Sustainable Futures 10 (2025) 100879

Contents lists available at ScienceDirect

Sustainable Futures

journal homepage: www.sciencedirect.com/journal/sustainable-futures

Optimizing sustainable urban mobility through digital integration

Waqas Ahmed

IRC for Finance and Digital Economy, KFUPM Business School, King Fahd University of Petroleum & Minerals, Dhahran, Saudi Arabia

A R T I C L E I N F O

Keywords:
Mobility as a service (MaaS)
Sustainable urban mobility
Digital dexterity
Service quality

A B S T R A C T

This study investigates the intention to endorse Mobility as a Service (MaaS) in a developing country context, examining its potential to mitigate car dependency by integrating multiple transport modes for seamless planning, booking, and payment digitally. To this purpose, a cross-sectional survey gathered data from 392 MaaS users, analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) and Importance-Performance Map Analysis (IPMA) to identify decisive elements in digital integration for sustainable urban practices. Findings reveal that Service Quality and Digital Dexterity are primary drivers of acceptance and continued intention to use, while Social Influence plays a lesser role. These results highlight the need for resilient, user-centered digital solutions to advance sustainable urban transit in developing economies. This research provides actionable comprehensions for policymakers and MaaS providers, supporting the design of effective, inclusive mobility strategies that nurture engagement and adoption in resource-constrained urban settings.

1. Introduction

The digital economy represents a transformative shift in how technological advancements integrate across social personal and professional domains to improve the sustainability of human life. This integration encompasses digital infrastructures designed to make public life more manageable, efficient, and resource-rich, addressing a wide range of contemporary challenges. The transportation sector is particularly impacted by this digital landscape, with Mobility as a Service (MaaS) emerging as a service model that combines multiple transport modes into a single accessible platform. Within this landscape, the digital transformation of the transportation sector stands out as particularly significant, offering substantial advantages to both governments and citizens. Technological innovations in transportation are indispensable for managing mobility challenges such as traffic control, congestion dwindling, commuter guidance, toll payments, smart parking, public transport promotion, car dependency reduction, and the implementation of environmentally friendly strategies, as well as supporting sustainable urban development goals [1]. MaaS exemplifies an essential outcome of this technological evolution. MaaS aims to enhance commuter efficiency by integrating journey planning, payment platforms, and various modes of transport into a unified service accessible via a single mobile application [2]. This innovative model is being adopted in both advanced and developing nations, with the primary objective of supporting urban residents in managing their daily commutes through multimodal options such as buses, trains, car-sharing, ferries, or bicycles [3]. MaaS provides multifaceted benefits: it helps governments control car dependency and manage urban mobility, while citizens benefit from a streamlined and organized commuting method, saving time and reducing inefficiencies. A growing body of recent research has focused on user perceptions toward MaaS adoption. These studies included the MaaS towards inculcation of sustainable public transportation [4], service experience [5], user experience and social impact [6,7], pricing strategies [5,8], and privacy concerns, risks, barriers, hopes and fears related to MaaS usability [9–12]. Information systems theories and models are also used to assess the motivational factors and willingness to adopt the MaaS mechanism [6,7,13–15].

Studies to date underscore the behavioral underpinnings essential to understanding MaaS uptake. For instance, a study in Noida, India, highlighted that socio-economic factors and personal vehicle ownership significantly influence user behavior towards app-based mobility services [16]. Another study employed Latent Class Cluster Analysis to investigate user preferences for various MaaS aspects, accentuating the need to tailor MaaS applications to meet the preferences of different user groups in Hungary [17]. Environmental benefits are also a focus area, as demonstrated by research in Padua, Italy, which estimated a potential 41 % reduction in pollutant emissions through MaaS adoption, highlighting the importance of multimodal mobility options [18]. In Russia, digital platform solutions like the Travel.RZD application are being implemented to integrate various transport modes, showcasing the potential for economic growth driven by digitalized communication technologies [19]. Moreover, the planning and implementation of MaaS

E-mail address: waqas331@gmail.com.

https://doi.org/10.1016/j.sftr.2025.100879
Received 9 June 2024; Received in revised form 11 June 2025; Accepted 15 June 2025
Available online 15 June 2025

in Athens, Greece, revealed several challenges and provided recommendations for achieving successful MaaS integration, emphasizing the importance of multimodal transport and user journey definitions [20]. Similarly, an event-based simulator assimilation mechanism proposed for evaluating MaaS scenarios highlighted the significance of integrated simulation models for improving user experience [21]. The development of AI frameworks for MaaS has shown promise in enhancing service quality by providing customized mobility options based on knowledge discovery from various data sources [22]. Additionally, a multi-stakeholder approach to MaaS in smart cities emphasizes the exigency for institutional restructuring and regulatory reforms to support the assimilation of MaaS within urban environments [23]. Understanding the factors influencing micromobility service adoption is also fundamental. Medina-Molina and Rey-Moreno [24] identified public transport satisfaction and traffic congestion perceptions as key determinants. Finally, research on the adoption of sustainable mobility modes among university students in Seville found that perceived sustainability impacts and economic issues significantly influence adoption, providing insights for promoting sustainable urban mobility [25]. Despite the promising potential of MaaS to revolutionize urban mobility, substantial gaps remain in the literature regarding its adoption and usability, especially in developing nations. Most research has predominantly focused on developed countries, which possess different infrastructural and socio-economic contexts compared to developing economies [26–29]. This disparity suggests that findings from developed nations may not fully apply to developing countries like Malaysia, which face unique challenges, such as a higher car-to-population ratio, stronger car dependency [30], and dense urban landscapes with both mobility obstacles and opportunities, including integrated public transport networks, multiple commuting modes for inter-city and intra-city travel [31], and government policies aimed at promoting user-friendly road systems.

A momentous, underexamined dimension in MaaS adoption is the convergence of personal traits such as innovativeness and technology self-efficacy into what is termed Digital Dexterity [32]. This eminence merges a user's readiness to adopt new technologies (i.e., MaaS) with confidence in digital interaction and is essential in shaping engagement in digital platforms. Digital dexterity directly influences initial uptake and sustained usage, positioning it as a central factor in the adoption process [30]. Digital dexterity has received growing scholarly attention in workplace settings, yet its implications for user interaction with public-facing platforms such as MaaS remain notably absent from existing research. The most recent study by Sahoo et al. [40] applied digital dexterity in B2B supply chain settings. However, that work was focused on internal business environments. This study takes a different route. It applies digital dexterity at the citizen level towards app usability to deal with real-time, public mobility systems. By framing digital dexterity as an essential user capability rather than a workplace skill, this study breaks new ground in addressing urban transport challenges. It marks one of the first applications of this concept to MaaS systems in emerging regions. Complementing this, service quality, measured through system reliability, intuitive interface design, responsiveness, and data security, meaningfully impacts user satisfaction and loyalty by addressing key domains around the functionality and dependability of transportation services [33]. High service quality builds trust, reducing the perceived risk associated with adopting new digital services [34]. Furthermore, when users experience reliable and responsive service, their likelihood of continued engagement with digital platforms such as MaaS increases, making service quality a cornerstone in sustaining adoption [35]. Moreover, social influence shapes adoption by embedding digitalization within societal norms and peer recommendations, either encouraging or discouraging uptake based on perceived social approval [6]. Social influence can meaningfully amplify adoption when users observe the benefits experienced by their peers, creating a ripple effect of acceptance [36]. Additionally, positive social endorsement serves to validate the technology's reliability, encouraging wider participation [37,38]. Together, Digital Dexterity, Service Quality, and Social Influence form a comprehensive analytical framework for comprehending MaaS adoption [39–41], a perspective not yet thoroughly examined or validated in current studies. Addressing this gap, the present study emphasizes the importance of grasping users' digital ability to fully benefit from MaaS technology, alongside their expectations and the social endorsements that influence adoption. This approach highlights that successful MaaS deployment requires more than technological solutions; it must resonate with users and surrogate broad social acceptance to achieve meaningful uptake.

This study explores underexamined areas within the existing MaaS literature and provides several distinct contributions to the field. To begin with, it adds to the discourse on MaaS adoption by introducing Digital Dexterity. A behavioral, cognitively based concept stemming from digital transformation literature underpinning the digital economy. Unlike other frameworks such as TAM or UTAUT, which mainly highlight perceived usefulness, convenience, general technology readiness, etc. Digital Dexterity centers on users' navigational prowess and adaptive behavior within complex multimodal digital ecosystems. This construct enhances the explanation of the individual digital capabilities influencing engagement with mobility platforms and integrated systems. The second contribution is forming a new multidimensional adoption model by integrating Digital Dexterity with Service Quality and Social Influence, thus bridging psychological, system, and socio-contextual frameworks. The third contribution is the empirical testing of the model in Malaysia, providing a perspective from an emerging market that is often overlooked in MaaS studies which focus on high-income European countries and overlooked the MaaS initiatives in developing territories. Pondering the integration of basic MaaS-level applications, such as Moovit, can pave the way for more sustainable societies and contribute to the digital maturity of urban dwellers. The fourth contribution is achieved by revealing the role of digitally empowered users interacting with modern transport systems in supporting sustainable urban mobility objectives and reducing the dependency on cars and environmental damage. Lastly, this study introduces empirically grounded, context-aware evidence to shape more tailored and inclusive design and policy interventions for digital systems. It situates its contribution within the specific realities of developing countries, highlighting infrastructural challenges, access inequalities, and socio-economic complexity. Taken together, these contributions position the research as a valuable catalyst for advancing both theory and practice in the pursuit of sustainable and accessible urban mobility futures. The research is proceeded with literature review on MaaS, followed by methodology and results. Then discussions on inferences for theory and practice are presented with future directions.

2. Literature review

2.1. Mobility as A service (MaaS)

Mobility as a Service (MaaS) is transforming urban transportation by unifying multiple modes of transport into a single, streamlined platform [20]. This innovative model integrates public transit, ridesharing, bike-sharing, car-sharing, and more within one accessible application, allowing users to plan, book, and pay for various transit options in one place [21]. MaaS aims to make urban mobility easier while reducing dependence on private vehicles, supporting greener and more sustainable transport solutions. A notable example of MaaS in action is the Moovit app, developed by Intel. Serving over 112 countries and 3400 cities, Moovit links users to 360 different shared and micro-mobility providers, including services like Uber, Lyft, bikes, scooters, and shared cars [42]. It has >100 million users across the world. This extensive fusion enables efficient navigation of urban spaces without the need for personal vehicles, ultimately forwarding a more sustainable approach to mobility [3]. In Kuala Lumpur, Moovit has been successfully adapted to local transit networks, demonstrating the platform's versatility across diverse urban settings. With plans to expand to 2000 more cities, Moovit exemplifies the ongoing growth and reach of MaaS [43].

