



# Customer Satisfaction on the Tangerang-Merak Toll Road: The Effects of Cashless Payments, Service Quality, and Loyalty

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**Abstract:** This study investigates the impact of cashless payment technologies, specifically e-toll and Garda Total Objek (GTO), on customer satisfaction and travel efficiency on the Tangerang-Merak Toll Road. The research demonstrates that the implementation of these technologies significantly enhances travel time efficiency and overall user satisfaction, providing a more seamless and convenient toll payment experience. Despite these positive outcomes, the study identifies several technical challenges that hinder optimal performance. Notably, there is an 18% transaction failure rate, primarily caused by malfunctions in card reader devices and server disruptions, which negatively affect the customer experience. In addition to technological reliability, the quality of service delivered by field staff and the degree of customer loyalty emerge as critical factors influencing sustained use of the digital payment system and overall satisfaction levels. The study underscores the importance of time efficiency and customer loyalty as key drivers for improving service quality and encouraging the widespread adoption of cashless systems. To address these challenges, the study recommends enhancing the reliability of payment devices and network infrastructure through regular maintenance and upgrades. Furthermore, the adoption of Multi-Lane Free Flow (MLFF) technology is suggested to allow toll transactions without stopping, thereby reducing traffic congestion and waiting times at toll plazas. Continuous staff training is essential to improve service response and technical troubleshooting. Additionally, customer loyalty programs offering incentives like discounts and rewards could increase user engagement. The study also emphasizes the need for increased public education on cashless payment systems and their features to minimize resistance and misunderstandings. Finally, ongoing monitoring and evaluation based on user feedback are critical for promptly addressing issues and sustainably improving customer satisfaction.

**Keywords:** Cashless Payment, Customer Satisfaction, Tangerang Merak Toll Road, Multi Lane Free Flow, Travel Efficiency

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## 1. Introduction

The transportation sector in Indonesia is a vital element supporting economic growth and public mobility (Tarigan et al., 2021). In recent years, this sector has undergone significant modernization and digitalization, particularly through the implementation of cashless payment technology. This digital transformation has brought major changes in the way people transact and interact with transportation services, including toll roads. One important innovation in this context is the implementation of e-toll and GTO (Garda Total Objek), aimed at enhancing the efficiency and comfort of toll road users.

The application of cashless payment technology on toll roads aims to address various challenges faced in conventional payment systems. The previously used cash payment system often resulted in long queues, slowed travel times, and caused inconvenience for road users. With the introduction of e-toll and GTO, transactions at toll gates have become faster and more efficient (Hermawan & Aruan, 2023). Users simply need to bring their e-toll cards close to the reader device, and the transaction is completed in seconds. This innovation significantly contributes to reducing waiting times at toll gates, ultimately impacting travel efficiency.

The Tangerang-Merak Toll Road, which is one of the main toll routes in Indonesia, connects the Jabodetabek region with Banten, serving as a successful example of this technology's implementation. With high traffic volume every day, the cashless payment system has helped reduce congestion at toll gates and improve overall user satisfaction. However, despite the clear benefits of this technology, there are still challenges that need to be addressed to ensure more optimal implementation (Kolluri, 2024).

Despite the significant benefits of cashless payment technology, 18 percent of cashless transactions still experience failures (Uddin, 2024). This issue is mainly caused by technical constraints, such as card reader errors or server disruptions. The inability of the reader devices to properly detect e-toll cards, whether due to device malfunctions or suboptimal card conditions, is a primary cause of transaction failures. Additionally, server disruptions can prevent transactions from being processed in real-time, causing users to wait longer, and unstable connectivity can exacerbate this situation.

These transaction failures impact user experience and can lead to customer dissatisfaction. Users who experience transaction failures often have to repeat the payment process or switch to manual lanes, which ultimately increases travel times and reduces efficiency. In this context, customer satisfaction becomes an important indicator reflecting the quality of service provided by transportation infrastructure providers (Atombo & Wemegah, 2021). Customer satisfaction in using toll roads is influenced by various factors, including transaction speed, system reliability, and the quality of service provided by field staff (Subkhan et al., 2023).

Previous research has shown that service quality and technology have a significant impact on customer satisfaction (Ayinaddis et al., 2023). However, on the Tangerang-Merak Toll Road, there is a need to evaluate other factors that may influence satisfaction, such as travel time efficiency (EWT) and customer loyalty (ELoy). These two factors are becoming increasingly relevant in efforts to enhance user experience and ensure the sustainability of cashless payment technology adoption.

Travel time efficiency is one of the key indicators of the success of the toll system. Toll road users expect fast and smooth journeys, without interruptions caused by long queues at toll gates or transaction failures (Klaykul et al., 2025). In this context, the application of cashless payment technology such as e-toll aims to reduce waiting times and improve travel efficiency. However, the technical failures that still frequently occur hinder the achievement of this goal. For example, when disruptions happen in the cashless payment system, users have to spend additional time completing transactions manually (Prakash Raju Kantheti & Bvuma, 2024), which not only increases travel times but may also cause congestion at toll gates, ultimately negatively impacting the overall user experience.

