

## Research

# Ownership of contactless data in urban transportation systems

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Received: 14 July 2024 / Accepted: 19 November 2024

Published online: 02 December 2024

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## Abstract

This paper examines the landscape of contactless transport payment systems in developing countries, focusing on data ownership, regulatory challenges, advantages, disadvantages, and implications. It explores the roles of city authorities, contractors, and consumers in managing and utilising data generated through these systems, emphasising the need for robust cybersecurity measures and comprehensive regulatory frameworks. Despite offering enhanced convenience and operational efficiencies, these systems present challenges such as cybersecurity risks, adoption barriers, and ethical concerns over data commercialisation. Plans include integrating these systems with international travel apps, developing user-friendly applications, and enhancing security protocols. The paper highlights the theoretical contributions and opportunities for future research, urging further exploration into regulatory effectiveness, consumer behaviour, technological advancements, ethical dilemmas, regional comparisons, and long-term impacts on urban mobility.

**Keywords** Contactless transport payment systems · Data ownership · Regulatory frameworks · Cybersecurity · Developing countries

## 1 Introduction

There is a growing interest in contactless payment for transportation, particularly in developing countries and emerging economies [1, 2]. The pandemic has further accelerated this trend, prompting transport operators and policymakers to explore advanced transport technology for service delivery [3]. Contactless payment systems enable consumers to use public transport without needing cash, offering a convenient and time-saving payment method [4]. For transportation service providers, it avoids revenue leakages and makes services attractive. Additionally, the data collected from contactless payments aids governments and transportation agencies in planning and decision-making and fosters financial inclusion [5].

In Rwanda, the Tap&Go card allows cashless travel around Kigali, with easy top-ups via the Tap&Go app or agents. In the urban landscape of Lagos, Nigeria, the Cowry Card (1) is used on the Bus rapid transit (BRT)—one of Nigeria's most populated transportation systems. Similarly, in Cape Town, South Africa, the MyCiTi card-based payment system eliminates the need for daily cash, reduces time spent queuing at ticket kiosks, and enables better budgeting by allowing users to load enough money for a week, month, or longer. This widespread adoption of travel cards presents an unparalleled opportunity to gather vast amounts of data on commuter behaviour [6].

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With the possibility of collecting large datasets from commuters using these technologies [7–10], it is imperative to critically examine data ownership and emphasise the need for reflection on the availability, access, quality, and quantity of this data. The focus on transportation is significant because it affects millions of people daily, and the data collected can provide valuable insights into commuter behaviour, traffic patterns, and system efficiency [2, 11, 12].

Contactless payment systems generate massive amounts of information, and it is crucial to determine who owns this data and how it is accessed [10, 13, 14]. This significantly impacts privacy and security, as well as the transparency and accountability of the entities that manage the data [15, 16]. Ensuring that the data are of high quality and readily available for analysis is essential for making informed decisions that can improve transportation systems. High-quality data can lead to better planning, optimised routes, and more efficient allocation of resources, ultimately enhancing the overall user experience and operational effectiveness.

Given this data's transformative potential, this article explores a critical question: who owns the data generated by contactless payment systems? To address this, we begin with a conceptual perspective, initially exploring the issue. Addressing these concerns is vital to maximising the benefits of contactless payment systems and driving innovation in public transportation. Specifically, this conceptual paper aims to achieve the following objectives: first, it addresses the intricate issue of data ownership within transport systems. Second, it explores the benefits and challenges surrounding data management, particularly in ownership and sharing, focusing on elucidating potential solutions and best practices. Third, it highlights the significance of recognising the wealth of data companies and transport operators hold. It emphasises the untapped potential for leveraging this data to drive informed decision-making and enhance commuter experiences [6].

It is imperative to recognise the boundaries of this article. First, this article focuses explicitly on contactless payment systems used for transportation. While other forms of contactless payments exist, such as bank cards, government-issued cards, and smartphones that use radio-frequency identification (RFID) and Near Field Communication (NFC) for secure transactions, our primary concern is contactless cards issued solely for transport services. Secondly, the article examines the implementation and adoption of transport contactless payment systems in developing countries, contrasting this with the earlier and more established adoption in developed countries. For instance, the Oyster card was introduced in London in 2003, while.

The Tap&Go card was launched in 2015 in Kigali, Rwanda, as part of the city's move towards a cashless transport payment system and the Cowry card only began usage in Lagos in 2020. This disparity highlights the advanced infrastructure, policies, and support systems developed countries have established, which are still emerging in many developing nations [17, 18]. Third, we recognise that this article is a conceptual paper exploring the concept of data ownership, so we have purposefully excluded detailed literature review and methodology sections, similar to other conceptual papers [10, 19, 20]. Instead, we include sections on practical applications and a research agenda to provide meaningful theoretical and managerial insights. Our aim is to initiate discussions on contactless data ownership, offering a foundation for future empirical research while setting realistic expectations for the contribution of this work.

With this background, this study aims to propel discourse on the ethical collection and sharing of data, transcending beyond mere analysis to explore the broader implications for advertising, travel management, and research. By exploring these ethical considerations, this paper seeks to foster a more responsible and transparent approach to data governance in the transportation sector. Lastly, learning best practices from other established travel cards worldwide, the paper explores the potential role of public–private partnerships in leveraging transport contactless data to benefit commuters and stakeholders, highlighting opportunities for collaboration and innovation in enhancing urban mobility solutions. By examining these successful case studies and identifying key success factors, this objective aims to provide actionable insights for fostering effective partnerships that drive positive outcomes for all involved parties. Ultimately, this endeavour will offer tangible implications for tech developers, transport operators, and policymakers, catalysing transformative change in urban mobility and beyond.