While the conceptual boundaries of MaaS continue to evolve, Sochor et al. [44] pose one of the most widely referenced frameworks by introducing a topological model. This categorizes MaaS into five progressive levels, from Level 0 (no integration) to Level 4 (full integration with societal goals). In this typology, Level 1 MaaS involves the integration of information only via platforms that offer multimodal trip planning, real-time updates, and system alerts. However, it comes with the absence of transactional features such as booking, ticketing, or payment. Moovit, as explicitly classified by Sochor et al. [44], is a representative Level 1 MaaS application. Which provides centralized access to multimodal travel information including buses, trains, micromobility, and walking options. While it lacks end-to-end integration, Moovit performs a significant enabling function in early-stage MaaS ecosystems. Specifically in contexts like Malaysia where infrastructural and regulatory incorporation are still emerging. Its role in familiarizing users with digital mobility tools positions it as a legitimate and valuable reference for understanding foundational adoption behavior.

The benefits of MaaS extend beyond convenience, offering substantial contributions to environmental sustainability, economic efficiency, and social inclusivity[45]. MaaS platforms such as Moovit provide personalized travel plans and real-time updates, leveraging a network of over 7500 mobility operators to give users access to options that best match their needs [46]. This diverse range of shared mobility options can help reduce urban traffic congestion and lower greenhouse gas emissions, as orchestrated by Moovit's inclusion of sustainable options like bikes and e-scooters [47]. From an economic standpoint, MaaS offers an affordable alternative to private vehicle ownership, particularly in urban areas where the costs associated with owning a car are often prohibitive [48]. MaaS also promotes social inclusivity by expanding transport options for people who may face mobility challenges or lack access to private vehicles. Moovit's network of 875,000 local editors from 142 countries ensures the platform remains locally relevant and accessible to diverse populations worldwide [49]. The future potential of MaaS will be driven by advances in autonomous vehicles, artificial intelligence, and data analytics. Moreover, public-private collaborations will play a decisive role in aligning stakeholders toward shared goals of sustainable, efficient, and inclusive urban mobility [42,47–50].

This study addresses certain research variances in the MaaS literature by pondering on adoption elements within developing countries, an area that remains largely underexplored in recent research. Most studies on MaaS adoption, mainly conducted in Europe and North America, focus on digitally advanced regions, which differ significantly from the socio-economic and infrastructural landscapes in developing economies [1]. For instance, Malaysia encounters unique socio-economic constraints, such as variable digital access and inconsistent public transit integration, which contribute to a distinct adoption environment not adequately represented in existing studies [7]. Research by Alyavina et al. [1] highlights infrastructure-based challenges within MaaS adoption, while Butler et al. [10] advocate for context-specific strategies tailored to the realities of countries like Malaysia. This study responds by exploring the impact of Digital Dexterity, comprised of personal innovativeness and technology self-efficacy, on MaaS adoption, offering a closer look at user readiness and engagement. Additionally, it examines service quality through aspects like interface design and system reliability, both pivotal to user satisfaction and adoption rates, especially in under-resourced environments [3,5].

Building on this foundation, the research further integrates social influence as a core factor in understanding MaaS adoption in communal societies prevalent across Southeast Asia. Social influence, encompassing peer and societal perceptions, emerges as an inherent driver in these settings, impacting user behavior through collective expectations and cultural norms [12]. By situating Digital Dexterity, Service Quality, and Social Influence within the context of Malaysia, this study broadens MaaS research beyond Western-centric findings, filling a significant knowledge gap in how these elements interact to shape adoption decisions. This contextualized approach not only advances the perception of MaaS adoption in developing nations but also provides empirical data that could guide policy and practice in urban mobility. Ultimately, the study's intellect offers a foundation for sustainable MaaS strategies applicable to diverse regions facing similar developmental challenges, contributing to the global discourse on MaaS adoption across varied socio-economic landscapes [14,18,22].

2.2. Service quality

Service quality is an elucidative concept in the domain of behavioral sciences globally, as it pertains to the attributes and features of a product, system, or service that enable it to meet user expectations effectively [30]. Toward the compass of MaaS, service quality can be defined through various facets of applications such as the "Moovit" app, which includes a responsive interface, security, performance abilities, flexibility, personalization, and other user-evaluated attributes. The quality of Global Positioning System (GPS) services, characterized by comfort, safety, unique functionality, and reliable information, has been shown to pointedly enhance user satisfaction [4]. Similarly, the service qualities of MaaS, such as informativeness and mobility convenience, have a positive and significant influence on users' behavioral intentions towards the adoption of these services [51]. These findings accentuate ore the importance of specific service attributes in shaping user satisfaction and adoption behavior.

Extending this understanding, another study on digital technology adoption found that factors such as safety, reliability, and utility of mobile payment apps are considerably associated with users' behavioral intentions [52]. This indicates that the principles governing service quality in MaaS are applicable across various digital platforms, reinforcing the need for high standards in safety and reliability to encourage user engagement. A comprehensive study by Rajabi et al. [22] exerted that users' behavioral intentions in adopting MaaS are influenced by factors such as infrastructure changes, service design, pricing, and public awareness. These findings emphasize the necessity for continuous enhancement of service quality dimensions to boost user adoption and satisfaction. The interconnected nature of these aspects highlights the comprehensive approach looked for to improve service quality comprehensively.

Moreover, Ahmed et al. [53] found that perceived service quality, perceived usefulness, and perceived ease of use appreciably impact users' intentions to continue using mobile applications for personal learning and development due to comfort while traveling the public transport. The impact of service quality on customer loyalty through perceived value and customer satisfaction was explored in the framework of mobile banking applications by Quddus et al. [33]. Their research revealed that higher service quality leads to greater perceived value and customer satisfaction, which in turn boosts customer loyalty. This suggests a similar potential impact for MaaS applications like Moovit, where improved service quality could enhance user loyalty and long-term engagement.

A growing body of research underscores the meaningful role of service quality in driving technology adoption, particularly in transportation. Service quality encompasses aspects like reliability, accessibility, and user support, each of which directly influences users' perception of technological value and usability. For example, Ricardianto et al. [16] find that high service quality in public transit not only bolsters trust but mitigates typical adoption barriers, including convenience and operational uncertainty. Similarly, extending the Technology Acceptance Model (TAM) with service quality and trust, Kim et al. [54] exert that trust and ease of use considerably enhance adoption willingness in urban air mobility. By addressing these elements, transportation technologies align more closely with user expectations, thus enhancing engagement and adoption rates [55,56]. Such findings illustrate that service quality impacts adoption through multiple pathways, establishing trust and perceived value as vital elements for achieving broad-based acceptance of transportation innovations.

Further supporting this perceptiveness, research by Eccarius and Lu [57] indicated that while service quality positively influences customer satisfaction, it does not directly affect behavioral intention. Instead, customer satisfaction serves as a mediator, emphasizing the importance of delivering high-quality services to achieve user satisfaction and subsequent behavioral intentions. This reinforces the concept that satisfaction is a key driver for continued use and advocacy. Additionally, Tussyadiah et al. [58] highlighted the relationship between service quality, customer satisfaction, and loyalty in the mobile social media market. Their findings suggest that service quality dimensions such as usefulness, convenience, design, and security/privacy are pivotal in enhancing customer satisfaction, which subsequently drives customer loyalty. This relationship could be extrapolated to the MaaS context, where similar service quality dimensions might influence user behavior. Therefore, this study hypothesizes that:

Hypothesis 1. (H1): Service quality positively impacts users' behavioral intention towards MaaS adoption.

2.3. Digital dexterity

Traditional models of technology adoption, like the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT), have offered indispensable perspectives on user behavior for years [59–63]. These models focus on attitudes and inclinations, for example, how easy and resourceful a particular technology is to adopt or the social pressures surrounding its use, while neglecting the intricate behavioral adaptive capabilities needed for modern digital environments. In response, this research attempts to fill the gap by proposing Digital Dexterity as a self-adaptive, innovative, and highly mobile construct representing the ability to self-automate reflexively within integrated digital mobility ecosystems. Digital Dexterity integrates personal innovativeness and technology self-efficacy to describe not just the willingness to adopt new technologies, but the proactive responsiveness required to effectively operate in real-time data environments with dynamic multilateral integration as well as interactions with complex adaptive systems [32], hallmarks of emerging MaaS ecosystems. This aim captures the micro-behaviors and adaptive mindsets that are critical, albeit not static, metrics of readiness to engage meaningfully with MaaS. Most importantly, this aspect has been extensively discussed in the context of enterprises and organizations [32,64–68] which makes it surprising that Digital Dexterity has not been empirically applied to mobility behavior at the user level, which renders the findings of this study both unique and rich in theoretical contribution.

Digital dexterity elucidates the individual skills and readiness essential for effectively using new products, services, or processes to navigate the evolving digital landscape. Individuals who exhibit Digital Dexterity are not only more agile and skillful but also show a greater willingness to engage with technological infrastructures and systems [69]. This agility and readiness enable them to leverage digital tools efficiently, contributing significantly to organizational success and personal innovation [32]. Research identifies two key aspects of Digital Dexterity: personal innovativeness and technology self-efficacy [68]. Personal innovativeness refers to a user's knowledge and expertise in experimenting with new systems, such as MaaS, reflecting a proactive approach to adopting and utilizing digital innovations [32]. Conversely, technology self-efficacy indicates a user's confidence in their ability to use new technologies effectively, featuring the psychological empowerment required for successful technology adoption [70]. The relationship between personal innovativeness and user behavioral intention has been extensively validated in recent studies. Individuals with higher personal innovativeness are empirically shown to exhibit stronger behavioral intentions toward adopting new technologies and systems [41,71]. For example, Cao et al. [72] exhibited that personal innovativeness temptingly predicts behavioral intention, establishing a positive correlation. Complementary findings by Sharma et al. [73] reveal that innovativeness enhances user intention by influencing ease of use perceptions in mobile payment services, while Kim and Garrison [74] note similar trends in RFID adoption, where innovativeness impacts the ease and speed of technology implementation in supply chains. Together, these insights accentuate personal innovativeness as a core driver in technology adoption models.

Similarly, technological self-efficacy positively influences behavioral intention. Users who believe in their capability to navigate new technological systems are more likely to adopt these systems, as they feel more confident in overcoming potential challenges [75]. This positive correlation between technology self-efficacy and behavioral intention has been confirmed by several studies, indicating that enhancing users' self-efficacy can significantly impact their willingness to adopt new technologies [68,76].

Building on the established roles of personal innovativeness and technology self-efficacy in shaping user behavioral intentions, both qualities are integral to MaaS adoption. Users with high personal innovativeness are naturally more inclined to explore and adopt MaaS, motivated by curiosity and openness to new technologies that foster initial acceptance and sustained engagement [77]. This curiosity mitigates common adoption barriers by encouraging users to embrace MaaS platforms confidently and continuously [71]. Technology self-efficacy complements this by instilling a sense of competence in users, allowing them to navigate MaaS applications effectively and engage with the technology over time [70,78]. By reinforcing both confidence and willingness, personal innovativeness and self-efficacy jointly form a strong foundation for overcoming entry barriers, enhancing user satisfaction, and supporting lasting commitment to MaaS services [79].