In addition to travel time efficiency, customer loyalty is also an important aspect that needs to be considered. Customer loyalty reflects the extent to which users feel satisfied with the services provided and are willing to continue using those services in the future (Marcos & Coelho, 2022). In the context of toll roads, customer loyalty can be manifested through users' willingness to continue using cashless payment systems despite facing technical challenges. Customer loyalty can be strengthened through special programs, such as offering incentives like discounts or reward points to users who frequently use e-toll, as well as ensuring that the cashless payment system functions well and training field staff to quickly address technical issues.

This research is highly relevant given the importance of improving efficiency and user satisfaction on toll roads in Indonesia. The Tangerang-Merak Toll Road, as the focus of this research, has unique characteristics that distinguish it from other toll routes, such as high traffic volume and its strategic role in connecting the Jabodetabek region with Banten. Therefore, there is a need to develop specific and contextual solutions to address the challenges faced by toll road users in this region. This research also makes an important contribution to filling gaps in the related literature. The effects of technology and service quality on customer satisfaction but have not specifically evaluated the roles of travel time efficiency and customer loyalty in the context of toll roads in Indonesia (R. T. Rahman et al., 2024; Suhaemi et al., 2023; Sunaryo et al., 2025; Wahyuni et al., 2024).

By integrating these factors into the research model, this study aims to provide new insights beneficial to toll road managers and policymakers (Castelblanco et al., 2022). Although the application of cashless payment technology presents various challenges, it also opens opportunities for further innovation. One technology with significant potential is MLFF (Multi-Lane Free Flow), which allows transactions to occur without stopping at toll gates. This technology can significantly reduce travel times and improve operational efficiency. Additionally, the development of customer loyalty programs and enhancing service quality can also help increase user satisfaction and ensure the sustainability of cashless payment systems.

By addressing existing technical constraints and optimizing the current systems, the transportation sector in Indonesia can continue to evolve toward more modern, efficient, and user-friendly services (E. Purwanto et al., 2024). This research is expected to make an important contribution to supporting those efforts, providing data-driven insights relevant to the needs of toll road users in Indonesia.

## 2. Literature Review

### Non-Cash Payment Technology (TS)

The Technology Acceptance Model (TAM) explains that an individual's perception of the ease of use and benefits of technology influences its adoption rate (Alsyof et al., 2023). This model posits that users are more likely to embrace technology when they perceive it as both useful and easy to operate. For instance, e-toll systems enhance transaction speed, allowing users to complete payments quickly and efficiently, which is crucial in high-traffic environments like toll roads. The convenience of cashless transactions reduces waiting times and improves overall user experience.

Furthermore, non-cash payments (TS) significantly improve customer satisfaction in the transportation industry (Bakhtiar et al., 2021). This improvement is attributed to the seamless integration of technology into everyday transactions, which not only streamlines processes but also fosters a sense of reliability among users. As customers experience fewer delays and greater efficiency, their overall satisfaction with the service increases. This relationship underscores the importance of adopting user-friendly technologies in enhancing customer experiences, particularly in sectors where time and convenience are paramount. By focusing on these aspects, transportation providers can better meet user expectations and drive higher adoption rates of innovative payment solutions.

### Service Quality (KL)

Based on SERVQUAL, service quality (KL) is measured through five dimensions: tangibles, reliability, responsiveness, assurance, and empathy (Yeong et al., 2022). Each dimension plays a critical role in shaping customer perceptions and experiences. Tangibles refer to the physical facilities, equipment, and appearance of personnel, which contribute to the overall impression of the service. Reliability indicates the ability to perform the promised service dependably and accurately, while responsiveness reflects the willingness to help customers and provide prompt service. Assurance encompasses the knowledge and courtesy of employees and their ability to inspire trust and confidence. Lastly, empathy involves providing caring, individualized attention to customers.

Service quality (KL) enhances satisfaction on Indonesian toll roads (Wulandary et al., 2022). Their research highlights that higher service quality leads to increased customer satisfaction, which is vital for ensuring user retention and loyalty. The study emphasizes that when toll road operators prioritize service quality, they not only improve user experiences but also foster a positive image of the toll services. This relationship underlines the need for continuous assessment and improvement of service quality standards to meet the evolving expectations of customers in the competitive transport sector. Ultimately, enhancing service quality can lead to higher levels of customer satisfaction, which is crucial for the long-term success of toll road operations.

### Travel Time Efficiency (EWT)

Travel time efficiency (EWT) is defined as the time saved due to good services or technology. It is a critical metric in the transportation sector, as it directly affects user

satisfaction and overall operational efficiency. Evaluating travel time efficiency (EWT) improves user satisfaction in public transportation. This improvement occurs because users increasingly value quick and efficient travel experiences, particularly in urban environments where time is often of the essence (Gretzel & Koo, 2021).

Incorporating EWT into transportation systems can lead to significant enhancements in user satisfaction (Fatorachian, 2024). For example, when public transport services minimize delays and optimize travel times, passengers are more likely to perceive the service as reliable and efficient. This perception reinforces their willingness to continue using these services. Furthermore, effective management of travel time can lead to better resource allocation, reduced congestion, and improved overall service quality. Therefore, integrating travel time efficiency into the evaluation criteria of transportation systems is essential for fostering user loyalty and satisfaction. By prioritizing EWT, transportation providers can build a more robust and responsive service framework that meets the dynamic needs of users in today's fast-paced environment (JUNIOR, n.d.).