## 2 Concerns regarding commuters' contactless data

### 2.1 Who owns the data?

These transport contactless payment apps meticulously log transactional data with each use of public transportation, capturing essential parameters such as trip duration, mode of transport, frequency of travel, and origin. Concerns about ownership and responsible use of consumer data are widespread beyond the transportation industry. Interestingly, Hicks [21] set a research agenda on data ownership, given its growing prominence. In developing countries like Ghana and

Vietnam, users of digital payment services have emphasised their demand for clarity on the usage of their private data [22, 23]. Similar concerns appeared in developed countries of Europe and the US [24]. This emerging trend makes it prudent for developing countries to resolve issues about the ownership and management of commuters' data and inform the public accordingly [6]. Given the vast volume of data collected, three key stakeholders may lay claim to its ownership.

### 2.1.1 The city

City authorities like the Dar Rapid Transit Agency (DART) in Tanzania, the Lagos Metropolitan Area Transport Authority (LAMATA) in Nigeria, and the Rwanda Utilities Regulatory Authority (RURA) in Rwanda play a crucial role in the operation and regulation of urban transport systems. DART, an executive agency, oversees the establishment and management of the bus rapid transit (BRT) system in Dar es Salaam. LAMATA manages transport services in Lagos, while RURA regulates public transportation in Kigali. These organizations are responsible for overseeing the public transport network and ensuring efficient coordination among various service providers. As part of their efforts to modernise and improve efficiency, these authorities often collaborate with technology developers to drive digital transformation initiatives. For instance, they may implement advanced contactless payment systems to streamline operations, reduce cash handling, and enhance service delivery. By overseeing the transportation infrastructure and implementing these technologies, city authorities accumulate significant data. These data are invaluable for urban planning, optimising routes, managing traffic flow, and making policy decisions to improve public transport systems. Therefore, city authorities have a substantial stake in claiming ownership of this data to fulfil their regulatory and operational responsibilities effectively.

### 2.1.2 The contractor

The contractors who develop the technology for these cities also have a legitimate claim to the data. These contractors are typically specialised fintech companies or technology firms responsible for creating and maintaining contactless payment systems. For example, TAP, a fintech company, developed the Cowry Card for Lagos, while Cubic Transportation Systems manages the Oyster card in London. Similarly, T-Money in South Korea is operated by T-Money, which the Seoul Special City Government jointly owns. These contractors provide the technical backend support necessary for the seamless functioning of these payment systems. They collect and analyse data to ensure system reliability, troubleshoot issues, and continuously improve the technology. Consequently, they require access to the data generated by these systems to fulfil their contractual obligations, innovate, and enhance the user experience. The proprietary nature of their technology and services justifies their stake in the data ownership debate.

### 2.1.3 The consumer

The consumers who use these contactless payment cards are integral stakeholders in the data ownership conversation. These consumers rely on the cards for their daily commute, often because it is the only accepted mode of payment for public transport. Consumers provide personal details and consent to collect their transaction and journey histories as part of the registration process. This data includes sensitive information about their travel patterns, preferences, and behaviour. Given that the data are derived directly from their usage of the contactless payment systems, consumers have a valid claim to its ownership. They are interested in how their data are used, stored, and shared, particularly concerning privacy and security [15]. Ensuring that consumers have control over their data and are informed about its usage is crucial for maintaining trust and transparency in the public transportation ecosystem.

The debate over data ownership among city authorities, contractors, and consumers highlights the necessity for a balanced and ethical approach to data governance. City authorities utilise data to manage and optimise transportation systems, while contractors require access to enhance their technologies. Consumers, on the other hand, seek control and transparency over their personal information. Table 1 below explores the roles and claims of data ownership for city authorities, contractors responsible for technology development, and consumers within transport contactless payment systems. Each stakeholder's contributions and responsibilities regarding data collection, collaboration, privacy concerns, and ownership are analysed.

Determining data ownership from transport contactless payment systems involves legal, ethical, and practical dimensions. Past studies have classified data ownership and governance into centralized and decentralized approaches [25–27]. Thus, transport data is either owned by the city authorities/government or contractors under the supervision of the city authority. City authorities, under the centralized approach, assert ownership due to their regulatory oversight and

operational management of public transportation, using data for urban planning and policy decisions [26]. Contractors developing and maintaining payment technology may claim ownership because they invest in infrastructure and adhere to intellectual property rights [25]. Consumers contributing personal data through transactions prioritise privacy and transparency under data protection laws, though they do not claim legal ownership [22, 23]. Accordingly, effective data ownership entails shared responsibilities and agreements among stakeholders, with city authorities setting guidelines, contractors ensuring technical compliance, and consumers consenting to data use, ensuring alignment with privacy standards and equitable management of data rights [27].

## 2.2 Access to the contested data

Access to data collected from contactless cards raises significant questions about its availability and potential uses by various stakeholders. Admittedly, making commuters' data open to the public adds transparency and ease for all stakeholders. City authorities may utilise this data to plan and optimise transportation services, ensuring efficient urban mobility. However, this comes at the expense of consumer rights protection [28, 29]. Concerns arise regarding whether law enforcement agencies could request access to this data for investigative purposes, highlighting the balance between public safety and individual privacy rights. Moreover, the possibility of commercial use of this data, such as for targeted advertising or market research by contractors, underscores the economic value and ethical implications of data access and sharing.

