior usage of e-wallet using meta-UTAUT model," *Int. J. Adv. Sci. Eng. Inf. Technol.*, vol. 13, no. 2, pp. 786-793, 2023, doi: 10.18517/ijaseit.13.2.18297.

[4] A. K. Faulhaber et al., "Development of a passenger assistance system to increase the attractiveness of local public transport," *Sustainability*, vol. 14, no. 7, 2022, doi: 10.3390/su14074151.

[5] D. Ponkratov, D. Kopytkov, and V. Dolya, "A comprehensive analysis of the electronic fare collection systems effectiveness implementation on public transit and prospective directions of its application in Ukraine," *Technol. Audit Prod. Reserv.*, vol. 4, no. 2, pp. 51-54, 2023, doi: 10.15587/2706-5448.2023.286614.

[6] S. Porru et al., "Smart mobility and public transport: Opportunities and challenges in rural and urban areas," *J. Traffic Transp. Eng.*, vol. 7, no. 1, pp. 88-97, 2020, doi: 10.1016/j.jtte.2019.10.002.

[7] D. Garcia-Retuerta et al., "An efficient management platform for developing smart cities: Solution for real-time and future crowd detection," *Electronics*, vol. 10, no. 7, pp. 1-15, 2021, doi:10.3390/electronics10070765.

[8] A. Iqbal and S. Olariu, "A survey of enabling technologies for smart communities," *Smart Cities*, vol. 4, no. 1, pp. 54-77, 2021, doi:10.3390/smartcities4010004.

[9] G. I. Hapsari et al., "Moving object activator in background subtraction algorithm for automatic passenger counter system in public transportation," *J. Appl. Eng. Technol. Sci.*, vol. 5, no. 1, pp. 73-87, 2023, doi: 10.37385/jaets.v5i1.1956.

[10] B. Frączek and A. Urbanek, "Financial inclusion as an important factor influencing digital payments in passenger transport: A case study of EU countries," *Res. Transp. Bus. Manag.*, vol. 41, 2021, doi:10.1016/j.rtbm.2021.100691.

[11] M. Simatele and E. Mbedzi, "Consumer payment choices, costs, and risks: Evidence from Zimbabwe," *Cogent Econ. Finance*, vol. 9, no. 1, 2021, doi: 10.1080/23322039.2021.1875564.

[12] M. K. Anam et al., "Analysis and identification of non-impact factors in smart city readiness using technology acceptance analysis: a case study in Kampar District, Indonesia," *J. Appl. Eng. Technol. Sci.*, vol. 5, no. 1, pp. 1-17, 2023, doi: 10.37385/jaets.v5i1.2401.

[13] E. Elyta, Herlan, and R. Daud, "Sustainable digital technology in supporting social recovery in the post-COVID-19 pandemic era: Political policy perspective," *Int. J. Adv. Sci. Eng. Inf. Technol.*, vol. 14, no. 6, pp. 1880-1888, 2024, doi: 10.18517/ijaseit.14.6.19740.

[14] K. N. Irvine et al., "Smart City Thailand: Visioning and design to enhance sustainability, resiliency, and community wellbeing," *Urban Sci.*, vol. 6, no. 1, p. 7, 2022, doi: 10.3390/urbansci6010007.

[15] P. P. Kumar et al., "Evaluating public transport efficiency: A cross-regional SFA approach," *Civ. Eng. Archit.*, vol. 12, no. 5, pp. 3512-3529, 2024, doi: 10.13189/cea.2024.120528.

[16] I. M. A. Widhyastana and R. Rachmawati, "Digital payment application as a cashless utilization and its benefit for the community in Denpasar City," *Int. J. Adv. Sci. Eng. Inf. Technol.*, vol. 12, no. 4, pp. 1650-1656, 2022, doi: 10.18517/ijaseit.12.4.12668.

[17] N. C. Kresnanto and W. H. Putri, "Transport demand management strategy priority assessment based on expert judgment," *J. Appl. Eng. Technol. Sci.*, vol. 4, no. 2, pp. 795-807, 2023, doi:10.37385/jaets.v4i2.1701.

[18] I. Olivková, "Comparison and evaluation of fare collection technologies in the public transport," *Procedia Eng.*, vol. 178, pp. 515-525, 2017, doi: 10.1016/j.proeng.2017.01.099.

[19] M. A. Khaliji and K. J. Ghalehteimouri, "Urban security challenges in major cities, with a specific emphasis on privacy management in the metropolises," *Discov. Environ.*, vol. 2, no. 1, 2024, doi:10.1007/s44274-024-00116-3.

[20] W. Brown, G. Wilson, and O. Johnson, "Exploring the adoption of digital payment systems in retail," 2024, doi:10.20944/preprints202407.2424.v1.

[21] M. R. I. Bhuiyan, M. S. Akter, and S. Islam, "How does digital payment transform society as a cashless society? An empirical study in the developing economy," *J. Sci. Technol. Policy Manag.*, 2024, doi: 10.1108/JSTPM-10-2023-0170.

[22] G. Dydkowski and A. Urbanek, "The impact of an integrated fare system on the public transport demand: A literature review," *Sci. J. Marit. Univ. Szczecin*, vol. 74, no. 146, pp. 16-27, 2023.