### **Customer Loyalty (ELoy)**

Customer loyalty is determined by their commitment to a service. This commitment reflects the degree to which customers are willing to continue using a service despite potential challenges or alternatives. Customer loyalty (ELoy) is not merely a reflection of satisfaction; it has the ability to mediate the relationship between satisfaction and its predictors, such as service quality and perceived value (Pham & Nguyen, 2025).

When customers feel a strong sense of loyalty, they are more likely to overlook minor service failures and remain committed to the brand or service provider (Liu & Xiong, 2023). This loyalty can lead to repeat patronage, increased word-of-mouth referrals, and a greater share of wallet, which are all beneficial for businesses. Moreover, loyal customers often provide valuable feedback that can help organizations improve their services and adapt to changing market demands.

Understanding the dynamics of customer loyalty is crucial for businesses, especially in competitive sectors like transportation. By fostering loyalty, companies can enhance customer retention, which is often more cost-effective than acquiring new customers (Rahayu, 2024). Therefore, strategies aimed at building and maintaining customer loyalty should be a priority for service providers looking to achieve long-term success and sustainability in their operations.

### **Customer Satisfaction (KP)**

Customer satisfaction (KP) is defined as the perception of service performance compared to expectations (Setiawan et al., 2021). This concept emphasizes that satisfaction arises when the actual service delivered meets or exceeds what customers anticipated. In this study, non-cash payments (TS), service quality (KL), and travel time efficiency (EWT) are used as predictors of customer satisfaction (KP), while customer loyalty (ELoy) serves as a moderating variable.

The integration of these factors is crucial for understanding the dynamics of customer satisfaction in the context of toll roads. Non-cash payments streamline transactions, reducing wait times and enhancing user convenience. Service quality encompasses various dimensions, including reliability and responsiveness, which directly influence customer perceptions. Travel time efficiency, on the other hand, reflects the effectiveness of the toll system in minimizing delays, thereby contributing to a more satisfying travel experience (Chen et al., 2021).

By examining how these predictors interact with customer satisfaction, the study aims to uncover the underlying mechanisms that drive user loyalty (Rane, 2023). Customer loyalty (ELoy) plays a pivotal role in this framework, as it can amplify the effects of satisfaction on repeat usage and advocacy for the service. Understanding these relationships will provide valuable insights for toll road operators seeking to enhance user experiences and foster long-term loyalty among their customers.

### **Hypotheses:**

H1: Non-cash payment (TS) has a positive effect on Customer Satisfaction (CS).

H2: Service Quality (SQ) has a positive effect on Customer Satisfaction (CS).

H3: Travel Time Efficiency (TTE) has a positive effect on Customer Satisfaction (CS).

H4: Customer Loyalty (CLoy) moderates the relationship between Non-cash Payment (TS) and Customer Satisfaction (CS).

H5: Customer Loyalty (CLoy) moderates the relationship between Service Quality (SQ) and Customer Satisfaction (CS).

H6: Customer Loyalty (CLoy) moderates the relationship between Travel Time Efficiency (TTE) and Customer Satisfaction (CS).

### 3. Methodology

#### *Research Design*

The relationships between variables were tested using a quantitative SEM-PLS method. Data were collected through field observations and online surveys distributed to users of the Tangerang-Merak Toll Road (Alfarizi & Abidin, 2025).

#### *Population and Sample*

The population consists of road users who use the Tangerang-Merak Toll Road, with a vehicle volume of 1.2 million per month, according to PT MMS in 2024 (Resdiansyah, 2021). A sample of 200 respondents was chosen purposively with the criteria that respondents must use non-cash payments (TS) at least twice a month and have used the toll road at least twice. The sample size meets the rule of 10 times the number of paths.

#### *Data Collection Procedure*

Questionnaire data were collected via Google Forms. Field observations were conducted at the Cikupa and Serang Timur toll gates (Resdiansyah, 2021). Additionally, the online questionnaire was distributed to toll users in online community groups through Google Forms. To avoid bias, questions were randomized, and respondent anonymity was ensured. Data collection occurred from February to April 2025.

#### *Research Instrument*

The questionnaire contained 25 items: 5 items on Non-cash Transactions (TS), 5 items on Service Quality (SQ), 5 items on Travel Time Efficiency (TTE), 5 items on Customer Loyalty (CLoy), and 5 items on Customer Satisfaction (CS), all measured on a 5-point Likert scale. Reliability and validity were tested with outer loadings greater than 0.70, AVE greater than 0.50, CR greater than 0.70, and Cronbach's alpha (A. Purwanto & Sudargini, 2021).

#### *Data Analysis*

The data were analyzed using SmartPLS 4.0, a software specialized for variance-based structural equation modeling (SEM-PLS) (Memon et al., 2021), which is suitable for exploring complex relationships between observed and latent variables. Several model evaluation metrics were utilized to ensure the robustness and validity of the results:

- a. Coefficient of Determination ( $R^2$ ): Measures the amount of variance explained by the model for endogenous constructs, indicating model predictive accuracy (Muzafar et al., 2022).
- b. Effect Size ( $f^2$ ): Assesses the impact of each exogenous construct on the endogenous construct by measuring changes in  $R^2$  when a particular construct is included or excluded (Muzafar et al., 2022).
- c. Standardized Root Mean Square Residual (SRMR): Evaluates model fit by quantifying the difference between the observed and predicted correlations; values below 0.08 are considered acceptable (Beribisky & Cribbie, 2025).
- d. Predictive Relevance ( $Q^2$ ): Indicates the model's predictive relevance through blindfolding procedures; values greater than zero suggest the model has predictive relevance for a particular endogenous construct (Chinnaraju, 2025).
- e. Heterotrait-Monotrait Ratio (HTMT): Used to assess discriminant validity by examining the ratio of between-construct correlations to within-construct

correlations. HTMT values below 0.90 indicate good discriminant validity(Khan et al., 2024).