Linking this foresight, it becomes clear that enhancing both personal innovativeness and technology self-efficacy is essential for promoting positive behavioral intentions toward MaaS adoption. Literature indicates that Digital Dexterity, integrating personal innovativeness and technology self-efficacy, eloquently influences users' intentions to adopt new technologies, especially in MaaS, where readiness to embrace innovative mobility solutions is crucial [58,80]. By cultivating digital dexterity, organizations can empower users to engage more effectively with new systems, leading to improved adoption rates and enhanced user experiences [81]. To support this, organizations and policymakers should implement strategies that promote Digital Dexterity by offering training and resources to boost users' confidence and competence in using new technologies [74]. Such initiatives create environments that support innovation and empower users to effectively embrace new mobility solutions [82]. Notably, there is currently no research specifically exploring the relationship between Digital Dexterity and MaaS adoption, making this study the first to address this gap and providing a foundation for future research in this key domain. Accordingly, this study proposes the following hypothesis:

Hypothesis 2. (H2): Users' Digital Dexterity positively impacts users' behavioral intention towards MaaS adoption.

2.4. Social influence

Social influence is a key construct in the Unified Theory of Acceptance and Use of Technology (UTAUT) model, reflecting both intended and unintended efforts to shape individuals' perceptions of new systems usage [36]. In this study, social influence is considered both the intentional and unintentional perceptions of users regarding the MaaS "Moovit" app, driven by the actions and communications of their social groups. The UTAUT model has extensively studied user willingness to accept MaaS. Findings consistently confirm that social influence affects user willingness to adopt MaaS [83]. This suggests that the opinions and behaviors of social networks play a decisive part in shaping individual decisions regarding new technology adoption.

A contemporary work using a stated preference survey to assess potential demands for MaaS found that social influence strongly impacts user willingness to subscribe to new services [8]. This indicates that the collective behavior and endorsements of peers can drive individual adoption rates. Similarly, research on integrated license service information systems adoption supports the notion that social influence momentously impacts user intention to utilize such systems [81]. These studies highlight the pervasive effect of social influence across various technological contexts. Towards automated road transport systems, social influence has been shown to play a pivotal role in public acceptance. Nordhoff et al. [84] expounded that social influence, alongside constructs from the Diffusion of Innovation Theory, significantly affects the acceptance of driverless automated shuttles. This underscores the idea that societal norms and peer opinions are powerful drivers in the adoption of innovative transportation solutions.

Moreover, in terms of sustainable urban transport systems, social influence has been identified as substantial in encouraging the adoption of environmentally friendly transportation options. Ariffin and Zahari [85] pointed out that social influence is essential for promoting sustainable transport behaviors in urban settings, illustrating its broad impact on transportation choices and potential to drive positive environmental outcomes. The role of social influence extends to the adoption of Internet of Things (IoT) technologies and electric vehicles as well. Building consumer trust through social influence can significantly enhance IoT technology adoption [86]. Similarly, Globisch et al. [87] found that social influence within commercial fleets was a profound factor in the acceptance of electric passenger cars, demonstrating its relevance across different technological domains.

Given the substantial evidence of social influence on technology adoption, integrating social influence into the UTAUT model and applying it to the Moovit app provides a wide-ranging framework to understand and predict user behavior. This study aims to fill a gap in the existing literature by specifically exploring the impact of social influence on MaaS adoption, contributing effective interpretations to the field of transportation technology. By acknowledging the power of social dynamics, this research underscores the importance of social influence in the successful deployment and adoption of new technological solutions [88,89]. Accordingly, this study posits the following hypothesis:

Hypothesis 3. (H3): Social influence positively impacts users' behavioral intention towards MaaS adoption.

3. Research methodology

A structured methodology grounded in the research onion framework guides this study, detailing each stage of the research process. This includes the research approach, strategy, choice of instruments, and methods of data analysis [90]. This study employs a deductive research design, aimed at investigating behaviors, preferences, and adoption factors related to the MaaS application. The survey approach was selected to collect quantifiable data from a targeted population of MaaS users in the Klang Valley, Malaysia. The non-probability sampling technique was utilized as a sampling method, leveraging respondents' social and professional networks to extend the sample size efficiently and hassle-free way in less time [91]. The survey was distributed through social media platforms and professional networks frequented by known MaaS users. The first wave of respondents was selected from frequent public transportation users in the Klang Valley who had prior experience with the MaaS application, i.e., Moovit. The survey was specifically designed to focus on current MaaS users to ensure that the collected data reflected actual user behaviors and experiences.

Before participating in the survey, respondents were asked screening questions to verify their use of the MaaS application within the past year. Only those who confirmed prior usage of MaaS platforms were invited to complete the full survey. After completing the survey, respondents were encouraged to refer other MaaS users from their social and professional circles to participate, thereby enabling the sampling process wider and more integrated. This technique allowed the survey to grow organically, expanding the sample size and ensuring that the data collected came from a relevant and engaged population of MaaS users. The data collection period extended from February 2023 to May 2023, providing ample time to gather responses from a diverse range of MaaS users. The sampling method yielded 392 valid responses, providing a strong dataset for PLS-SEM analysis. The three-month data collection window allowed for the inclusion of users with varied exposure to MaaS services. Such as ranging from new users to those with over six months of experience. It provides a well-rounded behavioral dataset that reflects different stages of user engagement without enforcing rigid adopter categories [92].

To contextualize the platform selection, this study draws on the Moovit application as a representation of early-stage MaaS integration. As classified by Sochor et al. [44], Moovit aligns with Level 1 MaaS maturity. This aligns with emerging MaaS ecosystems, where user behavior is often shaped by partial functionality and platform familiarity. It makes such applications analytically valuable for foundational engagement studies. The Moovit app is characterized by the fusion of real-time multimodal travel information without transactional capabilities such as booking or payment. In emerging urban contexts like Malaysia, where higher-level integration remains limited, Moovit serves as a functional and contextually relevant proxy for studying foundational user engagement with digital mobility platforms. Furthermore, the data collection spanned three months that denoted users with diverse engagement patterns shaped by usage frequency and tenure. While this timeframe does not support formal classification into adopter categories [39,93], it offers meaningful variation for examining behavioral trends across different stages of user familiarity. This framing allows the study to investigate adoption dynamics within a realistic operational setting reflective of current digital mobility offerings in the region.

The survey instruments were designed to measure key constructs related to MaaS adoption. The survey questionnaire was based on two discrete sections. Section A captured essential demographic data, including age, gender, income, occupation, location, MaaS usability, and public transportation usage. Section B focused on the core study variables: Behavioral Intention, Digital Dexterity, Service Quality, and Social Influence. The instrumentation strategy employed in this research involves adapting established measurement items from previous scholarly works to ensure high standards of validity and reliability. A five-point Likert-type scale, ranging from 'strongly disagree' (1) to 'strongly agree' (5), was used to quantify participant responses. The measurement items for behavioral intention were derived from seminal works by Chen & Chen [4] and Venkatesh et al. [93]. Similarly, the construct for Digital Dexterity was measured using validated items from prior research in technology management literature [41]. Social Influence was adopted from previous work of Venkatesh et al. [93]. Service Quality was assessed through criteria specifically tailored to evaluate MaaS platforms, reflecting user interface design, functionality, and reliability [4]. These measurement items, as shown in Table 02, are assessed for reliability and validity.

This study employs Partial Least Squares Structural Equation Modeling (PLS-SEM), conducted through SmartPLS v3 software, as the primary analytical method. PLS-SEM is particularly suited to assessing complex model structures and is valued for its robustness in theory testing and predictive analysis, especially with non-parametric data. This technique enables a detailed evaluation of both the measurement and structural models, examining construct reliability, validity, and testing the study's hypotheses within the MaaS adoption framework [94]. To enrich the insights from PLS-SEM, Importance-Performance Map Analysis (IPMA) is also applied. IPMA complements PLS-SEM by assessing the importance and performance of each construct, highlighting detailed factors that influence user satisfaction and adoption rates. This combined approach offers precise recommendations for improving MaaS platforms and informs policy adjustments aimed at enhancing user acceptance [95].

4. Results

4.1. Demographic profile

The survey yielded numerous results as descriptive outcomes are shown in Table 1. The response rates differed between male and female participants, with 61.49 % for males and 38.51 % for females. The majority of respondents were aged between 26 and 30 years, making up 32.18 % of the total. In terms of educational background, 43.10 % held bachelor's degrees, while 29.31 % had diplomas, and 27.59 % possessed master's or other advanced degrees. Regarding occupation, 46.55 % of the respondents were students, 33.91 % were employed, and 19.54 % were engaged in business activities. Most respondents (77.81 %) resided in urban areas, with the remaining 22.19 % from suburban locations. For Mobility-as-a-Service (MaaS) usage, 41.31 % had used it for 1 to 6 months, while 35.81 % had used it for less than a month, and 22.95 % had used it for more than six months. In terms of public transport usage, 58.21 % used it daily, 33.81 % weekly, and 7.98 % used it randomly.

4.2. Measurement model

In this study, the measurement model was rigorously assessed to ensure reliability and validity of the constructs used to evaluate the adoption behavior of MaaS. The outer loadings of the measurement items were analyzed to verify instrument reliability, with most values above the standard threshold of 0.70, indicating strong acceptance, while values above 0.50 also confirmed reliability [96]. Furthermore, the Variance Inflation Factor (VIF) was measured to test for multicollinearity, with all VIF values below the momentous value of 3, confirming that multicollinearity was not a concern in this study [97]. Table 2 outlines the outer loadings and VIF values for each measurement item that confirm indicator relevance and the absence of multicollinearity. This is followed by Table 3, which presents Cronbach's alpha, composite reliability, and AVE values, confirming the reliability and validity of the constructs prior to structural model evaluation. For construct reliability, the Cronbach's alpha (α) was employed to gauge the internal consistency of the latent variables, with values ranging from 0.726 to 0.923, exceeding the acceptable threshold of 0.70 [98]. This indicates a high level of internal consistency. Composite Reliability (CR)

Table 1
Respondents demographic.

Characteristics	Respondent Background	Frequency	%
Gender	Male	241	61.49
	Female	151	38.51
Age	≤ 20 years old	54	13.79
	21–25 years old	119	30.46
	26–30 years old	126	32.18
	> 30 years old	93	23.56
Education	Diploma	115	29.31
	Bachelor	169	43.10
	Masters / Others	108	27.59
Occupation	Student	182	46.55
	Employees	133	33.91
	Businessman	77	19.54
Location	Urban	305	77.81
	Suburban	87	22.19
MaaS Usability	Less than a month	140	35.81
	1 to 6 months	162	41.31
	>6 months	90	22.95
Public Transport Usability	Daily	228	58.21
	Weekly	133	33.81
	Randomly	31	7.98

Table 2
Outer loadings and outer VIF.