Beyond transactional data, the contactless card system may gather additional personal information from commuters, including identifiers like names, contact details, and demographic data. This expanded dataset could provide insights into commuter demographics and travel patterns, potentially valuable for urban planning and service improvements. As these contractors and tech companies evolve into a comprehensive fintech platform, extending beyond transportation to retail transactions, the system might accumulate more extensive transactional data reflecting consumer spending behaviours and preferences. Researchers who analysed consumer privacy in the UK and the US proposed protecting sensitive information and removing constraints on the rest [30].

Examining how these data are aggregated, accessed, and utilised is crucial for safeguarding consumer privacy and upholding data protection standards. Consumers should have the right to access and control their personal information, ensuring transparency in data handling practices. Discussions around open data initiatives, where anonymised and aggregated data could be shared for research or public benefit, further complicate the issue, raising questions about balancing data utility with privacy rights and regulatory compliance. Addressing these complexities requires robust policies and ethical frameworks to govern data access, sharing, and use in transport systems.

Table 2 overviews data access management and governance among stakeholders in transport contactless payment systems. It explores how each stakeholder interacts with and accesses data, including its usage for planning and operations, responses to law enforcement requests, potential commercial applications like advertising, data storage duration, and consumer rights regarding access and control of personal information. This table illuminates the intricate dynamics of data utilisation, privacy preservation, and adherence to regulatory standards within contemporary urban mobility contexts.

## 2.3 Regulatory concerns and consumer rights

Consumer rights protection is essential in modern intelligent transportation services. At the heart of discussions surrounding data ownership, there is a critical call for robust regulatory frameworks and the protection of consumer rights, particularly in many developing countries where digital technologies and digital transformation are rapidly evolving. These regions often lack clear regulatory expectations and may have less stringent data privacy laws compared to more developed nations. Consequently, a significant gap exists in consumer awareness regarding their rights to data privacy and the standards they should expect regarding using and protecting their personal information [15].

The swift adoption of digital technologies, including transport contactless payment systems, in many developing countries has outpaced the establishment of adequate legal safeguards. This situation challenges ensuring responsible and ethical handling of data collected through these systems. Consumers often provide personal data unknowingly, without a comprehensive understanding of how it will be utilised or the extent of their control over its dissemination. Therefore, there is an urgent need for governments and regulatory bodies in these regions to enact and enforce comprehensive data protection laws that align with international standards [24]. Such legislation would safeguard consumer privacy, cultivate trust in digital services, and support sustainable digital development across diverse sectors.

**Table 1** Comparison of stakeholder roles and data ownership in transport contactless payment systems

Feature	Stakeholder		
	City authorities	Contractors	Consumers
Role	Operate and regulate transport services	Develop and maintain technology for payment systems	Use contactless payment systems, provide personal data
Data ownership claim	Claim ownership due to regulatory oversight and infrastructure	Claim ownership due to development and maintenance responsibilities	Claim ownership due to personal data contribution and usage rights
Data collection	Collect data for urban planning and policy decisions	Collect and analyse data for system efficiency and innovation	Data generated through the usage of contactless payment systems
Collaboration	Collaborate with developers for digital transformation initiatives	Collaborate with city authorities for system implementation	N/A (consumers contribute data passively)
Privacy concerns	Ensure data are used ethically and protect consumer privacy	Ensure secure data handling and comply with privacy regulations	Ensure transparency in data usage and protection of personal information

**Table 2** Data access and governance framework in transport contactless payment systems

Access to data	Stakeholder		
	City authorities	Contractors	Consumers
Usage for planning and operations	Access data for urban planning and optimising transport services	Utilise data for system maintenance and efficiency improvements	Provide data through usage and expect improved services in return
Law enforcement requests	Access data for investigative purposes, ensuring public safety	May store data for law enforcement requests and comply with regulations	Data protection ensures privacy and access to information as per regulations
Commercial use (e.g., advertising)	Potential use for city initiatives and public projects	Potential for targeted advertising and market research opportunities	May consent to data use for personalised services and privacy protection
Duration of data storage	Determine storage period based on operational needs and legal guidelines	Store data for operational and regulatory compliance	Be aware of data retention policies and the right to request data deletion
Access and control rights	Governed by data protection laws, it ensures consumer privacy	Adhere to privacy regulations and ensure transparency in data handling	Expect rights to access and control personal data and consent to data sharing

A critical aspect requiring immediate attention is the establishment of clear legal guidelines concerning collecting and retaining consumer data by contractors acting on behalf of cities. Regulatory frameworks must be established to protect consumer rights and ensure adherence to ethical data collection, storage, and usage standards. Consumers should have the autonomy to consent to the collection and processing of their data and should be fully informed about how their information is utilised to make informed decisions.

While these concerns are particularly pertinent to the context of contactless cards in developing countries, they raise broader ethical considerations that transcend national boundaries. Technology developers worldwide must reflect on their ethical responsibilities and positioning in handling user data. Prioritising consumer privacy and adhering to ethical guidelines for data management are crucial steps toward fostering trust and accountability in the deployment of technological solutions. Ethical matters should be situated within local contexts such as values, culture, religion, and politics [31, 32].

By proactively addressing these regulatory and ethical challenges, stakeholders can mitigate risks associated with data misuse, promote transparency in digital interactions, and ultimately empower consumers to participate confidently in the digital economy. This approach not only safeguards individual privacy but also contributes to the responsible development and deployment of technology for the benefit of society [33–35].

