



Factors influencing usage and loyalty for payment app customers in Saudi Arabia

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ABSTRACT

Purpose: The present study is intended to determine the factors influencing the acceptance and loyalty towards payment of mobile applications in the Kingdom of Saudi Arabia, focusing on perceived convenience, security, compliance, and trust.

Design/methodology/approach: This research study adopted a quantitative method by using a questionnaire and targeting mobile payment app users as well as business entrepreneurs in Saudi Arabia. The survey yielded 290 fully completed questionnaires from the participants. Partial least squares equation modeling (PLS-SEM) was used to analyze the data.

Findings: The present study highlights that users' trust in mobile payment applications is primarily influenced by their perceptions of convenience and security, significantly affecting customer loyalty and app usage frequency. Compliance was found to have a less pronounced impact on trust.

Research limitations/implications: The study acknowledges the need for a diverse methodological framework in future research, including qualitative methods, to deepen understanding.

Practical implications: Insights are provided not only for FinTech companies but also for the policymakers, emphasizing the importance of user-centric design and supportive regulatory environments.

Social implications: The study's findings may lead to the progress of digital financial services that will allow parallel users' security, convenience, and trust needs, contributing to the broader acceptance and sustainability of these technologies.

Originality: This study offers a unique perspective by integrating technological advancements and demographic factors specific to Saudi Arabia, distinguishing it from prior research. It provides fresh insights into how convenience, security, and compliance influence user trust and loyalty within a rapidly evolving FinTech landscape.

1. Introduction

The implementation of mobile payment systems initially encountered numerous challenges, including tough competition, privacy concerns, limited user knowledge, complexity, and security issues. These difficulties, outlined by (de Luna et al., 2019), presented significant barriers to the widespread acceptance of this technology. Despite these initial hurdles, the landscape has shifted considerably, propelled by rapid technological advancements, consumer behavior, and lifestyle changes. This global transition, particularly in the financial services

industry, has profoundly transformed consumer habits, with mobile devices becoming a primary tool for making payments (Flavián et al., 2020). The impact of this technological revolution is especially evident in Saudi Arabia, where mobile internet user penetration is expected to reach about 97 % by 2025 (Alswaigh & Aloud, 2021).

This surge in mobile technology usage has dramatically altered lifestyles and behaviors, contributing to the prompt development of e-payment activities. The incorporation of mobile technology with payment solutions has gained widespread popularity and experienced significant global growth (Zhang et al., 2023). This trend follows the

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anticipated growth of the global e-commerce market, predicted to increase from USD 2.8 trillion in 2022 to USD 4.9 trillion by 2027, representing a compound annual growth (CAGR) of 12.2 % (Almaiah et al., 2022). Likewise, mobile payment transactions reached \$2.3 trillion in 2023 and are expected to grow by 15 % between 2023 and 2027. While U.S. brands like PayPal, Apple Pay, and Google Pay dominate the global markets, the countries with the highest implementation of mobile payment solutions are located in the continent of Asia, instead of Europe and the United States (Best, 2024).

This transformation is underpinned by the rapid evolution of Financial Technology (FinTech), which integrates advanced technological innovations with financial services to enhance and streamline financial accessibility for better efficiency (Jalal et al., 2023). Globally, the FinTech sector has exhibited exponential growth. Likewise, the Fintech sector in Saudi Arabia reached approximately USD 64 billion by the end of 2024, mainly due to extensive state and private investments. Digital payment systems, in particular, are one of the fastest growing Fintech areas, making financial services available to previously unbanked communities. Notably, digital payments now account for 70 % of retail transactions in Saudi Arabia, which shows a move towards a more inclusive and tech-driven economic landscape (Capital, 2024). This growth trajectory aligns with the Saudi Arabian Monetary Agency's (Samartha et al., 2022) initiatives under Saudi Vision 2030, which include fostering e-transactions to strengthen the Kingdom's economic development (Almuhammadi, 2020). Saudi Arabian Monetary Agency's (Samartha et al., 2022) role extends to formulating and supervising an industrial payment system, catalyzing the Kingdom's economic growth through strategic engagement with financial entities (Almaiah et al., 2022).