Variable	Items	Questionnaire statement	Outer loadings	VIF
Service Quality	SQ1	It is easy to find public transport stops or stations using the MaaS system.	0.679	1.451
	SQ2	The MaaS system helps me reach my destination without difficulty, covering all key areas in the city.	0.859	2.498
	SQ3	The MaaS system provides accurate and reliable public transport schedules.	0.79	1.933
	SQ4	The MaaS system helps ensure a comfortable journey by providing real-time information about crowding on public transport.	0.882	2.826
	SQ5	I feel safer using public transport because the MaaS system provides real-time updates and alerts about delays or incidents.	0.851	2.305
Digital Dexterity	DD1	I know how to effectively use the MaaS system to make my transportation more efficient and organized.	0.894	2.328
	DD2	I feel confident that my understanding of the MaaS system enables me to make smart, timely decisions during my travels.	0.781	1.715
	DD3	I often explore new features in the MaaS system to find better ways to enhance my travel planning and flexibility.	0.765	1.816
	DD4	Using the MaaS system helps reduce travel-related stress and improves the convenience of managing my journeys.	0.623	1.034
	DD5	I tend to adopt new features or updates in the MaaS system early, as they usually lead to a more streamlined and efficient experience.	0.945	2.813
Social Influence	SI1	People important to me think I should use the MaaS system for my commuting needs.	0.718	1.781
	SI2	My friends and family recommend the MaaS system for navigating public transport.	0.671	1.67
	SI3	I feel more inclined to use the MaaS system because it is popular within my social circle.	0.913	2.465
	SI4	I use the MaaS system because people around me expect me to use it for travel planning.	0.883	1.812
	SI5	The positive feedback from my peers encourages me to use the MaaS system more often.	0.528	1.777
Behavioural Intention	INT1	I intend to continue using the MaaS system for my daily transport needs.	0.938	1.155
	INT2	I will recommend the MaaS system to others who use public transport.	0.829	2.242
	INT3	I plan to increase my use of the MaaS system in the future.	0.835	2.374
	INT4	I prefer the MaaS system over other transport apps when planning my journeys.	0.911	1.076
	INT5	I am committed to using the MaaS system for all my public transportation needs.	0.86	2.654

Table 3
Reliability and validity results.

Variable	α	CR	AVE	HTMT			
				SQ	DD	SI	INT
Service Quality	0.872	0.908	0.665				
Digital Dexterity	0.736	0.835	0.581	0.63			
Social Influence	0.726	0.729	0.592	0.311	0.338		
Behavioural Intention	0.923	0.942	0.767	0.78	0.826	0.278	

was also computed, confirming the reliability of the constructs with CR values all above 0.70 [97]. Convergent validity was evaluated by calculating the Average Variance Extracted (AVE), with all constructs achieving AVE values exceeding the threshold of 0.50, thereby affirming adequate convergent validity [97]. Discriminant validity was assessed using the Heterotrait-Monotrait (HTMT) ratio, with all values $\leq$ 0.85, demonstrating that the constructs were distinct from each other [98]. The results for construct reliability (α & CR), convergent validity (AVE), discriminant validity (HTMT), outer loadings, and VIF comprehensively ensure a strong validation of the measurement model employed in this research.

4.3. Structural model analysis

The structural model analysis was executed using partial least squares structural equation modeling (PLS-SEM) via SmartPLSv3 to examine the causal relationships among key variables. The results point out several notable intuitions: Service quality (SQ) emerged as the most influential predictor of behavioral intention (INT), with a path coefficient of $\beta = 0.386$, $T = 2.42$, and $p = 0.008$, thereby supporting H1 (SQ → INT). Digital dexterity (DD) followed closely as a significant determinant of INT ($\beta = 0.380$, $T = 2.099$, $p = 0.018$), validating H2 (DD → INT). Social influence (SI) also illustrated a statistically significant impact on behavioral intention ($\beta = 0.128$, $T = 1.701$, $p = 0.045$), confirming H3 (SI → INT). Table 4 reports the structural path coefficients, indicating the strength and significance of hypothesized relationships among constructs.

To complement Table 4 output, Fig. 1 illustrates the full structural model, highlighting key causal links and effect sizes within the proposed theoretical framework. Further analysis of the structural model's explanatory power shows a coefficient of determination (R^2) of 0.524, indicating that SQ, DD, and SI collectively account for 52.4 % of the variability in behavioral intention. It denotes a value exceeding the standard 0.50 threshold and reflecting substantial predictive strength. Additionally, f^2 effect size metrics, as shown in Table 4, were calculated to assess the individual impact of each predictor variable, with all predictors meeting or surpassing the adequacy threshold of 0.02.

4.4. Importance-performance map analysis

The importance-performance matrix analysis (IPMA) highlights the relative importance of exogenous variables in explaining a particular endogenous variable. The importance scores represent the unstandardized total effects for the independent variables, while the performance scores reflect the predictors' scores for the unstandardized outer weights for their response variable. These scores are graded on a scale from 0 to 100 in the IPMA scatter plot. Table 5 displays the IPMA results, quantitatively ranking the constructs based on their impact and performance scores. Fig. 2 translates these IPMA results into a visual matrix through a four-quadrant diagram. It aids in identifying resolute intervention areas where performance enhancements can maximize behavioral intention toward MaaS adoption.

The vertical axis displays the performance scores for predictor variables (ranging from low to high performance), whereas the horizontal axis signifies the importance scores (categorized as low or high importance) [99]. In the framework of importance-performance analysis, this study categorized the four quadrants as follows: Q1 (no issues), Q2 (issues necessitating attention), Q3 (non-important construct with high performance), and Q4 (non-important construct with low performance) [95]. The findings revealed that Service Quality (SQ) and Digital Dexterity (DD) fall within the Q2 area of the quadrant diagram, indicating that these elements are vital for enhancing Behavioral Intention (INT) towards MaaS adoption. Additionally, it was found that Social Influence (SI) is less important for INT, but its performance level is high, placing it in the Q3 area. Consequently, while improvement efforts for SI are necessary, they are not of the highest priority. Table 5 shows the IPMA results, and Fig. 2 helps visualize these findings using the four-quadrant importance-performance matrix. Together, they make it easier to see which factors matter most and where performance can be improved. The quadrant layout provides a clear way to spot areas that require attention and those already performing well. This combined presentation of scores and visual mapping adds clarity to the analysis and makes it easier for other researchers to follow and apply the same method in similar studies using PLS-SEM.

Table 4
Hypothesis testing and R-square.

Hypotheses	β	Standard Deviation	T Statistics	P Values	Results	f-Square
H1: SQ → INT	0.386	0.154	2.42	0.008	Supported	0.048
H2: DD → INT	0.38	0.152	2.099	0.018	Supported	0.041
H3: SI → INT	0.128	0.053	1.701	0.045	Supported	0.023
Overall Impact on INT	**R-Square** 0.524			**R-Square Adjusted** 0.515		

5. Discussion

This study, centering on the adoption behavior of citizens towards the MaaS application, employed PLS-SEM and IPMA techniques for data analysis. The inferences provide empirical support for the proposed relationships, highlighting the significant influence of Service Quality (SQ), Digital Dexterity (DD), and Social Influence (SI) on the Behavioral Intention (INT) to use MaaS apps. The analysis orchestrated that service quality noticeably impacts behavioral intention, validating the commemorative role of SQ in the acceptance and usage of MaaS applications. This aligns with existing literature in transport and technology research [4,6,15], emphasizing that better service quality assessment and validation are essential for widespread MaaS adoption. For policymakers aiming at mass integration of MaaS, enhancing service provision is of utmost connotation. Furthermore, Digital Dexterity was found to positively relate behavioral intention, consistent with prior research indicating that the adoption of novel technology in transportation is driven by personal inclination towards innovative resourcefulness [30, 80,100]. This indicates that individuals with higher technological knowledge and an innovative mindset are more likely to be the early adopters of MaaS and continue using the service. Social influence also meaningfully impacts the intention to adopt MaaS technology. Although the effect of SI is smaller compared to SQ and DD, it remains noteworthy and aligns with existing literature [6,8,15]. The relatively small impact of social influence indicates that MaaS, being a new technology, would benefit from increased public awareness. Limited debate and knowledge about MaaS could somewhat slow its acceptance and broader adoption.

5.1. Theoretical implication

This study offers a paradigm-shifting contribution to the field of MaaS adoption by challenging the prevailing assumption that user acceptance of digital mobility systems can be sufficiently explained

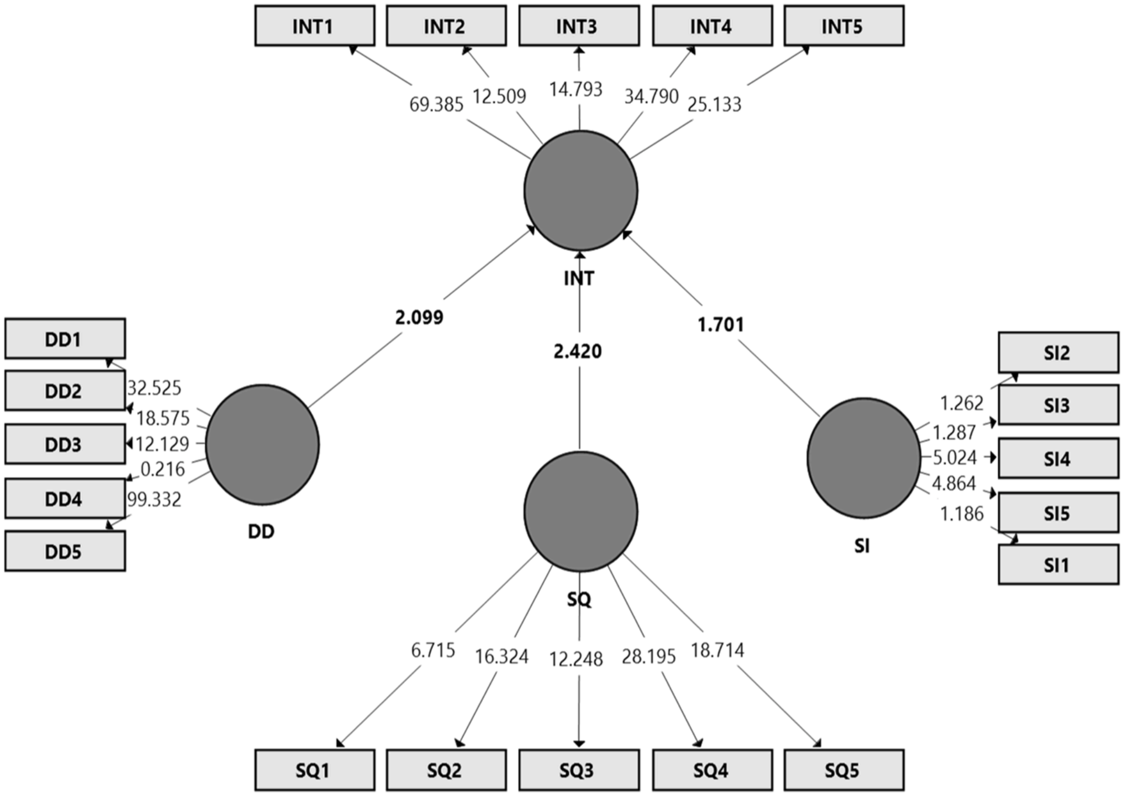

Fig. 1. Structural model.

Table 5
IPMA results.