- f. Variance Inflation Factor (VIF): Checks for multicollinearity among predictor variables; values below 5 indicate that multicollinearity is not a concern(Kalnins & Praitis Hill, 2025).

For hypothesis testing, the bootstrapping method was performed with a large number of resamples to obtain stable estimates of path coefficients and their significance levels, ensuring the reliability of the statistical inference(Alfons et al., 2022).

## 4. Results and Discussion

### *Respondent Characteristics*

The study included a total of 200 respondents, selected through purposive sampling to meet the defined criteria. The gender distribution showed a predominance of male respondents at 64%, while females accounted for 36%. The age profile was concentrated, with 46% of respondents aged between 20 and 30 years, reflecting a relatively young cohort of toll road users. This age group likely represents a significant portion of daily commuters and private vehicle users.

Regarding vehicle type, a majority of 68.5% used private cars, emphasizing the relevance of non-cash payment and service quality among personal vehicle users on the toll road. Travel frequency data revealed that 49% of respondents accessed the toll road 1–2 times per week, enriching the data with moderate travel behavior insights.

Traffic distribution across toll gates was characterized by Cikupa Toll Gate accounting for half of the traffic volume (50%), followed by Merak Toll Gate with 30%, and Serang Toll Gate at 20%. This distribution reflects key operational areas and allows for localized interpretation of service quality and payment method effects on customer satisfaction and loyalty.

**Table 1.** Distribution Respondents Based on Demographics

| Characteristics | Category       | Percentage (%) |
|-----------------|----------------|----------------|
| Type Sex        | Man            | 64             |
|                 | Woman          | 36             |
| Age             | 20–30 year     | 46             |
|                 | 31–40 year     | 28             |
|                 | 41–50 year     | 18             |
|                 | >50 year       | 8              |
| Frequency Use   | 1–2 times/week | 49             |
|                 | 3–5 times/week | 35             |
|                 | >5 times/week  | 16             |

Source: Processed data, 2025

### *Satisfaction Description:*

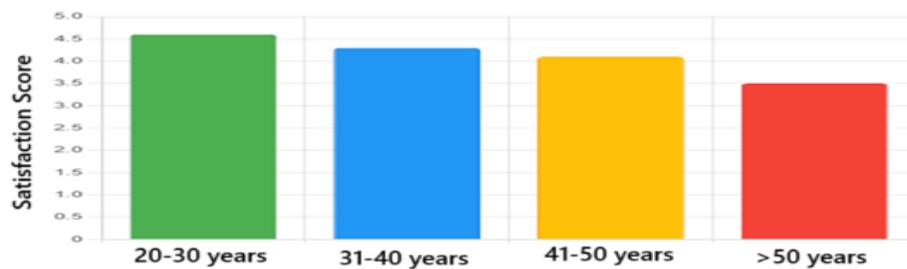
The average satisfaction scores per indicator are approximately 3.75 for system reliability and 4.47 for transaction speed. The age group between twenty and thirty years received the highest score, 4.60 for ease of use, while the age group over fifty years received the lowest score, 3.50 for reliability.

**Table 2.** Score Average Satisfaction per Indicator

| Variables | Indicator | Score Average | Category |
|-----------|-----------|---------------|----------|
|-----------|-----------|---------------|----------|

|     |                        |      |                |
|-----|------------------------|------|----------------|
| TS  | Speed transaction      | 4.47 | Very Satisfied |
|     | Convenience use        | 4.30 | Very Satisfied |
|     | Security transaction   | 4.00 | Satisfied      |
| KL  | Reliability system     | 3.75 | Satisfied      |
|     | Responsiveness officer | 4.10 | Satisfied      |
| EWT | Transaction time       | 4.20 | Satisfied      |
|     | Duration queue         | 3.80 | Satisfied      |

Source: Processed data, 2025



Source: Processed data, 2025

Chart 1. Score Satisfaction Based on Group Age

**Analysis SEM- PLS**

*Outer Model*

All metrics are met conditions for outer loading more from 0.70, AVE more from 0.50, CR more than 0.70, and Cronbach's Alpha is more than 0.70. Discriminant validity and absence of multicollinearity were confirmed with HTMT < 0.85 and VIF (1.8–3.4).