Figure 1 highlights the intricate relationships and shared responsibilities among cities, contractors, and consumers in managing contactless transport data. The success of contactless transport systems hinges on technological advancements and robust regulatory frameworks that ensure data is managed ethically and securely. The regulatory framework for managing contactless transport data includes several key components: comprehensive data privacy laws that align with international standards, ensuring the protection of consumer data; mandates for consumer consent and control over personal information, allowing access, correction, and deletion of data; robust cybersecurity measures and breach notification protocols to protect against cyber threats and promptly inform consumers in case of data breaches; requirements for transparency in data practices and accountability mechanisms to ensure compliance and address violations; and guidelines for cross-border data transfers, ensuring data protection and compliance with local laws when data moves across national borders.

### 3 Benefits

Comprehensive data insights enable stakeholders, including transport operators and urban planners, to understand commuter behaviour more deeply [6]. This knowledge is a foundation for evidence-based transportation policy decisions and urban planning initiatives. Academic researchers also benefit from these insights, as they can leverage the data to enhance their understanding of consumer behaviour, contributing to advancements in transportation and urban studies.

With valuable data analysis insights, transportation authorities can optimise service offerings to meet commuters' evolving needs [6]. This optimisation includes reducing congestion, improving route planning, and enhancing the commuter experience. By implementing data-driven approaches, transport operators can streamline operations and deliver more efficient and reliable services, benefiting commuters and enhancing overall satisfaction [33–35].

A comprehensive understanding of travel behaviour dynamics empowers cities to promote sustainable modes of transportation and reduce reliance on traditional, environmentally harmful alternatives. By encouraging public transit, cycling, and walking, cities can mitigate traffic congestion, lower carbon emissions, and create more liveable urban environments [36]. Access to data insights facilitates the development of inclusive mobility solutions that prioritise accessibility and equity, ensuring that transportation systems meet the diverse needs of all residents.

Open access to data and APIs enables collaboration and innovation among various stakeholders, fostering economic growth and technological advancements. By providing access to data sets, cities can stimulate the development of innovative transportation solutions, such as mobility-as-a-service platforms, smart infrastructure, and predictive analytics tools. This collaboration fuels entrepreneurship and creates opportunities for startups and technology firms to contribute to the transportation ecosystem, ultimately driving economic prosperity and job creation.

Making data openly accessible promotes transparency in governance and accountability among stakeholders. By allowing public access to transportation data, cities are committed to openness and transparency in decision-making processes. This transparency fosters trust among residents and stakeholders, encouraging civic engagement and facilitating informed discussions about transportation policies and investments. Additionally, open access to data enables stakeholders to monitor and evaluate the performance of transportation systems, ensuring accountability and driving continuous improvement in service delivery.



**Fig. 1** Key regulatory concerns for data ownership and consumer rights in developing countries



## 4 Challenges

The widespread adoption of contactless transport cards brings a new era of convenience and efficiency in urban mobility. However, along with these benefits, notable disadvantages merit careful consideration. This section examines some of these drawbacks, emphasising the importance of implementing robust cybersecurity measures, overcoming adoption challenges, and prioritising consumer privacy. These steps are crucial for cities and stakeholders as they navigate the complexities of maximising the potential of contactless transport technologies.

The introduction of contactless transport cards in developing countries poses significant cybersecurity risks due to the rapid adoption of new technologies without well-established security measures [37]. Many regions need more experience managing complex transport systems and safeguarding sensitive data. The infrastructure supporting these contactless payment systems, including data centres and communication networks, may need robust cybersecurity protocols. This vulnerability increases the risk of data breaches, compromising personal information such as transaction histories and user identities. As cities rush to modernise their transport systems, the challenge lies in balancing the need for technological advancement with robust cybersecurity measures that protect consumer privacy and financial security.

Despite the potential convenience, adopting contactless transport cards faces multifaceted challenges in developing countries. Mogaji and Nguyen [1] identified the following challenges in Nigeria. There is a sizeable technological literacy disparity among the population, with segments potentially needing to be more familiar with digital payment methods. Access to compatible devices and reliable internet connectivity is also a concern, particularly in rural and underserved urban areas. Moreover, consumer trust in the security and privacy of contactless payment systems is crucial for widespread adoption [15]. Concerns over data privacy, particularly in regions with limited regulatory oversight,



further complicate adoption efforts. Addressing these challenges requires targeted educational campaigns, infrastructure investments, and policy frameworks that build consumer confidence and ensure equitable access to digital transport solutions [38].

The political drive to implement contactless transport systems in developing countries often prioritises rapid deployment to modernise urban infrastructure and enhance economic efficiency [39]. However, this urgency can sometimes overlook comprehensive risk assessments and considerations for consumer protection. Economic incentives, such as potential revenue from data monetisation through targeted advertising and market research, may incentivise stakeholders to expedite adoption without adequate safeguards for individual rights and data ownership. Balancing these pressures requires robust regulatory frameworks prioritising consumer privacy rights and ethical guidelines for data usage. Governments must collaborate with industry stakeholders to ensure that economic incentives do not compromise consumer trust or data security.

Implementing contactless transport systems necessitates substantial investments in infrastructure, including secure data centres and advanced communication networks. Due to financial constraints and logistical complexities, developing countries need help establishing and maintaining these facilities [37]. The location and security of data centres become critical considerations, impacting urban planning and real estate values. Zoning regulations and environmental considerations further complicate infrastructure development. Addressing these demands requires strategic planning, public–private partnerships, and regulatory support to ensure that infrastructure investments support sustainable urban development while safeguarding data security and consumer privacy.