Predictors	Outcome variables	
	Importance (Effect)	Performance
Service Quality	0.386	72.523
Digital Dexterity	0.380	71.564
Social Influence	0.128	73.51
Mean	**0.298**	**72.532**

through traditional models focused on static attitudes or perceived usefulness. In contrast to legacy frameworks such as TAM, UTAUT, and TTF, which conceptualize adoption behavior as a largely rational response to system features or social pressure, this research asserts that MaaS adoption represents a more complex behavioral transformation. It is deeply embedded in digital adaptability, platform navigation, and cognitive fluidity. The primer of Digital Dexterity (DD) lies at the heart of this theoretical perceptive. The concept of DD is drawn from digital transformation and organizational behavior literature but recontextualized here as a user-centric behavioral capability. This construct captures not merely a readiness to use technology, but a proactive, reflexive, and skillful engagement with data-intensive, and dynamically integrated digital environments. In doing so, the study reconceptualizes the user not as a passive consumer of a mobility service, but as an active digital agent navigating a real-time decision space, mediated by adaptive learning, multitasking, and interface mastery. This move advances existing theoretical expressions by shifting attention from user intention to user agility, a concept critically underexplored in the MaaS domain.

This conceptual advancement is embedded within a multidimensional behavioral framework that unites three domains: individual cognitive capacity (Digital Dexterity), experiential system quality (Service Quality), and socio-environmental influence (Social Influence). These dimensions are often studied in isolation. This model brings these into conversation, enabling a more complete understanding of how users engage with integrated transport ecosystems. By doing so, the model transcends functionalist accounts of adoption and responds to recent calls for behaviorally rich, ecologically valid models in the transportation literature [1,9,10]. Moreover, the empirical setting, Malaysia, anchors this exemplar in a transitional urban milieu, where the digital divide, infrastructural hybridity, and behavioral diversity intersect. This context brings out the model's explanatory depth, demonstrating its ability to account for heterogeneous user-profiles and market maturity levels, unlike most prior studies focused on digitally saturated environments in Europe and North America [11–14]. Finally, the use of PLS-SEM and Importance-Performance Matrix Analysis (IPMA) strengthens the theoretical claims by aligning predictive precision with practical priority. This methodologically integrated approach enables not only the validation of construct interrelationships but also the strategic ranking of behavioral levers for MaaS adoption. Eventually presenting a framework that is not only conceptually innovative but also actionable for policymakers and platform designers alike [101–103].

5.2. Practical implication

In regions where private vehicle dependence is high, such as the Klang Valley, improving the utility of public transport requires more than infrastructure expansion. It demands a redesign of the mobility experience that matches the convenience, reliability, and responsiveness typically associated with private car use. The empirical prominence of service quality in shaping MaaS adoption orchestrates the need to prioritize both digital interface performance and the seamless orchestration of multimodal transfers. These elements should be treated as foundational in the design and delivery of integrated transport systems. The study inferences direct that accurate real-time service, user-friendly interfaces, and quick recovery from errors are not ancillary but essential to the behavioral intention change. These conclusions highlight a broader challenge at the systems level. Public transit systems still lack the digital operational integration needed to support seamless

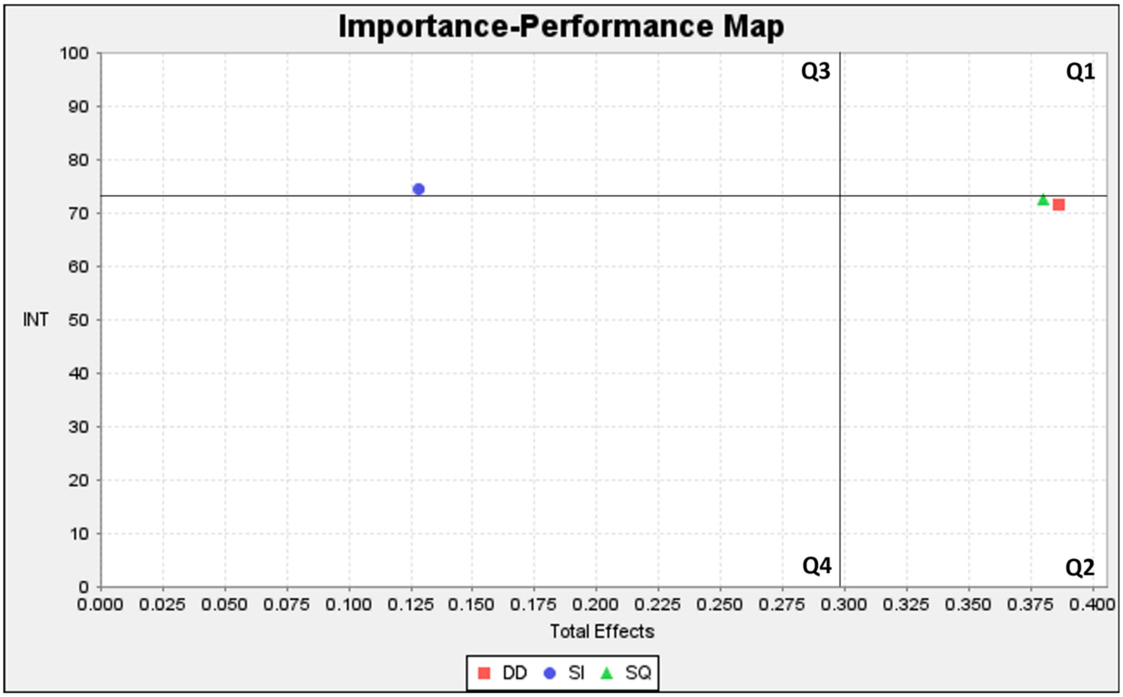

Fig. 2. IPMA diagram.

multimodality, which severely limits their potential to replace entrenched car use. Therefore, stakeholders should focus on the coordinated development of digital setup and mobility services, ensuring that system reliability is matched by high standards of user interface design. To support this, evaluation frameworks should be based on user satisfaction metrics and applied consistently across all transport modes, allowing for responsive improvements aligned with commuter expectations.

The simultaneous presence of internationally adopted MaaS platform such as Moovit alongside govt-based local applications like MyRapid PULSE illustrates an overarching trend of operational fragmentation within the MaaS ecosystem in Malaysia. While Moovit offers comprehensive multimodal coverage and high accessibility, and PULSE provides moderately detailed insights related to the Rapid KL transit system [104], neither platform has unrestricted access to integrated payment systems, universal ticketing, or service bundling, which are characteristic of more developed MaaS systems. This establishes the system's current level 1 maturity wherein advanced planning features still exist in isolation from transactional elements. Instead of considering these platforms as having competitive business models, their coexistence should be taken as a chance for convergence in the ecosystem. Regulatory and policy frameworks need to change in ways that allow for shared data frameworks, API cross-compatibility, and Touch 'n Go seamless cash payments. Such convergence would integrate fragmented services into a singular digital mobility infrastructure, thereby streamlining the transition toward level 2 and level 3 MaaS capabilities.

The emphasis of Digital Dexterity in the context of MaaS adoption requires rethinking the digital inclusion gap as a capability infrastructure challenge, rather than a question of mere access provision. In digitally advancing economies, differences in digital fluency, linked to age, location, and education, can limit equitable access to mobility services. As MaaS platforms become more integrated and real-time, the capability to navigate apps, opt for travel options, and respond to live updates is the epitome of full participation. These inferences point to the significance of user-centred design, entailing adaptable interfaces, multilingual support, and built-in guidance features, to ensure that digital mobility systems remain inclusive across diverse user groups. For developers, this means designing adaptable user interfaces and environments that respond to different levels of digital fluency. For public transport authorities, it means integrating digital capacity-building programs into broader mobility reform initiatives, especially in regions that are diverse or under-serviced demographically. If the deepening integration of MaaS platforms goes alongside asymmetric accommodation of these digital skill gaps, transport inequalities will be exacerbated instead of alleviated.

Even though Social Influence had a moderate impact as per the structural model, the IPMA performance score suggests that it functions as a potential behavioral reinforcement latent lever. In terms of infrastructure and interface optimization, this means that in addition to these factors, social frameworks and inter-people networks have the potential to serve as adoption accelerators, especially for hesitant or late-stage adopters. This orchestrates the strategically effective demand-side interventions as peer-to-peer referral programs, active commuting schemes, university partnerships, and influencers-led campaigns to shift the social norm tide towards greater adoption of sustainable mobility solutions. From the transport governance perspective, this argues for the integration of social marketing and behavioral nudges into MaaS policy frameworks as central, rather than peripheral, components to sustain virtually autocatalytic adoption processes. Especially in developing policies where formal incentive schemes might be absent, employing social validation strategies could provide a low-cost option to initiate the needed early network effects for scaling MaaS ecosystem.

The use of IPMA provides a diagnostic approach from which resource distribution across system elements can be optimally directed. As Service Quality and Digital Dexterity were identified in the analysis as high-importance and high-performance factors, it justifies investment concentration where maximum behavioral and operational impact is achieved. This approach differs from conventional multi-indicator development strategies that risk amplifying resource waste in the institution. IPMA promotes precision planning, which is inclined towards service refinements, infrastructure-enabled user capability cultivation, and, most importantly, directing resource allocation and operational efforts. This type of prioritization is best suited to emerging-market cities trying to cope with public funding limitations and the pace of digital service deployment. Thus, the study not only develops a theoretical model of MaaS adoption but also provides a practical roadmap for intervention-based systemic strategies that shift operational focus toward user-defined preference fulfillment.

Moreover, as MaaS continues to evolve, its value proposition is no longer confined to transport-only services. Research highlights the trajectory toward integrated lifestyle ecosystems, where MaaS platforms are increasingly bundled with adjacent offerings such as parcel delivery, event access, or local commerce services[105]. This convergence expands the utility of MaaS beyond commuting. It positions MaaS as a digital infrastructure for broader urban living needs. Cities transitioning toward higher maturity levels of MaaS must embrace this cross-domain functionality to unlock new layers of value and user engagement. Doing so will not only improve adoption rates but also embed MaaS more deeply into the rhythms of daily urban life, solidifying its role as a cornerstone of smart and sustainable city systems.

5.3. Limitation and future direction

This research provides a compelling theoretical and empirical framework for understanding the adoption of MaaS within the digitally transforming urban environments of Southeast Asia, yet some limitations still exist that can be addressed in future research. The implementation of cross-sectional design is a drawback because it does not capture changes in behavior over time, making it inaccessible to evaluate how users' preferences and digital skills advance with increased exposure to the platform or the maturation of the market. Adoption behavior over time in reaction to policy changes, new features, or transitioning life stages could be deeply insightful with a longitudinal or panel-based approach. Although the quantitative approach provides sufficient statistical representation, it is inadequate in capturing the emotional, situational, and experiential facets of user interaction. Employing mixed methods such as interviews, usage diaries, or ethnographic methods could shed light on what it means to use, adapt to, or disengage from MaaS services. The survey was conducted over three months, and while the data captures a broad time span, the study does not formally classify participants as early or late adopters under conventional innovation diffusion theory. Rather, it depicts users with diverse experiences in usage shaped by duration and self-reported frequency. As such, the temporal spread is not sufficient to capture generational adoption curves or track behavior over innovation lifecycle phases. Future research should consider longitudinal tracking or cohort-based segmentation to more precisely examine the dynamics of adoption timing and sustained engagement.