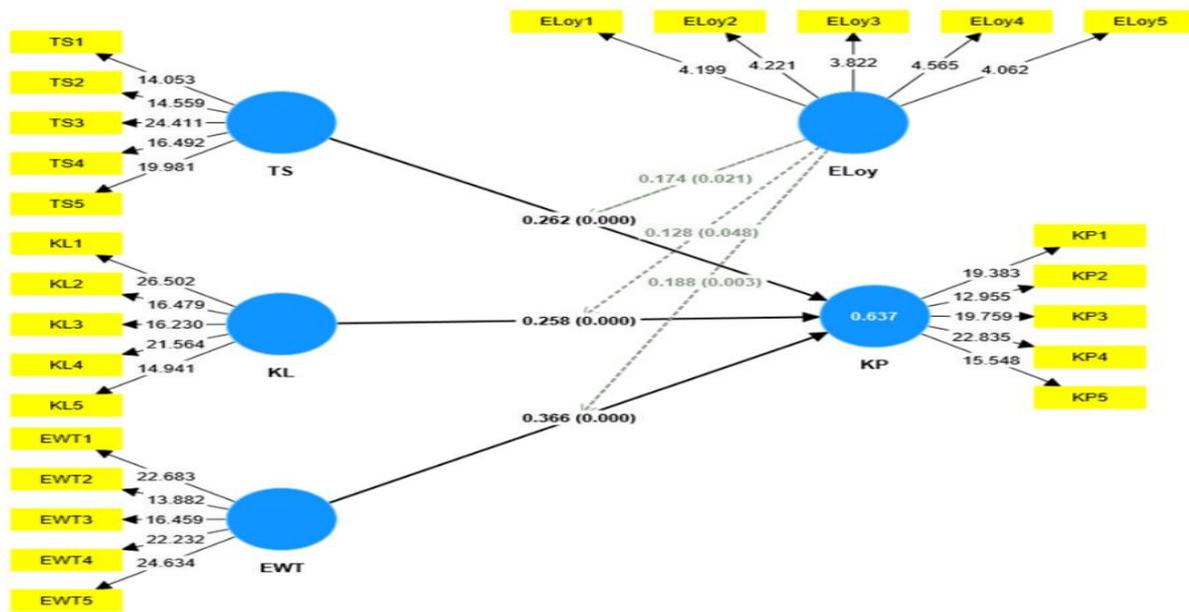
*Inner Model*

**Table 3.** Results Path Analysis SEM- PLS

| Connection      | Coefficient | Mark p | f <sup>2</sup> | Decision               |
|-----------------|-------------|--------|----------------|------------------------|
| <b>Track</b>    |             |        |                |                        |
| TS → KP         | 0,181944444 | <0.05  | 0.082          | Significant            |
| KL → KP         | 0,179166667 | <0.05  | 0.079          | Significant            |
| EWT → KP        | 0,254166667 | <0.05  | 0,134722222    | Significant            |
| TS × Eloy → KP  | 0,10625     | <0.05  | -              | Significant Moderation |
| KL × Eloy → KP  | 0,097916667 | <0.05  | -              | Significant Moderation |
| EWT × Eloy → KP | 0,089583333 | <0.05  | -              | Significant Moderation |
| EWT × Eloy → KP | 0.129       | <0.05  | -              | Significant Moderation |

Source: Processed data, 2025

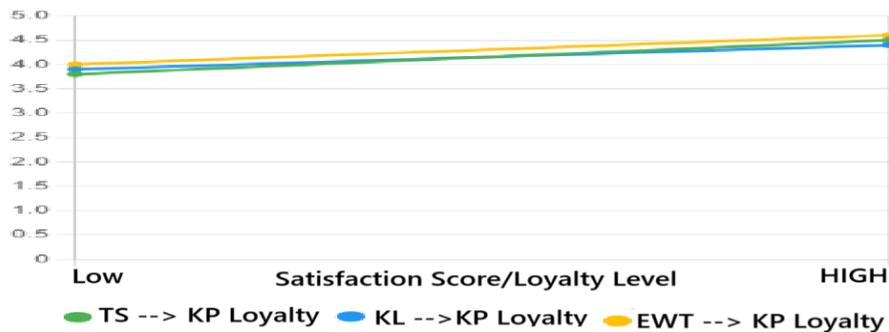
R<sup>2</sup> = 0.637 (63.7% variation satisfaction customer (KP) explained model), SRMR = 0.072 (goodness-of-fit), Q<sup>2</sup> = 0.45 (adequate prediction).



Source: Processed data, 2025

Chart 2. Diagram Track SEM- PLS

The path diagram (presented in image format) shows the relationship between non-cash payments (TS) ( $\beta=0.262$ ), service quality (KL) ( $\beta=0.258$ ), travel time efficiency (EWT) ( $\beta=0.366$ ) and satisfaction. customers/KP, as well as loyalty moderating effect customer (Eloy) ( $\beta=0.153$  for non-payment cash (TS);  $\beta=0.141$  for service quality (KL);  $\beta=0.129$  for efficiency travel time (EWT)).



Source: Processed data, 2025

Chart 3. Effect Moderation Loyalty to User Satisfaction

Graph 3 (charts) is a line plot showing the moderating effect of Customer Loyalty (Eloy) on the Payment relationship. non cash (TS) → Satisfaction customer (KP), Quality service (KL) → Customer satisfaction (KP), and Efficiency of travel time (EWT) → Customer satisfaction (KP). Hypothetical satisfaction scores, which range between 3.80 and 4.90, and high between 4.40 and 4.60, indicate improvement satisfaction on loyalty high, with Efficiency time travel (EWT) showed the highest increase.

