

RFID in Payment Systems: The Implementation and Ramifications

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ABSTRACT

This research paper explores the implementation and impact of Radio Frequency Identification (RFID) technology in toll collection systems, emphasizing its role in enhancing payment efficiency and user experience. With the introduction of RFID lanes in toll plazas across Malaysia, the study examines the growth in RFID adoption, noting a significant increase in registered vehicles equipped with RFID tags from 1.55 million in 2021 to 2.36 million by the end of 2022. The paper reviews previous studies to establish a foundation for understanding consumer intentions and satisfaction with RFID payment systems, highlighting the importance of effective information policies to alleviate concerns and enhance acceptance. By analyzing the current landscape of contactless payment technologies, this study aims to provide insights for future research and policy development, ultimately contributing to the advancement of intelligent transportation systems.

INTRODUCTION

Radio Frequency Identification (RFID) is a wireless technology used for identifying and tracking items or components by transmitting data via low-energy radio waves. RFID systems operate through radio frequencies and consist of radiofrequency (RF) readers and corresponding tags (Loh, 2023). This innovative technology enables efficient tagging and monitoring of objects, though its full potential remains underutilized in many fields. The ramifications of the underutilization of RFID usage will include lost tracking, insufficient monitoring and much more (Loh, 2023). There are notable examples of RFID technology such as in manufacturing companies, agriculture, hospitality, parking management and transportation sectors (Davinder, 2012). For example, in transportation sectors, the Electronic Toll Collection (ETC), payment can be categorized into two types: manual and electronic. Manual payment involves users paying the toll fare with cash, whereas electronic payment involves the use of a contactless

smart card and other technology, i.e., Smart Tag system. To enhance electronic payment, toll concessionaires have implemented RFID technology (Loh, 2023). The increasing demand for efficient transportation systems has prompted significant advancements in toll collection methodologies, particularly with the advent of Open Road Tolling (ORT). ORT represents a transformative approach to toll collection that eliminates traditional barrier of toll booths, allowing vehicles to pass through tolling points at highway speeds without stopping. This innovative system utilizes ETC technologies, such as transponders and RFID, to automatically charge tolls, thereby reducing transaction-related delays and enhancing traffic flow (Yang, 2012).

Compared to traditional toll plaza designs, open road tolling (ORT) with electronic toll collection (ETC) can reduce the number of lanes and booths required to maintain traffic flow. With automated ETC, drivers can pass through tolls without delays for cash payments or token collection (Shahrier, 2024). Contactless tokens have been integrated into various cashless payment systems. In closed systems, a single organization manages the entire payment process. This means that customers use payment tokens provided by the same organization to pay for its services. These systems typically operate on a prepaid model, where customers purchase credit in advance, making such payments particularly suitable for public transport payments (Yang, 2017). In an Electronic Toll Collection system, the action of a vehicle passing through a toll booth can have various indirect effects. For example, when an RFID tag is read, it not only deducts the toll fare from the vehicle's account but may also trigger updates in traffic management systems, notify law enforcement if the vehicle is flagged, or adjust the toll rates based on real-time traffic conditions. Understanding these indirect effects is crucial for the system's overall functionality as it impacts on the ramifications of using RFID technology. Ramifications, in this context, is defined as complexities associated with managing indirect effects until a satisfactory resolution is attained (Thielscher, 1997). Thus, the study of the ramifications arising from the use of RFID is crucial and necessary to boost system efficiency which, in the long run, will create a productive socio-economic environment in a country.

LITERATURE REVIEW

Previous Studies in RFID

According to Khusiani (2023), the ultra-high frequency (UHF) RFID reader demonstrated a 100% success rate in reading tags at distances of 1 to 3 meters, but this rate decreased to 80% at distances of 5 and 6 meters due to radio frequency interference. This suggests that the reader is highly effective at close range, but its performance declines as the distance increases (Khusaini, 2023).

An outstanding advantage of RFID is that it allows for wireless automatic identification and data collection, making it possible to track and trace items throughout the entire supply chain. It works by using a device that sends out radio waves to automatically identify people or objects in the space between the reader and the tags. Many countries have extensively used RFID technology for tracking vehicles, electronic toll collection, and user identification. One of the advantages of RFID tags is that they work effectively from a distance and do not require direct contact with the device (Othman, 2023).