Geographically, the research focuses on Moovit, a globally available trip-planning application that falls under the Level 1 MaaS maturity model and does not integrate ticketing or payment systems. This context, rather than limiting the study's contribution, offers a unique opportunity for timely cross-country comparisons of early-stage MaaS platforms to investigate differing user expectations and behavior in markets with similar maturity levels. The sample for this study is concentrated on an actively engaging metropolitan area which may not represent adoption patterns in rural and low-infrastructure populated areas. Further research should look beyond the urban fringe boundary to determine how the lack of digit access, service provision, and transport infrastructure impact user engagement in those regions. Though social influence had a low direct impact and effect on behavioral intention, the high score in IPMA suggests unfulfilled work. Trust, habit, or perceived value as a mediator and/or moderator should be examined to amplify social factors that influence adoption, particularly through peer networks, community advocacy, or institutional campaigns.

Furthermore, the real-time customization of AI enhances MaaS technologies, and while these innovations continue to unfold, there is a need to study the impact of expectations and engagement models on user research. This model was also not able to include broader structural factors such as regulatory changes, economic conditions, and environmental impacts, but the system dynamics at this level are quite important for understanding personal adoption and organizational implementation. With existing external conditions like increasing fuel prices, pandemic-induced behavioral changes, and goals for sustainability, these factors should be integrated into future adoption frameworks. Collectively, these limitations can be addressed by increasing the scope of the research to build more immaculate, universal, and policy-transforming proposals focused on designing responsive and digitally robust MaaS frameworks.

6. Conclusion

This study reaffirms that the successful adoption of MaaS in urbanizing contexts, especially within developing economies, rests not only on digital innovation, but on the alignment of technological, behavioral, and social systems. Through the integrated influence of Service Quality, Digital Dexterity, and Social Influence, this research unveils a triadic pathway to sustainable urban mobility. This path values reliability, adaptability, and social endorsement as pillars of transformative commuter behavior. Service Quality appears not merely as a technical standard but as a trust architecture. It defines the interface between human expectations and digital service delivery. Digital Dexterity, in turn, reframes adoption not as a matter of access alone, but as a function of users' cognitive flexibility and digital resilience. It is pivotal in navigating nascent multimodal mobility platforms. Meanwhile, Social Influence shows the relational dynamics of adoption, where trust, norms, and community play a decisive role in reshaping mobility culture at scale. Beyond these empirical findings, the research surfaces a series of practical lessons that reimagine MaaS as more than a product, it is a public good, a sustainability instrument, and a vehicle for equity and innovation. The roadmap forward involves establishing enforceable service quality benchmarks. It includes integrating transparent and user-friendly payment systems and embedding real-time feedback mechanisms into MaaS platforms. Digital inclusion must be prioritized through community-driven literacy programs, multilingual support features, and interface personalization. It ensures that MaaS does not become another layer of exclusion for those with lower digital readiness.

Furthermore, the behavioral shift away from private vehicles demands more than functionality. It requires incentive systems that reward sustainable choices. Dynamic fare models, off-peak travel discounts, and targeted subsidies for low-income groups can catalyze a modal shift toward shared mobility. Governments, private operators, and technology firms must form synergistic alliances to create a cohesive ecosystem. The system that enables seamless intermodality while safeguarding user data, accessibility, and equity. Importantly, this transformation is incomplete without narrative change. Public awareness campaigns ought to reframe MaaS not as an alternative but as a mainstream lifestyle mobility solution, reliable, green, and empowering. As this research suggests, MaaS can serve as a foundational framework for advancing inclusive and sustainable mobility. This is markedly relevant as cities in the Global South face the dual challenges of rapid urbanization and ongoing digital transformation. The success of MaaS will depend not only on the quality of its algorithms and interfaces, but also on its integration into local cultures, social contexts, and trust networks. When fully operational, MaaS will not simply move people from one place to another. Rather, it will transform how we sustain, connect, and reimagine urban life in an increasingly globalized world.

CRediT authorship contribution statement

Waqas Ahmed: Writing – review & editing, Writing – original draft, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The author declares that there are no conflicts of interest regarding the publication of this article.

Data availability

Data will be made available on request.

References

[1] E. Alyavina, A. Nikitas, E.T. Njoya, Mobility as a service (MaaS): a thematic map of challenges and opportunities, Res. Transp. Bus. Manag. 43 (Jun. 2022) 100783, https://doi.org/10.1016/j.rtbm.2022.100783.
[2] H.C.Q. Hensher D A, D.J. Reck, Mobility as a service and private car use: evidence from the Sydney MaaS trial, Transp. Res. Part A Policy Pract. 145 (2021) 17–33.
[3] H. Makino, K. Tamada, K. Sakai, and S. Kamijo, "Solutions for urban traffic issues by ITS technologies," 2018.10.1016/j.iatssr.2018.05.003.
[4] W.C. Chan, W.H.W. Ibrahim, M.C. Lo, M.K. Suaidi, S.T. Ha, Sustainability of public transportation: an examination of user behavior to real-time gps tracking application, Sustain. 12 (22) (Nov. 2020) 1–20, https://doi.org/10.3390/su12229541.
[5] C.-F. Chen, Y.-X. Chen, Investigating the effects of platform and mobility on mobility as a service (MaaS) users' service experience and behavioral intention: empirical evidence from MeNGo, Kaohsiung, Transportation (Amst) (2022) 1–20, https://doi.org/10.1007/s11116-022-10309-5.
[6] S.K. Trivedi, P. Patra, P.R. Srivastava, A. Kumar, F. Ye, Exploring factors affecting users' Behavioral intention to adopt digital technologies: the mediating effect of social influence, IEEE Trans. Eng. Manag. (2022) 1–13, https://doi.org/10.1109/TEM.2022.3182361.
[7] J. Ye, J. Zheng, F. Yi, A study on users' willingness to accept mobility as a service based on UTAUT model, Technol. Forecast. Soc. Change 157 (2020), https://doi.org/10.1016/j.techfore.2020.120066.
[8] V. Caiati, S. Rasouli, H. Timmermans, Bundling, pricing schemes and extra features preferences for mobility as a service: sequential portfolio choice experiment, Transp. Res. Part A 131 (2020) 123–148, https://doi.org/10.1016/j.tra.2019.09.029.
[9] L. Butler, T. Yigitcanlar, A. Paz, Barriers and risks of Mobility-as-a-service (MaaS) adoption in cities: a systematic review of the literature, Cities 109 (Feb. 2021) 103036, https://doi.org/10.1016/j.cities.2020.103036.
[10] M.J. Alonso-González, S. Hoogendoorn-Lanser, N. van Oort, O. Cats, S. Hoogendoorn, Drivers and barriers in adopting Mobility as a Service (MaaS) – A latent class cluster analysis of attitudes, Transp. Res. Part A Policy Pract. 132 (Feb. 2020) 378–401, https://doi.org/10.1016/j.tra.2019.11.022.
[11] G. Smith, J. Sochor, I.C.M. Karlsson, Intermediary MaaS Integrators: a case study on hopes and fears, Transp. Res. Part A Policy Pract. 131 (Jan. 2020) 163–177, https://doi.org/10.1016/j.tra.2019.09.024.
[12] S. Huang, Listening to users' personal privacy concerns. The implication of trust and privacy concerns on the user's adoption of a MaaS-pilot, Case Stud. Transp. Policy 10 (4) (Dec. 2022) 2153–2164, https://doi.org/10.1016/j.cstp.2022.09.012.
[13] I. Lopez-Carreiro, A. Monzon, D. Lois, M.E. Lopez-Lambas, Are travellers willing to adopt MaaS? Exploring attitudinal and personality factors in the case of Madrid, Spain, Travel Behav. Soc. 25 (Oct. 2021) 246–261, https://doi.org/10.1016/j.tbs.2021.07.011.
[14] J. Schikofsky, T. Dannewald, M. Kowald, Exploring motivational mechanisms behind the intention to adopt mobility as a service (MaaS): insights from Germany, Transp. Res. Part A Policy Pract. 131 (Jan. 2020) 296–312, https://doi.org/10.1016/j.tra.2019.09.022.
[15] N. Puspitasari, M.B. Firdaus, C.A. Haris, H.J. Setyadi, An application of the UTAUT model for analysis of adoption of integrated license service information system, Procedia Comput. Sci. 161 (2019) 57–65, https://doi.org/10.1016/j.procs.2019.11.099.
[16] P. Kant, P.K. Machavarapu, H. Gajjar, Assessment of drivers and barriers in the adoption of Mobility as a Service (MaaS): a case study of Noida, India, Urban, Plan. Transp. Res. 11 (1) (Dec. 2023), https://doi.org/10.1080/21650020.2023.2247044.
[17] W. Kriswardhana, D. Esztergár-Kiss, Cluster analysis of user preferences related to MaaS aspects, in: 2023 8th International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS), IEEE, Jun. 2023, pp. 1–6, https://doi.org/10.1109/MT-ITS56129.2023.10241445.
[18] R. Ceccato, A. Baldassa, F. Orsini, R. Rossi, M. Gastaldi, MaaS adoption and sustainability for systematic trips: estimation of environmental impacts in a medium-sized City, Sustainability 15 (11) (May 2023) 8690, https://doi.org/10.3390/su15118690.
[19] I. Gulyi, V. Shavurskaya, Digital platform solutions of Russian Railways as a tool for the development of the concept of MaaS (Mobility as a Service), E3S Web Conf. 383 (Apr. 2023) 01015, https://doi.org/10.1051/e3sconf/202338301015.
[20] L. Mitropoulos, A. Kortsari, V. Mizaras, G. Ayfantopoulou, Mobility as a service (MaaS) planning and implementation: challenges and lessons learned, Futur. Transp. 3 (2) (Apr. 2023) 498–518, https://doi.org/10.3390/futuretransp3020029.
[21] Y. Fujita, M. Kuwahara, E. Ueda, MaaS blender: integration of mobility simulators for mobility as a service evaluation, IEEE Access 11 (2023) 105105–105114, https://doi.org/10.1109/ACCESS.2023.3319079.
[22] E. Rajabi, S. Nowaczyk, S. Pashami, M. Bergquist, G.S. Ebby, S. Wajid, A knowledge-based AI framework for mobility as a service, Sustainability 15 (3) (Feb. 2023) 2717, https://doi.org/10.3390/su15032717.
[23] I. Lopez-Carreiro, A. Monzon, E. Lopez, MaaS implications in the smart City: a multi-stakeholder approach, Sustainability 15 (14) (Jul. 2023) 10832, https://doi.org/10.3390/su151410832.
[24] C. Medina-Molina, M. Rey-Moreno, The determinant conditions and causal mechanisms that explain the use of micromobility services, Cuad. Gestión 24 (1) (Jan. 2024) 7–20, https://doi.org/10.5295/cdg.231965cm.
[25] C.J. Rodríguez-Rad, M.-Á. Revilla-Camacho, M.-E. Sánchez-del-Río-Vázquez, Exploring the intention to adopt sustainable mobility modes of transport among Young university students, Int. J. Environ. Res. Public Health 20 (4) (Feb. 2023) 3196, https://doi.org/10.3390/ijerph20043196.
[26] P. Ricardianto, et al., The impact of service quality, ticket price policy and passenger trust on airport train passenger loyalty, Uncertain Supply Chain Manag 11 (1) (2023) 307–318, https://doi.org/10.5267/j.uscm.2022.9.012.
[27] R.S.S.S. Vij A, S. Harris, Consumer preferences for mobility-as-a-service (MaaS) in Australia, Transp. Res. Part C Emerg. Technol. 117 (2020) 102699.
[28] T.A.P.I. Tsouros I, A. Polydoropoulou, MaaS users: who they are and how much they are willing-to-pay, Transp. Res. Part A Policy Pract. 148 (2021) 470–480.
[29] H. D. A. M. C. Ho C. Q. Y.Z. Wong, Potential uptake and willingness-to-pay for Mobility as a Service (MaaS): a stated choice study Transp. Res. Part A Policy Pract. 117 (2018) 302–318.
[30] W. Ahmed, S.M. Hizam, I. Sentosa, H. Akter, E. Yafi, J. Ali, Predicting IoT service adoption towards Smart mobility in Malaysia: sEM-neural hybrid pilot study, Int. J. Adv. Comput. Sci. Appl. 11 (1) (2020) 524–535, https://doi.org/10.14569/IJACSA.2020.0110165.
[31] S.M. Hizam, W. Ahmed, H. Akter, I. Sentosa, Understanding the public rail quality of service towards commuters' loyalty behavior in Greater Kuala Lumpur, Transp. Res. Procedia 55 (2021) 370–377, https://doi.org/10.1016/j.trpro.2021.06.043.
[32] W. Ahmed, S.M. Hizam, I. Sentosa, Digital dexterity: employee as consumer approach towards organizational success, Hum. Resour. Dev. Int. 25 (5) (Oct. 2022) 631–641, https://doi.org/10.1080/13678868.2020.1835107.
[33] M. Quddus, F. Rahman, F. Monsuur, J. de Ona, M. Enoch, Analyzing bus passengers' Satisfaction in Dhaka using discrete choice models, Transp. Res. Rec. 2673 (2) (2019) 758–768, https://doi.org/10.1177/0361198119825846.
[34] I. AlHadid, et al., Predictors for E-government adoption of SANAD app services integrating UTAUT, TPB, TAM, trust, and perceived risk, Int. J. Environ. Res. Public Health 19 (14) (Jul. 2022) 8281, https://doi.org/10.3390/ijerph19148281.
[35] E. Haskasap, T. Saner, S. Eyupoglu, C.S. Gunsel Haskasap, Influence of organizational democracy on organizational citizenship behaviors in digital transformation: mediating effects of job satisfaction and organizational commitment for smart services, Sustain 15 (1) (Dec. 2023) 452, https://doi.org/10.3390/su15010452.
[36] R. Madigan, et al., Acceptance of automated road transport systems (ARTS): an adaptation of the UTAUT model, Transp. Res. Procedia 14 (0) (2016) 2217–2226, https://doi.org/10.1016/j.trpro.2016.05.237.
[37] W.K. Zhang, M.J. Kang, Factors affecting the use of facial-recognition payment: an example of Chinese consumers, IEEE Access 7 (2019) 154360–154374, https://doi.org/10.1109/ACCESS.2019.2927705.
[38] W. Madhlangobe, "Assessment of factors influencing intent-to-use big data analytics in organization in a post-adoption context : a survey study research questions," no. 1054, pp. 1–6, 2016.
[39] Thong Venkatesh, Xu, Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology, MIS Q 36 (1) (2012) 157, https://doi.org/10.2307/41410412.
[40] S. Sahoo, N. Islam, A. Kumar, S.K. Mangla, Exploring relationship between digital dexterity, supply chain quality management, agility and performance – Empirical evidence from Indian B2B manufacturers, Ind. Mark. Manag. 127 (May 2025) 44–61, https://doi.org/10.1016/j.indmarman.2025.03.008.
[41] S.M. Hizam, W. Ahmed, H. Akter, I. Sentosa, M.N. Masrek, Web 3.0 adoption behavior: PLS-SEM and sentiment analysis, in: CEUR Workshop Proceedings (DBIS-2022 Conference, LATVIA), CEUR-WS, Riga, LATVIA, 2022, pp. 113–126.
[42] R. Giesecke, T. Surakka, M. Hakonen, Conceptualising mobility as a service, in: 2016 Eleventh International Conference on Ecological Vehicles and Renewable Energies (EVER), IEEE, Apr. 2016, pp. 1–11, https://doi.org/10.1109/EVER.2016.7476443.
[43] J. Turienzo, P. Cabanelas, J.F. Lampón, The mobility industry trends through the lens of the social analysis: a multi-level perspective approach, SAGE Open 12 (1) (Jan. 2022) 215824402110691, https://doi.org/10.1177/21582440211069145.
[44] A.H.K.I.M. Sochor J, S. Sarasini, A topological approach to Mobility as a Service: a proposed tool for understanding requirements and effects, and for aiding the integration of societal goals, Res. Transp. Bus. Manag. 27 (2018) 3–14.
[45] R. Utriainen, M. Pöllänen, Review on mobility as a service in scientific publications, Res. Transp. Bus. Manag. 27 (Jun. 2018) 15–23, https://doi.org/10.1016/j.rtbm.2018.10.005.
[46] P. Jittrapirom, V. Marchau, R. van der Heijden, H. Meurs, Future implementation of mobility as a service (MaaS): results of an international Delphi study, Travel Behav. Soc. 21 (Oct. 2020) 281–294, https://doi.org/10.1016/j.tbs.2018.12.004.
[47] J. Eckhardt, A. Aapaoja, L. Nykänen, J. Sochor, M. Karlsson, The European Roadmap 2025 for mobility as a service, Transp. Res. procedia (2018).
[48] A. Polydoropoulou, I. Pagoni, A. Tsirimpa, Ready for Mobility as a Service? Insights from stakeholders and end-users, Travel Behav. Soc. 21 (Oct. 2020) 295–306, https://doi.org/10.1016/j.tbs.2018.11.003.
[49] S. Paiva, F. Mourao, Mobility-as-a-service challenges and opportunities in the post-pandemic, in: 2021 IEEE Global Conference on Artificial Intelligence and Internet of Things (GCAIoT), IEEE, Dec. 2021, pp. 136–141, https://doi.org/10.1109/GCAIoT53516.2021.9693025.