The current literature on mobile payment apps covers diverse regions such as Italy (Migliore et al., 2022), the United States (Arli & Bakpayev, 2023), India (Srivastava et al., 2024), and China (Hosain & Kamal, 2024) provides significant insights into consumer behavior in digital payments. However, these studies have not fully addressed critical aspects, e.g., the payment app usage frequency and how demographic factors such as education, gender, and age might impact users' loyalty. In Saudi Arabia, the shift towards cashless transactions is driven by advancements in mobile technologies and the Saudi Central Bank's (Samartha et al., 2022) efforts to foster technological localization (Almuhammadi, 2020). SAMA plays a key role by promoting locally tailored payment solutions and enhancing trust through regulatory frameworks like the Saudi Payments system. In Saudi Arabia, Gull et al. (2022) examined how mobile payment methods are utilized and integrated within e-commerce applications. The authors aimed to enhance customer perception and usability of mobile payment methods. However, their study lacks an in-depth analysis of important aspects of these apps, like convenience, trust, security, and compliance, that are relevant in the determination of loyalty as well as usage frequency.

This study endeavors to report these gaps and emphasizes the unique needs of payment app users in Saudi Arabia, especially when considering recent changes like the introduction of national payment systems such as Mada Pay and STC Pay; this study adopts a contemporary approach to exploring these areas. Additionally, Yi et al. (2024) emphasized quality factors like app design, security, customer service, and payment convenience using text analytics of user reviews. However, they identify significant gaps in understanding how demographic factors like gender, education level, and age influence user loyalty and usage frequency. Similarly, Almaiah et al. (2022) suggest further research to explore additional variables, such as consumer education and awareness levels, highlighting the importance of addressing behavioral and contextual factors for mobile payment adoption. However, it's worth mentioning that the rise in mobile payments globally is also accompanied by security challenges, as evidenced by the 39 % of mobile-based fraudulent transactions in the USA in 2021. This study thus addresses these shortcomings by incorporating demographic factors into the framework and exploring the role of perceived convenience, security,

legal compliance, and trust in influencing customer loyalty and usage frequency in specific Saudi Arabian contexts.

Regarding selecting various constructs for this study, trust, security, compliance, and customer loyalty are deeply rooted in established theories and frameworks in technology adoption and consumer behavior. The role of perceived use and usefulness is emphasized in the technology acceptance model (TAM) framework, which is in accordance with convenience as a vital component of adopting technology (Al-Hattami et al., 2023; Davis, 1989). Trust, compliance, and security are also integral to the Unified Theory of Acceptance and Use of Technology (UTAT) and its extensions. These facts highlight a thoughtful need for trust in mitigating perceived risk and promoting technology acceptance (Al-Saedi & Al-Emran, 2021; Venkatesh et al., 2003). Furthermore, the loyalty concept has already been examined extensively with the Expectation Confirmation Theory (ECT) which links customer satisfaction to trust and continuous use (AlSokkar et al., 2024; Oliver, 1980). These theoretical footings justify analyzing these constructs in the context of payment apps, particularly in an emerging economy like Saudi Arabia, where the cultural and regulatory environment continuously shapes customer behavior.

This study addresses several research questions, focusing on the intricate connections between perceived convenience, compliance security, trust, payment app usage, and customer loyalty, and how age and education moderate the relationship between trust and pay-tech app usage. The significance of the present study is to potentially illuminate the influential elements, such as trust and convenience, that mold the adoption and loyalty towards FinTech mobile payment apps in Saudi Arabia. These findings may provide valuable perceptions for the policymakers and businesses in this rapidly evolving sector.

The paper's structure comprises the following sections: Section 2 formulates hypotheses development, Section 3 summarizes the research methodology which is followed by Section 4 representing the study's findings, however, an extensive discussion is mentioned in Section 5, and lastly, Section 6 delivers a concise conclusion.

2. Literature review and hypotheses development

2.1. Theoretical presentation

Developed by Davis (1989), the Technology Acceptance Model (TAM) argues that technology adoption is greatly affected by perceived ease of use, and perceived usefulness. The latter term refers to the level to which one perceives that utilizing a particular technology will improve one's performance (He et al., 2018), while the perceived ease of use is the extent to which an individual considers it easy to practice the technology. Collectively, these structures shape a user's disposition towards technology utilization, therefore impacting behavioral intention and actual usage (Kashada & AllaEddinGhaydi, 2020). In this study, we adapt the Technology Acceptance Model (TAM) to better suit the particular context of mobile payment acceptance. In particular, we introduce additional constraints influencing trust in mobile payments: perceived convenience, compliance, and security. These factors serve as antecedents to perceived trust in mobile payment systems. According to TAM, customers are more likely to trust a system if it is convenient and easy to use. Compliance with regulatory standards boosts consumer confidence by ensuring adherence to security measures and protecting against risks (Howells, 2020). In addition, perceived security is crucial, as users are more willing to interact with a system that protects financial dealings (Chellappa & Pavlou, 2002). Therefore, this study extends TAM by incorporating these factors as important antecedents to trust in adopting mobile payments.