[23] U. T. Munikrishnan et al., "Modelling the intention and adoption of cashless payment methods among the young adults in Malaysia," *J. Sci. Technol. Policy Manag.*, vol. 15, no. 2, pp. 374-395, 2024, doi: 10.1108/JSTPM-04-2022-0077.

[24] L. Sanny et al., "The impulse buying of Gen Z when using e-wallet in Indonesia," *J. Appl. Eng. Technol. Sci.*, vol. 5, no. 1, pp. 88-100, 2023, doi: 10.37385/jaets.v5i1.2600.

[25] P. A. M. Internasional, "Laporan transaksi detail Trans Jogja periode 02-2024," Yogyakarta, 2024.
[26] E. Mogaji and N. P. Nguyen, "Evaluating the emergence of contactless digital payment technology for transportation," *Technol. Forecast. Soc. Change*, vol. 203, 2024, doi: 10.1016/j.techfore.2024.123378.
[27] S. Owusu-Agyemang et al., "Transit made easy: Examining the adoption and impact of mobile fare payment technology among bus riders," *Transp. Res. Interdiscip. Perspect.*, vol. 25, p. 101086, 2024, doi: 10.1016/j.trip.2024.101086.
[28] J. Berrada and A. Poulhès, "Economic and socioeconomic assessment of replacing conventional public transit with demand responsive transit services in low-to-medium density areas," *Transp. Res. A Policy Pract.*, vol. 150, pp. 317-334, 2021, doi: 10.1016/j.tra.2021.06.008.
[29] J. Göransson and H. Andersson, "Factors that make public transport systems attractive: a review of travel preferences and travel mode choices," *Eur. Transp. Res. Rev.*, vol. 15, no. 1, 2023, doi: 10.1186/s12544-023-00609-x.
[30] P. Ramanuj et al., "Development of mode choice behavior model for inter-regional public transport - a case study of India," *Suranaree J. Sci. Technol.*, vol. 30, no. 3, 2023, doi: 10.55766/sujst-2023-03-e0113.
[31] D. Yanocha, J. Mason, and J. Hagen, "Using data and technology to integrate mobility modes in low-income cities," *Transp. Rev.*, vol. 41, no. 3, pp. 262-284, 2021, doi: 10.1080/01441647.2020.1834006.
[32] L. Tóth and K. Rados, "Social influences of economic decision making: an identity economics approach," *Foresight Res. Case Stud. Futur.*, pp. 191-201, 2023, doi: 10.29180/9786156342560_11.
[33] V. Bandyopadhyaya and R. Bandyopadhyaya, "Understanding public transport use intention post Covid-19 outbreak using modified theory of planned behavior: Case study from developing country perspective," *Case Stud. Transp. Policy*, vol. 10, no. 4, pp. 2044-2052, 2022, doi: 10.1016/j.cstp.2022.09.002.
[34] A. M. Sofi, I. A. Reshi, and D. T. Sudha, "How psychological factors influence economic decision-making, and the implications for policy," *J. Account. Res. Util. Financ. Digit. Assets*, vol. 1, no. 4, pp. 370-375, 2023, doi: 10.54443/jaruda.v1i4.57.
[35] M. Nadeem et al., "Does bus rapid transit system (BRTS) meet the citizens' mobility needs? Evaluating performance for the case of Multan, Pakistan," *Sustainability*, vol. 13, no. 13, 2021, doi: 10.3390/su13137314.
[36] B. Z. Malik et al., "Investigating users' travel behaviours and perceptions of single-corridor BRT: Lessons from Lahore," *J. Transp. Geogr.*, vol. 91, 2021, doi: 10.1016/j.jtrangeo.2020.102942.
[37] A. Karakurt and I. Gokasar, "Evaluation of user costs in terms of public transportation fare: A literature review," vol. 2, no. 1, pp. 285-299, 2024, doi: 10.31181/jopi21202426.
[38] B. K. Nambiar and K. Bolar, "Factors influencing customer preference of cardless technology over the card for cash withdrawals: an extended technology acceptance model," *J. Financ. Serv. Mark.*, vol. 28, no. 1, pp. 58-73, 2023, doi: 10.1057/s41264-022-00139-y.
[39] L. Deepa et al., "An analysis of individuals' usage of bus transit in Bengaluru, India: Disentangling the influence of unfamiliarity with transit from that of subjective perceptions of service quality," *Travel Behav. Soc.*, vol. 29, pp. 1-11, 2022, doi: 10.1016/j.tbs.2022.05.001.
[40] S. Sayfuddin, "Study on factors affecting the successful implementation of construction projects in West Lombok District and Mataram City," *J. Appl. Eng. Technol. Sci.*, vol. 3, no. 2, pp. 223-234, 2022, doi: 10.37385/jaets.v3i2.825.
[41] K. Aggarwal, S. Malik, D. K. Mishra, and D. Paul, "Moving from cash to cashless economy: Toward digital India," *J. Asian Finance, Econ. Bus.*, vol. 8, pp. 43-54, 2021.
[42] A. Golub et al., "Equity and exclusion issues in cashless fare payment systems for public transportation," *Transp. Res. Interdiscip. Perspect.*, vol. 15, 2022, doi: 10.1016/j.trip.2022.100628.
[43] I. B. Alhassan et al., "Public transport users' willingness-to-pay for a multi-county and multi-operator integrated ticket: Valuation and policy implications," *Res. Transp. Bus. Manag.*, vol. 45, p. 100836, 2022, doi: 10.1016/j.rtbm.2022.100836.