Ganesan (2022) cites transportation consultant Rosli (2022), as saying that the RFID is comparable to a product's barcode reader or a label that is read by a supermarket reader device. The system makes use of a sticker that is affixed to the vehicle's windscreen or headlights and contains a radio frequency chip. Every RFID sticker is distinct and can only be linked to a single car. An overhead scanner reads the RFID sticker's radio frequency as a car drives through the toll booth and the fare charge is deducted from the user's Touch 'n Go eWallet balance, which is connected to the chip.

Nevertheless, because cars still need to slow down to be scanned, Rosli claims that the RFID may not be suitable for Malaysian traffic with no noticeable advantage to using it over a SmartTag reader. The

public's main grievance with the system was traffic congestion caused by the toll booths' slow RFID sticker detection. Exposure to extreme weather could have a detrimental effect on the RFID chip (Ganesan, 2022).

Moreover, Electronic Toll Collection is a system designed to streamline toll payments, minimize delays, and enhance traffic flow by automating the payment process. The implementation of an Electronic Toll Collection system simplifies and accelerates the payment process, making it more user-friendly and efficient (Hidayat, 2021). With the installation of 302 RFID lanes in toll plazas, the toll collection method utilizing RFID technology was introduced in 31 open toll system highways and closed system highways for class 1 vehicles on January 1, 2020. In 2021, 1.55 million vehicles were registered and equipped with RFID tags; as of December 31, 2022, there were 2.36 million vehicles, a 52.25% increase. The average rate of use of RFID payment modes for class 1 vehicles in 2022 has also reached 18% of the total use of other payment modes, namely SmartTag and Touch 'n Go (Lembaga Lebuhraya Malaysia, 2022).

To better understand the nature and functions of RFID, it is necessary to peruse previous studies that tackled related research topics or theories (Mazumdar, 2022). The goal of previous studies is to lay the groundwork for future research (Pedada, 2023). Some previous research studies have been summarized in Table 1 below:

Table 1: Previous Studies of The Use of RFID in Highway Toll Concessioners

Fiedler & Öztüren. (2014)	To provide insights that can be utilized in the implementation and design phases of contactless payment systems, ensuring they meet customer needs and preferences.	Quantitative	The study emphasizes the importance of providing individuals with adequate information about contactless payment technologies. An effective information policy can help alleviate concerns and enhance acceptance.
Chieh-Yu, Lin. (2009)	To understand how the concept of innovation, particularly in the context of logistics technologies, affects the adoption of RFID.	Quantitative	The research indicates that when employees possess higher levels of expertise and the ability to innovate, there is a corresponding increase in the organization's willingness to adopt RFID technology.
Glavic, et al. (2017)	To provide a structured decision-making framework that can evaluate various tolling technologies based on multiple criteria, including ecological, social, and service levels.	Mixed Method	The selection of optimal toll collection technologies (TCT) significantly impacts ecological, social, and economic factors.
Kasim, et al. (2019)	To explore the implementation of ICT, specifically RFID for automatic materials tracking.	Qualitative	The study reveals that despite the usage of basic ICT tools, there is a significant lack of advanced technologies like RFID for automatic materials tracking.

Bijker, et al. (1987)	To explore how technological systems are socially constructed and how various social groups influence the creation, demand, production, diffusion, acceptance, or opposition to new technologies.	Qualitative	The study revealed that individual preferences and evaluations can significantly impact the success or failure of technologies, indicating that understanding consumer behavior is essential for comprehending technological trajectories.
Gu & Black (2020)	To explore the impact of Task-Technology Fit (TTF) and network effects on the adoption of RFID technology, providing insights into how these factors influence individual performance and decision-making within healthcare organizations.	Quantitative	The study found that the perceived network externality did not significantly moderate the relationship between TTF and RFID adoption, suggesting that while both factors are important, they do not enhance each other's effects in this context.
Shammar, & Zahary (2019)	To identify and address the challenges and open research issues that need to be overcome for the successful adoption and dissemination of IoT technologies.	Qualitative	The paper discusses a wide range of applications for IoT, emphasizing its potential to transform various sectors by enabling smart objects to communicate and collaborate effectively.

Use of RFID in Highway Toll Concessioners in Malaysia

In Malaysia, the Electronic Toll Collection (ETC) system for toll payment was first implemented in 1994, which has since undergone numerous changes. Touch 'n Go and Smart TAG make up the most recent ETC system, which is the nation's only ETC system (Kamarulazizi & Ismail, 2010). Prior to this drivers were required to pay cash to the operators at toll plazas in the past, and transactions were manually entered into the toll collection system. However, this payment method contributed to heavy traffic congestion as the drivers had to stop their cars, hand over cash to the operators, and wait for the transaction to be completed (Er et. al., 2023). Even with the implementation of the Touch 'n Go cash free system, the issue of congestion still occurs as drivers have to stop at the tolls to place the card at the readers before being able to proceed. This action of stopping at the tolls creates a major backlog of traffic especially during peak hours. To alleviate these issues, the RFID system was introduced.