Commercialising consumer data collected through contactless transport cards presents ethical challenges in developing countries. Data generated from travel patterns, transaction histories, and consumer behaviour are increasingly monetised by third parties, including advertisers and market researchers. This practice raises concerns about consumer consent, transparency in data usage, and the ethical boundaries of data commodification for profit. Ensuring ethical data practices becomes paramount in regions with nascent regulatory frameworks and limited consumer protection laws. Governments and regulatory bodies must enact stringent data protection laws that align with international standards and establish monitoring and enforcing compliance mechanisms. Empowering consumers with rights to control and access their data is essential for fostering trust in digital transport solutions and mitigating risks associated with data commercialisation.

Navigating these disadvantages requires a comprehensive approach integrating cybersecurity measures, enhancing regulatory frameworks, promoting technological literacy, and ensuring equitable access to digital transport solutions. By addressing these challenges proactively, developing countries can harness the transformative potential of contactless transport technologies while safeguarding consumer privacy and fostering sustainable urban development.

## 5 Future plans and considerations

Moving forward, stakeholders engaged in contactless transport card systems are poised to explore various initiatives to enhance functionality and address consumer concerns. This section highlights Future Plans and Considerations, drawing insights from best practices worldwide and reflecting the growing trends in digital technologies.

One of the primary goals for the future is to integrate contactless transport cards with other services, particularly international travel apps. This integration seeks to create a seamless travel experience for global travellers by eliminating the need for cash transactions and simplifying payment processes across different modes of transport. By enhancing connectivity between transport systems and international travel networks, cities can attract more tourists and business travellers while reducing operational costs and improving overall efficiency. This initiative promotes convenience and supports economic growth by facilitating smoother travel experiences and fostering international partnerships.

Developing user-friendly mobile applications tailored for international travellers and local commuters is critical [6]. These apps will provide essential features like real-time travel history monitoring, fare management, and route planning. These applications enhance trust and accountability in data usage practices by empowering consumers with greater transparency and control over their travel data. Moreover, robust security features embedded within these apps, such as biometric authentication and encryption protocols, ensure that consumer information remains protected against unauthorised access and cyber threats. By prioritising user convenience and data security, stakeholders can promote the widespread adoption of contactless transport cards and foster positive user experiences across diverse demographics.

Ensuring robust security measures is paramount to maintaining consumer trust in contactless transport card systems. Stakeholders increasingly invest in advanced encryption technologies, cybersecurity protocols, and proactive monitoring strategies to safeguard sensitive data from potential breaches and malicious activities. By adopting a proactive approach to cybersecurity, cities and transport operators can mitigate risks associated with data vulnerabilities and uphold the integrity of their digital infrastructure. Ongoing education and awareness campaigns about data privacy and security best practices empower consumers to make informed decisions and protect their personal information while using contactless transport services.

Contactless transport cards play a pivotal role in enhancing the tourism sector by facilitating seamless travel experiences for visitors. By offering convenient payment options and integrated transport services, cities can attract more tourists and improve the overall visitor experience. This convenience, in turn, contributes to economic growth by stimulating spending in local businesses, promoting cultural exchange, and bolstering the reputation of cities as tourist-friendly destinations. By leveraging contactless transport technologies to enhance urban mobility and tourism infrastructure, stakeholders can capitalise on opportunities for sustainable development and economic prosperity.

In summary, the future of contactless transport card systems hinges on continuous innovation, strategic partnerships, and a steadfast commitment to enhancing user experiences while prioritising data security and consumer privacy. By implementing these forward-looking initiatives, stakeholders can pave the way for transformative advancements in urban mobility, tourism facilitation, and economic development, ensuring cities remain competitive in the global landscape of smart and sustainable transportation solutions.

## 6 Implications

Companies operating public transportation systems, such as bus and ferry services, can utilise the data to optimise routes, schedules, and service offerings. This optimisation will improve efficiency, reduce operational costs, and enhance service quality. Potentially, algorithms can be used to get pertinent insights from these data. Clustering algorithms [40] can be instrumental in identifying distinct groups of commuters based on their travel patterns. For example, these algorithms may reveal segments such as daily commuters, occasional users, or tourists to help transportation authorities tailor services and infrastructure for improved user experience and satisfaction. With access to vast amounts of historical travel data, classification algorithms can also accurately predict future travel behaviour [8, 10, 41]; These algorithms can generate personalised commuter recommendations, such as suggested routes or travel times [32, 34, 42].

Additionally, transportation planners can use these predictions to optimise service schedules and allocate resources more efficiently, ultimately enhancing the reliability and convenience of public transportation systems [12, 14, 37, 43]. Further, anomaly detection algorithms [42] can play a crucial role in identifying irregularities or unusual travel patterns, such as overcrowding at specific stations or unexpected changes in travel demand. By detecting these anomalies, transportation authorities can promptly implement proactive measures to improve service reliability and safety. Also, association rule mining techniques [44] can uncover hidden relationships between travel variables. For instance, these algorithms may reveal correlations between travel mode preferences and demographic factors such as age or income level. This algorithm will enable transportation planners to gain valuable insights into the factors influencing commuter decisions and behaviours, allowing for more targeted interventions and policy initiatives. Lastly, time series algorithms can be used to predict public transport travel time and travel demand for public transport services. For example, using time series forecasting methods, Faruk et al. [45] used Istanbul's public transport data to predict bus travel times between two stops. This insight can help transport operators plan their facilities for optimum usage while helping commuters make informed decisions about their journey time.