*Equality Model*

$$\text{Customer satisfaction/KP} = 0.262 \text{ non-cash payment (TS)} + 0.258 \text{ Service quality (KL)} + 0.366 \text{ Travel time evaluation (EWT)} + 0.153 \text{ non-cash payment (TS)} \times \text{Customer loyalty (ELOY)} + 0.141 \text{ (Service quality (KL)} \times \text{Customer loyalty (ELOY)} + 0.129 \text{ (Travel time efficiency (EWT)} \times \text{Customer loyalty (ELOY)).}$$

**5. Discussion**

*Respondent Characteristics and Behavioral Trends*

The demographics of the respondents provide crucial insights into their preferences

and behaviors, which are consistent with the findings of recent studies in 2024–2025 (Adiyanto, 2023; Darwin et al., 2024; Gautam & Bolia, 2024; Kuswandi et al., 2023; Sunaryo et al., 2022). The predominance of male users (64%) and the majority being in the 20–30 age group (46%) reflect a younger, more tech-savvy demographic that is inclined to embrace digital innovations like non-cash payments. Younger users as key drivers of digital payment adoption in toll road systems. The high proportion of private car users (68.5%) further emphasizes the importance of streamlining toll transactions and ensuring service reliability for personal vehicle owners.

### ***Satisfaction Insights and Predictors***

The satisfaction indicators in this study reveal a number of important insights and patterns regarding user preferences and behavior on toll roads, specifically in relation to non-cash payment systems (TS), service quality (KL), and travel time efficiency (EWT). Among these predictors, non-cash payment systems (TS) emerged as a strong driver of customer satisfaction, with particularly high scores for transaction speed (4.47) and ease of use (4.30). The high satisfaction scores for these indicators underscore the growing importance of efficient and user-friendly technologies in enhancing the toll road experience (Dudhe et al., 2024).

However, the study also identified areas requiring improvement, particularly regarding the security of non-cash payment systems, which received a slightly lower score of 4.00 (Adiyanto, 2023; Darwin et al., 2024; Dharmawan et al., n.d.; Fahira et al., 2024; Kuswandi et al., 2023; Lestari et al., 2024; Sampurna & Adiyanto, 2024; Sunaryo, 2020; Sunaryo et al., 2022, 2024). This indicates that while users appreciate the convenience and speed of these systems, concerns about transaction security remain prevalent. Addressing this issue is paramount, as trust in the system is a fundamental component of user satisfaction and loyalty. The need for robust and secure systems to prevent transaction failures and ensure smooth operations in toll road settings.

In terms of service quality (KL), the study found that the reliability of the system scored 3.75, which, while satisfactory, reflects a notable gap in meeting user expectations (Omosigho & Okoekhian, n.d.). Reliability is a critical determinant of customer satisfaction, as users depend on consistent and uninterrupted service when using toll roads. The relatively moderate score suggests that occasional technical issues or operational inefficiencies may be undermining user trust in the system's reliability. Similarly pointed out that system reliability is a significant factor influencing satisfaction in toll road operations, particularly in high-traffic areas where even minor disruptions can have a cascading effect on user experience (Pentyala, 2024).

Another key dimension of service quality examined in this study was the responsiveness of toll road officers, which received a score of 4.10 (Numbi, 2024). This indicates that users generally perceive the service provided by on-site personnel to be satisfactory, particularly in terms of their willingness to assist and resolve issues. However, maintaining high levels of responsiveness is essential to ensure that users feel supported during their interactions with the toll road system, especially in cases of technical difficulties with non-cash payments.

Travel time efficiency (EWT), a critical predictor of satisfaction, was also evaluated through two key indicators: transaction time and queue duration (Bassey et al., 2025). The study found that transaction time scored 4.20, reflecting user satisfaction with the speed at which transactions are completed. This aligns with the primary objective of implementing non-cash payment systems, which is to reduce delays and enhance the overall efficiency of travel. However, the queue duration received a slightly lower score of 3.80, suggesting that while non-cash payment systems have improved transaction times (Yamaguti Mondego, 2024), bottlenecks at toll plazas may still occur due to other factors, such as insufficient lanes or technical glitches.

The importance of travel time efficiency (EWT) in driving satisfaction cannot be overstated (Shelat et al., 2021). Time savings are a critical motivator for users in adopting digital payment technologies. In the context of toll roads, users expect seamless and efficient travel experiences, free from unnecessary delays caused by long queues or system failures (Barua & Kaiser, 2024). The findings of this study underscore the need for toll road operators to focus not only on optimizing transaction times but

also on addressing other factors that contribute to queue duration, such as lane capacity and the integration of advanced technologies like Multi-Lane Free Flow (MLFF) systems.

The moderating role of customer loyalty (ELoy) further enriches the understanding of satisfaction dynamics in this study (Lavuri & Akram, 2024). The interaction between loyalty and the predictors—non-cash payment systems (TS), service quality (KL), and travel time efficiency (EWT)—demonstrates the amplifying effect of loyalty on user satisfaction. For instance, the interaction between non-cash payment systems and loyalty ( $\beta=0.153$ ) suggests that loyal users are more likely to appreciate the benefits of digital payment methods, even when occasional issues arise. Similarly, the interactions between service quality and loyalty ( $\beta=0.141$ ) and between travel time efficiency and loyalty ( $\beta=0.129$ ) highlight the importance of fostering a strong sense of loyalty among users to enhance their overall satisfaction with the toll road system.

Loyal customers are generally more forgiving of minor service lapses and more likely to continue using a service despite occasional challenges. In the context of toll roads, loyalty can be cultivated through targeted initiatives such as loyalty programs, discounts for frequent users, and consistent communication about system improvements. By strengthening customer loyalty, toll road operators can create a more resilient user base that is less likely to be deterred by temporary setbacks (Diaz-Moriana et al., 2025).