[50] B. Maas, Literature Review of Mobility as a service, Sustainability 14 (14) (Jul. 2022) 8962, https://doi.org/10.3390/su14148962.
[51] R.G. Mugion, M. Toni, H. Raharjo, L. Di Pietro, S.P. Sebathu, Does the service quality of urban public transport enhance sustainable mobility? J. Clean. Prod. 174 (2018) 1566–1587, https://doi.org/10.1016/j.jclepro.2017.11.052.
[52] D.Q. Nguyen-Phuoc, D.N. Su, P.T.K. Tran, D.T.T. Le, L.W. Johnson, Factors influencing customer's loyalty towards ride-hailing taxi services – A case study of Vietnam, Transp. Res. Part A Policy Pract. 134 (2020) 96–112, https://doi.org/10.1016/j.tra.2020.02.008.
[53] A.Kumar Bhardwaj, A. Garg, Y. Gajpal, Determinants of blockchain technology adoption in supply chains by small and medium enterprises (SMEs) in India, Math. Probl. Eng. 2021 (Jun. 2021) 1–14, https://doi.org/10.1155/2021/5537395.
[54] Y.W. Kim, C. Lim, Y.G. Ji, Exploring the user acceptance of Urban air mobility: extending the technology acceptance model with trust and service quality factors, Int. J. Human–Computer Interact. 39 (14) (Aug. 2023) 2893–2904, https://doi.org/10.1080/10447318.2022.2087662.
[55] S. Nazari Enjedani, E. Alvandi Behineh, K. Tehranian, S. Jazayerifar, S. Saeidi, Factors affecting public transportation use during Pandemic, Teh. Glas. 18 (3) (Jul. 2024) 342–353, https://doi.org/10.31803/tg-20230601145322.
[56] A. Ongel, H. Cornet, P. Kong, R. Khoo, T. Liu, M. Kloeppel, Public transport service quality improvement using universal design standards and advanced vehicle technologies, in: 2018 International Conference on Intelligent Autonomous Systems (ICoIAS), IEEE, Mar. 2018, pp. 211–216, https://doi.org/10.1109/ICoIAS.2018.8494057.
[57] T. Eccarius, C.C. Lu, Adoption intentions for micro-mobility – Insights from electric scooter sharing in Taiwan, Transp. Res. Part D Transp. Environ. 84 (2020), https://doi.org/10.1016/j.trd.2020.102327.
[58] I.P. Tussyadiah, F.J. Zach, J. Wang, Attitudes toward autonomous on demand mobility system: the case of self-driving taxi, in: R. Schegg, B. Stangl (Eds.), Information and Communication Technologies in Tourism 2017, Information and Communication Technologies in Tourism 2017, 156, Springer International Publishing, Cham, 2017, pp. 755–766, https://doi.org/10.1007/978-3-319-51168-9_54.
[59] M.T. Alshurideh, B. Al Kurdi, Factors affecting social networks acceptance: an extension to the technology acceptance model using PLS-SEM and Machine learning approach, Int. J. Data Netw. Sci. 7 (1) (2023) 489–494, https://doi.org/10.5267/j.ijdns.2022.8.010.
[60] W.J. Obidallah, et al., Beyond the hype: a TAM-based analysis of blockchain adoption drivers in construction industry, Heliyon 10 (19) (Oct. 2024) e38522, https://doi.org/10.1016/j.heliyon.2024.e38522.
[61] M.G. Salimon, O. Kareem, S.S.M. Mokhtar, O.A. Aliyu, J.A. Bamgbade, A. Q. Adeleke, Malaysian SMEs m-commerce adoption: TAM 3, UTAUT 2 and TOE approach, J. Sci. Technol. Policy Manag. 14 (1) (Feb. 2023) 98–126, https://doi.org/10.1108/JSTPM-06-2019-0060.
[62] N. Rizun, C. Alexopoulos, S. Saxena, F. Kleiman, R. Matheus, How do personality traits influence Open Government Data (OGD) adoption and usage? Investigating the indirect and moderating effects, in: ACM Int. Conf. Proceeding Ser., 2023, pp. 458–467, https://doi.org/10.1145/3598469.3598521.
[63] T.-Y. Pak, B. Bae, C. Lee, I. Jung, B.-J. Jang, Modeling public acceptance of demand-responsive transportation: an integrated UTAUT and ITM framework, J. Public Transp. 25 (2023) 100067, https://doi.org/10.1016/j.jpubtr.2023.100067.
[64] D. Soule, A. Puram, G. Westerman, and D. Bonnet, "Becoming a digital organization: the journey to digital dexterity," 301, 2016.
[65] D. Bonnet, A.D. Puram, J. Buvat, S. KVJ, and A. Khadikar, "Organizing for digital : why digital dexterity matters organizational design is key to reaping the rewards from technology adoption," pp. 1–17, 2015.
[66] Gartner, "Executive guidance: digital dexterity at work," 2018. [Online]. Available: https://www.gartner.com/en/executive-guidance/digital-dexterity.
[67] Gartner, "Executive guidance: digital dexterity at work," *Gartner*, no. October, pp. 1–29, 2018, [Online]. Available: https://www.gartner.com/en/executive-guidance/digital-dexterity.
[68] H. Akter, W. Ahmed, I. Sentosa, S.M. Hizam, F.H. Sharin, I. Mina, Building a better future workforce: digital dexterity and psychological empowerment, in: 2023 3rd International Conference on Computing and Information Technology (ICCIT), IEEE, Sep. 2023, pp. 626–632, https://doi.org/10.1109/ICCIT58132.2023.10273912.
[69] D. Bonnet, A.D. Puram, J. Buvat, S. KVJ, and A. Khadikar, "Organizing for digital : why digital dexterity matters organizational design is key to reaping the rewards from technology adoption," 2015.
[70] A. Adhiatma, O. Fachrunnisa, K. Sudarti, Individual dexterity and psychological empowering leadership for digital workplace, Int. J. Technol. Hum. Interact. 18 (1–21) (2022), https://doi.org/10.4018/IJTHI.299354.
[71] A.A. Alalwan, A.M. Baabdullah, N.P. Rana, K. Tamilmani, Y.K. Dwivedi, Examining adoption of mobile internet in Saudi Arabia: extending TAM with perceived enjoyment, innovativeness and trust, Technol. Soc. 55 (Nov. 2018) 100–110, https://doi.org/10.1016/j.techsoc.2018.06.007.
[72] J. Cao, Y. Shang, Q. Mok, I.K.-W. Lai, The impact of personal innovativeness on the intention to use cloud classroom: an empirical study in China, in: S. Cheung, J. Jiao, L. Lee, X. Zhang, K. Li, Z. Zhan (Eds.), Communications in Computer and Information Science, Communications in Computer and Information Science, 1048, Springer, Singapore, 2019, pp. 179–188, https://doi.org/10.1007/978-981-13-9895-7_16.
[73] S.K. Sharma, Integrating cognitive antecedents into TAM to explain mobile banking behavioral intention: a SEM-neural network modeling, Inf. Syst. Front. 21 (4) (2019) 815–827, https://doi.org/10.1007/s10796-017-9775-x.
[74] S. Kim, G. Garrison, Understanding users' behaviors regarding supply chain technology: determinants impacting the adoption and implementation of RFID technology in South Korea, Int. J. Inf. Manage. 30 (5) (Oct. 2010) 388–398, https://doi.org/10.1016/j.ijinfomgt.2010.02.008.
[75] R. Thakur, M. Srivastava, Adoption readiness, personal innovativeness, perceived risk and usage intention across customer groups for mobile payment services in India, Internet Res 24 (3) (2014) 369–392, https://doi.org/10.1108/IntR-12-2012-0244.
[76] Y.-H. Cheng, T.-Y. Huang, High speed rail passengers' mobile ticketing adoption, Transp. Res. Part C Emerg. Technol. 30 (May 2013) 143–160, https://doi.org/10.1016/j.trc.2013.02.001.
[77] C. Morton, J. Anable, J.D. Nelson, Research in transportation business & management exploring consumer preferences towards electric vehicles : the in fl uence of consumer innovativeness, Rtbm (2016), https://doi.org/10.1016/j.rtbm.2016.01.007.
[78] R.A. Acheampong and F. Cugurullo, "Capturing the behavioural determinants behind the adoption of autonomous vehicles: conceptual frameworks and measurement models to predict public transport, sharing and ownership trends of self-driving cars," 2019.10.1016/j.trf.2019.01.009.
[79] Z. Lin, R. Filieri, Airline passengers' continuance intention towards online check-in services: the role of personal innovativeness and subjective knowledge, Transp. Res. Part E Logist. Transp. Rev. 81 (2015) 158–168, https://doi.org/10.1016/j.tre.2015.07.001.
[80] Y. Wang, S. Wang, J. Wang, J. Wei, C. Wang, An empirical study of consumers' intention to use ride-sharing services: using an extended technology acceptance model, Transportation (Amst) (2018), https://doi.org/10.1007/s11116-018-9893-4.
[81] B.C. Altay, A. Okumuş, User adoption of integrated mobility technologies: the case of multimodal trip-planning apps in Turkey, Res. Transp. Bus. Manag. (2021), https://doi.org/10.1016/j.rtbm.2021.100706 xxxx.
[82] M. Barth, P. Jugert, I. Fritsche, Still underdetected - social norms and collective efficacy predict the acceptance of electric vehicles in Germany, Transp. Res. Part F Traffic Psychol. Behav. 37 (2016) 64–77, https://doi.org/10.1016/j.trf.2015.11.011.
[83] R. Madigan, T. Louw, M. Wilbrink, A. Schieben, N. Merat, What influences the decision to use automated public transport? Using UTAUT to understand public acceptance of automated road transport systems, Transp. Res. Part F Traffic Psychol. Behav. 50 (2017) 55–64, https://doi.org/10.1016/j.trf.2017.07.007.
[84] S. Nordhoff, V. Malmsten, B. van Arem, P. Liu, and R. Happee, "A structural equation modeling approach for the acceptance of driverless automated shuttles based on constructs from the Unified Theory of Acceptance and Use of Technology and the Diffusion of Innovation Theory," 2021.10.1016/j.trf.2021.01.001.
[85] R.N.R. Ariffin, R.K. Zahari, Towards a sustainable urban transport system in the Klang Valley, Malaysia: the key challenges, Procedia - Soc. Behav. Sci. 85 (2013) 638–645, https://doi.org/10.1016/j.sbspro.2013.08.391.
[86] A. AlHogail, M. AlShahrani, Building consumer trust to improve Internet of Things (IoT) technology adoption, Adv. Intell. Syst. Comput. 775 (2019) 325–334, https://doi.org/10.1007/978-3-319-94866-9_33.
[87] J. Globisch, E. Dütschke, J. Schleich, Acceptance of electric passenger cars in commercial fleets, Transp. Res. Part A Policy Pract. 116 (June) (2018) 122–129, https://doi.org/10.1016/j.tra.2018.06.004.
[88] S.Y. Chen, Using the sustainable modified TAM and TPB to analyze the effects of perceived green value on loyalty to a public bike system, Transp. Res. Part A Policy Pract. 88 (2016) 58–72, https://doi.org/10.1016/j.tra.2016.03.008.
[89] S.M. Hizam, H. Akter, I. Sentosa, W. Ahmed, Digital competency of educators in the virtual learning environment: a structural equation modeling analysis, in: IOP Conference Series: Earth and Environmental Science, IOP Press, Yogyakarta, Indonesia, Mar. 2021 012023, https://doi.org/10.1088/1755-1315/704/1/012023.
[90] J.F. Hair, Research methods for business, Educ. + Train. 49 (4) (2007) 336–337, https://doi.org/10.1108/et.2007.49.4.336.2.
[91] R. Bougie, U. Sekaran, Research methods for business: a skill building approach, Long Range Plann. 26 (2) (1993) 136, https://doi.org/10.1016/0024-6301(93)90168-f.
[92] S. Hoeffler, Measuring preferences for really new products, J. Mark. Res. 40 (4) (Nov. 2003) 406–420, https://doi.org/10.1509/jmkr.40.4.406.19394.
[93] V. Venkatesh, M.G. Morris, G.B. Davis, F.D. Davis, User acceptance of information technology: toward a unified view, MIS Q 27 (3) (2003) 425–478 [Online]. Available: http://www.jstor.org/stable/30036540.
[94] J.F. Hair, G.T.M. Hult, C.M. Ringle, M. Sarstedt, N.P. Danks, S. Ray, Partial Least Squares Structural Equation Modeling (PLS-SEM) Using R: A Workbook, Springer Nature, Cham, Switzerland, 2021, https://doi.org/10.1007/978-3-030-80519-7.
[95] J. García-Fernández, J. Fernández-Gavira, A.J. Sánchez-Oliver, P. Gálvez-Ruíz, M. Grimaldi-Puyana, G. Cepeda-Carrión, Importance-performance matrix analysis (Ipma) to evaluate servicescape fitness consumer by gender and age, Int. J. Environ. Res. Public Health 17 (18) (2020) 1–19, https://doi.org/10.3390/ijerph17186562.
[96] M. Soelton, N. Noermijati, F. Rohman, M. Mugiono, I.N. Aulia, R.E. Siregar, Reawakening perceived person organization fit and perceived person job fit: removing obstacles organizational commitment, Manag. Sci. Lett. 10 (2020) 2993–3002, https://doi.org/10.5267/j.msl.2020.5.026.