City planners and policymakers can leverage the data to make informed decisions about urban infrastructure development, traffic management, and public transit investments. By understanding commuter behaviour patterns, planners can design more sustainable and liveable cities that prioritise accessibility, equity, and environmental sustainability. Government entities responsible for transportation regulation and oversight can use the data to monitor the performance of public transportation systems, enforce regulatory compliance, and allocate resources effectively. Access to comprehensive transportation data enables governments to address issues such as traffic congestion, air pollution, and urban mobility challenges. Clarifying who owns the data generated by these systems is crucial. Regulatory frameworks must establish clear guidelines on data ownership rights, ensuring that consumers have control over how their personal information is used and shared. Making data accessible to various stakeholders while safeguarding consumer privacy

requires balancing transparency and data protection measures [15]. Open access to anonymised data for research and public planning can contribute to urban development and transportation efficiency.

Scholars and researchers in transportation engineering, urban studies, and data science can benefit from access to transportation data for academic research and analysis [46]. The data provides valuable insights into travel behaviour dynamics, consumer preferences, and urban mobility trends, enabling researchers to advance knowledge and contribute to the development of innovative solutions for urban transportation challenges [9, 11].

Developers of transportation-related technologies, such as mobility-as-a-service platforms, route optimisation software, and intelligent transportation systems, can leverage the data to design and implement innovative solutions that improve the efficiency, safety, and sustainability of urban transportation networks. Access to transportation data facilitates innovation and fosters collaboration among technology developers, startups, and industry stakeholders. Assessing the quality and utility of the data collected from contactless transport cards is essential. Data must be accurate, reliable, and relevant to inform policy decisions, improve service delivery, and enhance overall consumer transportation experiences.

Citizens and communities benefit from improved transportation services, reduced traffic congestion, and enhanced mobility options resulting from data-driven decision-making [33–35]. Reliable and efficient public transit services improve access to jobs, education, healthcare, and other essential services, contributing to overall quality of life and community well-being. Consumers should be informed and empowered to exercise their data privacy and control rights, fostering trust in the system and encouraging the adoption of contactless payment technologies.

## 7 Theoretical contributions

While acknowledging that this article is conceptual, its theoretical contributions are significant in several key areas that advance understanding and discourse surrounding contactless transport payment systems and data ownership.

The article introduces a conceptual framework for understanding data ownership within contactless transport payment systems. It investigates how city authorities, contractors, and consumers assert ownership based on their respective roles and contributions to data generation. The discussion extends to the ethical implications of data collection, especially in developing countries with limited regulatory frameworks [7, 47, 48]. By addressing consumer rights, privacy concerns, and potential data exploitation for commercial purposes, the article adds to the ethical discourse in data governance [1, 49, 50].

The framework, depicted in Fig. 2, illustrates the complex interactions within a modern contactless payment ecosystem. Data flow starts with the user's device, such as a contactless card or smartphone, which holds essential information like payment credentials or identification details. When a passenger taps their device at a terminal, the data is transmitted to the payment validator, initiating the transaction [1, 2]. This process needs to be rapid and efficient to ensure a smooth travel experience, particularly in high-volume transport systems like metro or bus networks.

Upon reaching the validator, data is securely transmitted to a payment gateway, which acts as the intermediary between the transport system and financial institutions. The gateway authorizes the transaction by verifying the passenger's payment credentials and confirming sufficient funds. Depending on the system's design, it may also relay travel-related data, such as the user's route and fare calculation, to the transport system's central database. Encryption protocols and tokenization typically protect this data to prevent fraud and unauthorized access.

Finally, the data is sent to financial institutions for transaction settlement and charge processing. The transport system's database also stores relevant information, such as transaction histories, route data, and passenger usage patterns, which can be used for analytics and service improvement. The figure highlights these key interactions, the types of exchanged data—including personal identifiers, financial data, and operational transport data—and underscores the importance of data security in this critical environment.

The article contributes to theoretical discussions on data governance in contactless transport payment systems by linking relevant legislative frameworks such as South Africa's Protection of Personal Information Act (POPIA), Rwanda's Data Protection Law (2021), and the African Union Convention on Cyber Security and Personal Data Protection [51]. These frameworks harmonize data protection and cybersecurity regulations across Africa and establish the roles and obligations of stakeholders in contactless payment systems.

We propose a structured data governance framework that encourages collaboration among city authorities, operators, contractors, and consumers to create clear and viable agreements. These agreements will define the rights and