Overall, the satisfaction insights and predictors examined in this study provide a comprehensive understanding of the factors influencing user satisfaction on toll roads (Luo et al., 2023). The high scores for transaction speed and ease of use highlight the success of non-cash payment systems in meeting user expectations, while the moderate scores for security, reliability, and queue duration point to areas requiring further attention. By addressing these gaps and leveraging the moderating role of loyalty, toll road operators can enhance the overall user experience and foster long-term satisfaction and loyalty among their customers. These findings contribute to the growing body of research on digital payment systems and service quality in transportation, providing valuable insights for policymakers and industry stakeholders seeking to modernize Indonesia's toll road sector (Hadiningrat et al., 2024).

### ***Efficiency and Loyalty as Critical Variables***

The study's focus on travel time efficiency (EWT) as a key determinant of customer satisfaction represents a novel and valuable contribution to the literature in the field of transportation technology and customer experience (Krishnan et al., 2024). Time savings as a critical component of user satisfaction, their work did not specifically evaluate this variable within the context of toll roads. This study addresses that research gap by demonstrating that EWT has the strongest impact on satisfaction ( $\beta = 0.366$ ), positioning it as a central element in toll road operations. This finding is particularly relevant in the context of heavily trafficked toll roads, such as those in Indonesia, where delays caused by queuing or inefficient payment systems can significantly affect user experience (Mutungwa, 2024).

Moreover, the study underscores the moderating role of customer loyalty (ELoy) in amplifying the effects of EWT, non-cash payment systems (TS), and service quality (KL) on customer satisfaction. The interaction effects, such as  $TS \times ELoy$  ( $\beta = 0.153$ ),  $KL \times ELoy$  ( $\beta = 0.141$ ), and  $EWT \times ELoy$  ( $\beta = 0.129$ ), indicate that loyalty not only enhances user satisfaction but also strengthens the relationship between these predictors and the overall customer experience. Loyalty as a critical factor in the adoption of new technologies and the retention of long-term users. Loyal customers tend to have a higher tolerance for minor service lapses and are more likely to perceive improvements in payment systems, service quality, and travel time efficiency as significant enhancements to their overall experience (Pandey, 2024).

The emphasis on EWT in this study is particularly noteworthy given the operational challenges faced by toll road operators in Indonesia (Novak, 2025). Users expect seamless travel experiences with minimal delays, and EWT directly addresses this expectation by evaluating how effectively toll systems reduce transaction times and queuing durations. The implementation of non-cash payment systems, such as e-toll

and GTO, has been instrumental in improving EWT by enabling faster transactions. However, technical issues, such as failed transactions or system malfunctions, may still hinder the achievement of optimal efficiency. These challenges highlight the need for continuous system enhancements, such as the adoption of Multi-Lane Free Flow (MLFF) technology (Kamiliah & Wijaya, 2024), which allows vehicles to pass through toll plazas without stopping, further reducing travel times.

The findings also suggest that while travel time efficiency has the most significant direct impact on satisfaction, its effects are further amplified when paired with high levels of customer loyalty (O'Connor & Assaker, 2024). This indicates the strategic importance of fostering loyalty among toll road users, as loyal customers are more likely to perceive time savings as a meaningful improvement. Programs aimed at increasing loyalty—such as offering rewards for frequent users or creating tiered benefits for consistent e-toll users—can thus play a vital role in enhancing the customer experience (Jumiati & Maulana, 2024).

Another key implication of this study is the interplay between service quality (KL) and loyalty. While service quality elements, such as system reliability and officer responsiveness, contribute positively to satisfaction, their impact is significantly enhanced when customers have a strong sense of loyalty to the service provider (Bungatang & Reynel, 2021). This finding underscores the importance of maintaining high standards of service quality while simultaneously implementing initiatives to build and sustain loyalty among users. Toll road operators can achieve this by ensuring that their systems are reliable, responsive, and capable of addressing user concerns promptly and effectively.

In conclusion, the study enriches the understanding of travel time efficiency (EWT) as a critical determinant of satisfaction and highlights the strategic importance of customer loyalty (ELoy) in moderating its effects (A. Rahman et al., 2023). By addressing both technical and operational challenges and fostering loyalty among users, toll road operators can significantly enhance the overall user experience. These findings provide valuable insights for policymakers and industry stakeholders aiming to modernize toll road systems and improve customer satisfaction in Indonesia and beyond (Napitupulu et al., 2024).

### ***Contribution to the 2024–2025 Research Landscape***

This study builds on and extends the findings of prior research by integrating travel time efficiency and customer loyalty into the Technology Acceptance Model (TAM) framework (Bano & Siddiqui, 2024). This study uniquely combines non-cash payments, service quality, and travel time efficiency in the context of toll road operations in Indonesia. The inclusion of customer loyalty as a moderating variable provides a more comprehensive understanding of how these factors interact to influence satisfaction.

### ***Practical Implications and Future Directions***

The findings highlight several actionable insights for toll road operators. First, improving the reliability and security of non-cash payment systems can enhance user trust and satisfaction (Gonzalez Zapata, 2025). Second, initiatives to reduce travel times, such as the implementation of Multi-Lane Free Flow (MLFF) technology, can address the critical need for efficiency. Third, fostering customer loyalty through targeted programs, such as discounts for frequent users, can amplify the positive effects of these improvements (Felix & Rembulan, 2023). These recommendations align with the broader goals of digital transformation in Indonesia's transportation sector.