[97] J.F. Hair, J.J. Risher, M. Sarstedt, C.M. Ringle, When to use and how to report the results of PLS-SEM, Eur. Bus. Rev. 31 (1) (2019) 2–24, https://doi.org/10.1108/EBR-11-2018-0203.

[98] M. Sarstedt, C.M. Ringle, J.F. Hair, Partial least squares structural equation modeling. *Handbook of Market Research*, in Classroom Companion: Business, Springer International Publishing, Cham, 2021, pp. 1–47, https://doi.org/10.1007/978-3-319-05542-8_15-2.

[99] C.M. Ringle, M. Sarstedt, Gain more insight from your PLS-SEM results, Ind. Manag. Data Syst. 116 (9) (Oct. 2016) 1865–1886, https://doi.org/10.1108/IMDS-10-2015-0449.

[100] X. Pan, Technology acceptance, technological self-efficacy, and attitude toward Technology-based self-directed learning: learning motivation as a mediator, Front. Psychol. 11 (Oct. 2020) 1–11, https://doi.org/10.3389/fpsyg.2020.564294.

[101] G. Tomaino, et al., Mobility as a service (MaaS): the importance of transportation psychology, Mark. Lett. 31 (4) (Dec. 2020) 419–428, https://doi.org/10.1007/s11002-020-09533-9.

[102] Y. Zhang, M. Kamargianni, A review on the factors influencing the adoption of new mobility technologies and services: autonomous vehicle, drone, micromobility and mobility as a service, Transp. Rev. (Sep. 2022) 1–23, https://doi.org/10.1080/01441647.2022.2119297.

[103] G. Lyons, P. Hammond, K. Mackay, The importance of user perspective in the evolution of MaaS, Transp. Res. Part A Policy Pract. 121 (Mar. 2019) 22–36, https://doi.org/10.1016/j.tra.2018.12.010.

[104] MyRapid, "Myrapid PULSE," MyRapid. [Online]. Available: https://myrapid.com.my/pulse/mobile-app/.

[105] M. Le Pira, L.A. Tavasszy, G.H. de, A. Correia, M. Ignaccolo, G. Inturri, Opportunities for integration between Mobility as a Service (MaaS) and freight transport: a conceptual model, Sustain. Cities Soc. 74 (Nov. 2021) 103212, https://doi.org/10.1016/j.scs.2021.103212.