However, it is important to conduct a detailed analysis of costs and benefits, business objectives, and tolling policies to ensure the system meets the goals of local highway and transportation authorities (Noor et. al., 2016). The traffic congestion on Malaysian highways, particularly in urban areas, is an increasingly severe issue. Despite efforts by the government and private authorities to address the problem, challenges persist due to the continuous rise in the number of registered motor vehicles each year. To address delays, toll operators have implemented two types of transactions in electronic toll collection (ETC): the contactless smart card system (Touch 'n Go lane) and the non-stop barrier lane system (SmartTAG lane). These systems aim to reduce queue times, enhance toll fee collection efficiency, and alleviate traffic congestion at toll

plazas during both peak and off-peak hours. Both methods operate on the same fundamental principle, relying on smartcard technology for functionality (Ibrahim, 2007).

The Touch 'n Go company introduced RFID and stopped selling SmartTag devices in 2018. Before being deployed on all Malaysian highways, the RFID system underwent testing and improvement during the pilot phase to make sure it functioned effectively and efficiently. Furthermore, the RFID sticker is less expensive than the SmartTag device, which costs RM35 and can only be connected to a single car (Er et. al., 2023). In 2017, the RFID toll payment system by Touch 'n Go and PLUS (the acronym for Projek Lebuhraya Utara Selatan in Bahasa Malaysia) was initially announced with the goal of reducing traffic congestion, according to Minister of Works Fadillah Yusof. To test the new system, only 17 RFID toll lanes were initially opened on major thoroughfares such as the Guthrie Corridor Expressway (GCE) and the New Pantai Expressway (NPE). However, several concerns regarding the RFID have emerged due to the recent chaos at the toll plazas along the North-South Expressway (NSE) (Ganesan, 2022). In addition, according to a study by Othman (2023), the service providers need to improve the features of the RFID system to better align with consumer needs, which would enhance user performance and boost adoption rates.

On the flip side, the overall impact of the new system led to reduced truck waiting times and queues at the receiving area, thereby enhancing the productivity of the container terminal operations. This improvement also contributed to increased customer satisfaction (Kadir et al., 2016). Within the scope of RFID by highway toll concessionaires in Malaysia, grasping the wider implications and theoretical foundations that support this technology is crucial. The deployment of RFID systems represents a major improvement in toll collection, seeking to reduce traffic congestion and improve efficiency at toll booths.

LIMITATIONS AND RECOMMENDATIONS

RFID systems boast exceptional accuracy, often achieving rates exceeding 99%, which enhance reliability and user trust (Hung, 2018). Many countries, including the United States, Japan, and China, have adopted and continually enhanced ETC, leading to substantial cost savings and greater operational efficiency. Several categories of technologies are commonly used worldwide, such as Dedicated Short-Range Communications (DSRC), Automatic Number Plate Recognition (ANPR), and the Global Navigation Satellite System (GNSS) (Shahrier, 2024). The research is geographically focused on Malaysia, potentially limiting the generalizability of the findings to other regions with different technological infrastructures and user behaviors. To address these limitations, future research should incorporate primary data collection methods, such as surveys or interviews, to gain deeper insights into consumer attitudes and experiences. Furthermore, expanding the scope of the study to include comparative analyses with other countries implementing RFID technology could provide a more comprehensive understanding of its effectiveness and user acceptance across diverse contexts.

CONCLUSION

The research into the ramifications arising from the use of RFID technology can be framed within the context of established theories such as the Diffusion of Innovation Theory and the Theory of Planned Behavior (TPB). The Diffusion of Innovation Theory provides a framework for understanding how innovations, like RFID technology, are used and spread within a social system. It explores factors such as relative advantage, compatibility, complexity, trialability, and observability that influence the usage of RFID. On the other hand, the TPB offers insights into individual behavior change by examining the interplay between attitudes, subjective norms, and perceived behavioral control. By applying these theories, the research can delve into how individuals perceive RFID technology, the factors that influence their usage decisions, and the potential consequences of its widespread use.

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