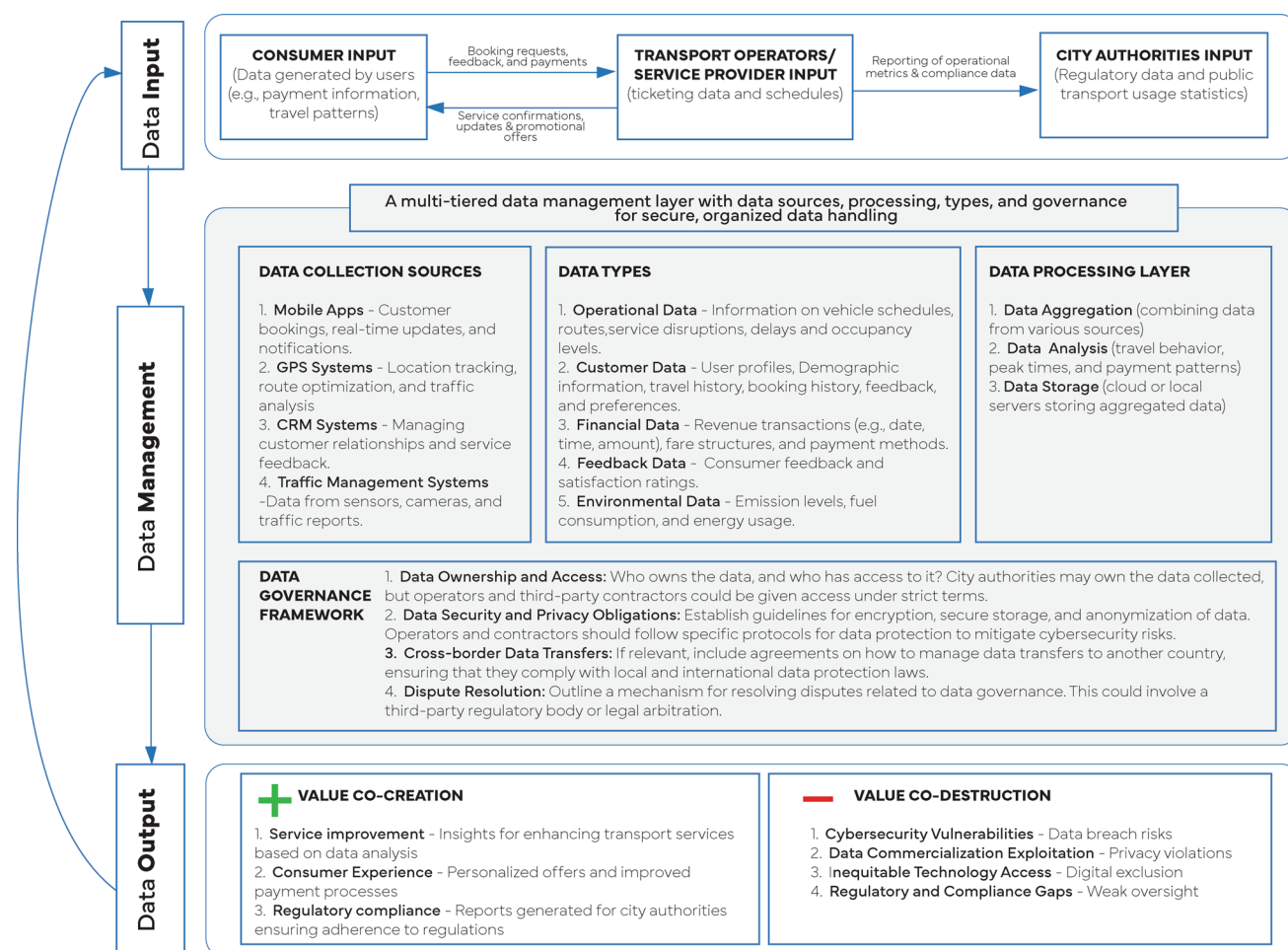


Fig. 2 Data flows and data types in contactless transport payment systems

responsibilities of each party, including data ownership, security protocols, and lawful data transfer conditions, ensuring compliance with both local and international regulations.

Our framework also addresses the ethical implications of data commercialization and emphasizes data justice. By protecting consumer privacy and promoting local economic development, we aim to prevent exploitative data extraction practices. A negotiated data governance agreement, supported by regulatory oversight, will help stakeholders develop a transparent, secure, and equitable system for managing contactless payment data.

Additionally, the article explores the regulatory landscape of data ownership and privacy laws in both developed and developing countries. It highlights the need for robust regulatory frameworks to safeguard consumer rights and promote responsible data management practices [1, 7, 48]. The article also contributes to the literature on technology adoption and innovation in urban mobility, using contactless payment systems as a case study. It examines how digital technology advancements can transform public transportation systems while presenting challenges related to cybersecurity, infrastructure, and equitable access [7, 52, 53].

Another theoretical contribution of this study on contactless transport payment systems is presenting a range of critical agendas for future research. These include examining the impact of regulatory frameworks on data ownership and privacy protection, understanding consumer behaviour and privacy concerns, developing technological solutions for data security, addressing ethical implications of data commercialisation, conducting comparative studies across

regions to assess governance disparities, integrating with innovative city initiatives for urban sustainability, analysing public–private partnerships and governance models, and exploring long-term impacts on urban mobility. Table 3 presents a structured overview of key research agendas related to contactless transport payment systems, offering insights into potential research questions and directions for further exploration in this evolving field.

## 8 Conclusion

This conceptual paper has explored critical aspects of contactless transport payment systems in developing countries, focusing on data ownership, regulatory concerns, advantages, disadvantages, plans, and implications. The discussion underscores the complexities surrounding data ownership, highlighting the roles of city authorities, contractors, and consumers in the management and utilisation of data generated through these systems [7, 13, 43, 53]. In many developing countries, where regulatory frameworks are still evolving, and consumer awareness of data privacy rights is limited, navigating these challenges becomes pivotal for ensuring responsible data governance and safeguarding consumer interests [47, 48, 54].

The advantages of contactless transport cards, such as enhanced convenience and operational efficiencies, are tempered by significant disadvantages, including cybersecurity risks, adoption challenges, and concerns over data commercialisation [1, 47]. These issues necessitate robust cybersecurity measures, comprehensive regulatory frameworks, and transparent data practices to mitigate risks and build trust among stakeholders [55]. Future plans envision enhanced connectivity, customer-focused applications, and improved security measures to address these concerns and enhance user experiences.