In summary, this study not only reinforces but also advances the understanding of factors influencing customer satisfaction in toll road systems. By addressing gaps in prior research and providing practical recommendations, it contributes significantly to the ongoing efforts to modernize Indonesia's transportation infrastructure (Napitupulu et al., 2024).

### **Limitations of the Research**

This study, while contributing valuable insights into the implementation of non-cash

payment technologies and their effects on customer satisfaction and loyalty in Indonesia's toll road sector, has several limitations that should be acknowledged (Raissa, 2022).

First, the geographical scope of the research is limited to the Tangerang-Merak Toll Road, a significant route in Indonesia. While this toll road is heavily trafficked, it represents only a portion of the overall toll road network in the country. Therefore, the findings may not be generalizable to other regions or toll roads with differing characteristics, traffic volumes, or operational challenges (Shang et al., 2022).

Second, the sample size of 200 respondents, selected through purposive sampling, may limit the generalizability of the results. Although this sample size is adequate for statistical analysis, it may not comprehensively represent the diverse demographic and behavioral characteristics of all toll road users across Indonesia. The predominance of younger users, particularly those aged 20–30 years, reflects a specific segment of the population that may not fully represent the views and experiences of older or less tech-savvy users (Myhre, 2022).

Third, the research primarily focuses on non-cash payment systems as a key predictor of customer satisfaction, which, while relevant, may overlook other critical factors influencing user experience (Alrawad et al., 2023), such as road infrastructure quality, traffic management systems, and alternative toll payment methods. A broader examination of these factors could provide a more comprehensive understanding of the user experience in toll road settings.

Moreover, the study utilizes a cross-sectional design, capturing data at a single point in time. While this approach is effective for identifying trends and correlations, it does not allow for an assessment of changes over time or the long-term effects of non-cash payment adoption on customer satisfaction and loyalty. A longitudinal study would be more suitable for understanding the sustainability of these impacts (Olsson et al., 2022).

Additionally, while the research examines customer loyalty as a moderating variable, the complexities of loyalty dynamics are not fully explored (Rasool et al., 2021). External factors such as competitive pricing, government policies, and promotional strategies employed by toll operators could influence loyalty but were not accounted for in this study. Examining these aspects could deepen the insights into how loyalty interacts with other variables (Kim et al., 2021).

Another limitation concerns the reliance on self-reported data from respondents, which may be subject to biases such as social desirability bias or recall errors (Quinio & Lam, 2021). Objective data, including actual transaction times, failure rates, or usage statistics, could complement the findings and provide a more robust understanding of the issues at hand (Teng & Khong, 2021).

Furthermore, the study does not investigate psychological factors, such as trust, perceived fairness, or emotional attachment, that can significantly affect user behavior and satisfaction (Miao et al., 2022). Exploring these dimensions could enhance the understanding of customer satisfaction in the context of technology adoption.

Lastly, the research does not include a comparative analysis between non-cash payment systems and traditional cash-based systems or other emerging payment technologies (Goel, 2021). Such a comparison would shed light on the relative advantages and disadvantages of these systems in enhancing customer satisfaction and loyalty.

In conclusion, while this study offers important contributions to the understanding of non-cash payment technologies in the toll road sector, it is imperative to recognize these limitations (Hermawan & Aruan, 2023). Future research should aim to address these gaps by expanding the geographical scope, using larger and more diverse samples (Rega-Brodsky et al., 2022), adopting longitudinal designs, and incorporating a wider array of variables to provide a more holistic view of customer satisfaction and loyalty in toll road systems.

## 6. Conclusion

This study highlights that the implementation of cashless payment technologies such as e-toll and Garda Total Objek (GTO) on the Tangerang-Merak Toll Road has a significantly positive impact on travel time efficiency and customer satisfaction. However, technical challenges remain, particularly a transaction failure rate of 18% caused by disruptions in card reader devices and servers, which can diminish the user experience. Additionally, service quality and customer loyalty play crucial roles in determining the level of customer satisfaction and the sustainability of this digital payment system. The factors of time efficiency and customer loyalty are key to enhancing service quality and the sustainable adoption of technology. The study recommends further technological development, such as the implementation of Multi-Lane Free Flow (MLFF) technology, which enables transactions without stopping, thereby reducing congestion and waiting times.

## 7. Recommendations

The study recommends several key actions to improve the customer experience on the Tangerang-Merak Toll Road. First, it is essential to enhance and maintain the reliability of e-toll card reader devices and server systems to reduce transaction failures, including upgrading network infrastructure and conducting regular maintenance. Second, the implementation of Multi-Lane Free Flow (MLFF) technology is advised to allow transactions to occur without stopping, which will improve travel efficiency and reduce congestion at toll gates. Third, continuous training for field staff is necessary so they can promptly address technical issues and provide excellent service to toll users. Fourth, developing customer loyalty programs that offer incentives like discounts or reward points can increase user engagement and loyalty to the cashless payment system. Fifth, increasing public awareness and education about the use of cashless systems and new features is critical to minimizing misunderstandings and resistance to new technology. Finally, ongoing monitoring and evaluation should be conducted based on user feedback to identify and address issues in real-time, thereby enhancing overall user satisfaction.

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