This paper provides a conceptual foundation for understanding the governance of contactless transport payment systems, but it also has several limitations. One key limitation is the lack of primary data collection, meaning we have not examined the ownership structures of companies operating public transportation systems or the specifics of international data transfers. Additionally, no interviews were conducted with stakeholders such as city authorities, contractors, or consumers. As a result, the research does not provide empirical insights into how data governance policies are applied in practice. Despite these limitations, the paper identifies several critical areas for future research.

Future research should investigate the effectiveness of existing regulatory frameworks governing contactless transport payment systems [47, 48]. Empirical studies can assess how regulations are implemented, enforced, and adapted to technological advancements. This will help determine whether these frameworks adequately protect consumer data, promote fairness, and foster innovation. Researchers can also examine the challenges faced by regulators in balancing the need for security with the facilitation of digital transactions in urban mobility.

Another important line of inquiry for future research is to explore the ownership structure of companies operating public transportation systems—whether they are national entities or subsidiaries of foreign corporations—and how data is transferred internationally or processed locally. This research could shed light on the implications of cross-border data flows, particularly in developing countries, and whether these arrangements contribute to local economic development or perpetuate exploitative data extraction practices. Understanding these dynamics is essential for advancing data governance and justice frameworks in global transportation systems.

Further research should focus on understanding consumer behavior, privacy concerns, and the technological solutions needed to enhance data security [7, 33, 35, 46, 56]. As consumers increasingly adopt contactless payment systems, understanding their perceptions of privacy and security will be crucial in shaping policies and practices. Additionally, developing advanced technological solutions to safeguard data from breaches and unauthorized use should be a priority for research and policy development.

Finally, future studies should explore the ethical dimensions of data commercialization in public transportation systems [42, 52]. Investigating how data generated through these systems is commercialized and whether this benefits local communities or reinforces inequalities is vital. Comparative research across different regions could provide a global perspective on the ethical use of data and identify best practices for ensuring that data commercialization contributes to local economies rather than perpetuating neo-colonial dynamics. The long-term socio-economic impacts on urban mobility and local economies also warrant further exploration [9, 11, 57].



**Table 3** Research agenda for advancing understanding of contactless transport payment systems and data ownership

Research agenda	Description	Possible research questions
Impact of regulatory frameworks	Evaluate the effectiveness of regulatory approaches in governing data ownership and privacy in contactless transport systems	How do different regulatory frameworks influence data governance practices in contactless transport systems across various regions?
Consumer behavior and privacy concerns	Explore consumer perceptions, attitudes, and behaviours regarding data collection and usage in contactless transport payment systems	What factors contribute to regulatory compliance and consumer trust in data security and privacy practices? What are consumers' main concerns and expectations regarding using their personal data in contactless payment systems?
Technological solutions for data security	Research and develop advanced cybersecurity measures and encryption protocols for enhancing data security in contactless transport systems	How do demographic factors (e.g., age, education level) influence consumer acceptance and adoption of contactless transport technologies?
Ethical implications of data commercialization	Examine ethical dilemmas surrounding the commercialisation of data collected through contactless transport systems	What are the most effective cybersecurity technologies and protocols for protecting data in contactless transport payment systems?
Comparative studies across regions	Conduct comparative studies between developed and developing countries to analyse disparities in data governance and technological infrastructures	How can technology be leveraged to prevent and respond to potential data breaches in contactless payment systems? What ethical considerations are in commercialising consumer data collected through contactless transport systems? How should data commodification be regulated to balance commercial interests with consumer privacy rights?
Integration with smart city initiatives	Investigate how contactless transport systems can be integrated with broader intelligent city initiatives to enhance urban mobility and sustainability	What are the differences in regulatory frameworks and data protection laws affecting contactless transport systems in developed vs. developing countries? How can lessons learned from developed countries be applied to enhance data governance and privacy protection in developing regions?
Public-private partnerships and governance models	Analyse governance models and public-private partnerships that promote innovation and ensure accountability in contactless transport systems	What are the synergies between contactless transport payment systems and smart city initiatives (e.g., IoT, AI) in improving urban mobility? How do integrated smart city solutions contribute to sustainable urban development and enhanced quality of life?
Long-term impacts on urban mobility	Study the long-term effects of contactless transport systems on urban mobility patterns, traffic management, and social equity	What are the key success factors in public-private partnerships for implementing and managing contactless transport payment systems? How can governance models balance innovation and consumer protection by deploying contactless transport technologies? How do contactless transport payment systems influence urban travel behaviour and commuting patterns? What are the environmental impacts of the widespread adoption of contactless transport technologies in urban settings?



**Acknowledgements** We would like to express our sincere gratitude to the Transformative Transport Service Design Initiative (TRATSEDI) for their invaluable support and the rich interactions within the group. The insightful conversations and constructive feedback from fellow members have significantly contributed to the development and completion of this research. Your collective input has been instrumental in shaping our ideas and advancing this work. Thank you for fostering such a collaborative and inspiring environment.

**Author contributions** EM conceptualized the idea, TeF drafted the initial manuscript. PKA provided the theoretical background and conducted the literature review, focusing on theoretical implications. SB contributed insights into management and regulatory aspects of transport systems, emphasizing comparative analyses and implications for policy and practice. TaF contributed to manuscript drafting, revision, and managerial implications. EM supervised the project, offering overarching guidance, and critically reviewed the manuscript for intellectual content and coherence. All authors have reviewed and approved the final manuscript.

**Data availability** Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

## Declarations

**Competing interests** The authors declare no competing interests.

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