Moreover, the construct of perceived usefulness is expanded to include factors such as trust, convenience, and system security, which are critical considerations for consumers when selecting a mobile payment system. Likewise, perceived ease of use includes aspects such as how easy it is for app interfaces to be intuitive, how convenient it is to

associate payment options, and how convenient it is to get things done during a transaction. These make the constructs directly applicable to the dynamic nature of mobile payments.

TAM has been the prevailing model for the investigation of mobile payment adoption during the last two decades. For example, using the TAM framework, [Almaiah et al. \(2022\)](#) emphasize the influence of social factors, trust, and information quality on user behavior for mobile payment adoption. [Alswaigh and Aloud \(2021\)](#) highlighted the significance of compatibility and perceived usefulness within a cultural context. [Sinha et al. \(2024\)](#) discussed behavioral intention and financial inclusion through the UTAUT-2 model. Whereas [Lei et al. \(2022\)](#) indicated that trust, convenience, and system security positively influence mobile payment adoption but negatively affect ATM usage. [Table 1](#) provides an overview of prior research that has utilized the Technology Acceptance Model (TAM) in the context of mobile payment applications.

Various perspectives highlight the evolving role of mobile payment systems, from enabling seamless transactions to integrating advanced financial technologies. Multiple studies have used different perspectives to emphasize its utility. For example, [Hsiao \(2019\)](#) uses the expectancy-value theory framework to explain how mobile payment services facilitate value co-creation between consumers and merchants. [Chakraborty et al. \(2022\)](#) highlight that trust, customer involvement, and consumption values bridge value gaps, enhancing user engagement and trust in mobile payments. [Bertilsson and Hult \(2013\)](#) highlight how mobile payment systems make transactions faster, support instant payments,

and meet user needs, helping drive their adoption and ease of use in Sweden. Similarly, [Taylor \(2016\)](#) indicates that mobile payments make the shopping experience faster, more convenient, and more easily connected with loyalty programs, enhancing both customer experience and business operations.

[Saha and Sanyal \(2014\)](#) distinguish mobile payments into two types: remote and proximity. Remote payments do not involve direct interaction with the merchant's POS system, allowing customers to use various apps for transactions. Proximity payments, conversely, involve direct interaction with the POS system, often facilitated by NFC technology, enabling efficient transaction completion. This mobile payment evolution, crucial to e-commerce growth, sees a rapid adoption rate globally, especially in emerging markets. Studies, such as those by [Talwar et al. \(2020\)](#) and [Tavera-Mesías et al. \(2023\)](#), further delve into the factors influencing mobile payment adoption, noting significant impacts of perceived usefulness, trust, and gender differences on user behavior and technology adoption. [Long et al. \(2023\)](#) explore the effects of financial literacy on ePayment services adoption in Japan, highlighting the positive correlation between financial literacy and ePayment adoption.

Recent studies on mobile payment adoption have emphasized various factors influencing user attitudes and intentions. [Raffinal and Senalasari \(2021\)](#) applied the TAM, showing that perceived usefulness and ease of use significantly affect user intentions and attitudes. [Shankar and Datta \(2018\)](#) found that perceived utility, self-efficacy, and simplicity are key drivers in India, but personal innovation and societal norms showed little impact. [Thakur and Srivastava \(2014\)](#) emphasized that adoption readiness acts as a mediator between the influence of ease of use and social influence and facilitates changes in behavioral intentions. [S. Moghavvemi et al. \(2021\)](#) focused on the merchant perspective, identifying efficiency, security, and convenience as adoption motivators, while complexity, cost, and technological compatibility were barriers. These studies collectively enhance the understanding of mobile payment adoption, underlining the importance of ease of use, usefulness, utility, and social influences across different cultural contexts.

2.2. Hypotheses development

Convenience is a powerful motivator in mobile payment system adoption, primarily impacting user expectations and attitudes. As posited by [Obe and Balogun \(2007\)](#) and furthered by [Lai and Liew \(2021\)](#), the convenience of mobile payment, as indicated by its efficiency and ease of use, played a critical role in its perceived value, especially in e-commerce. This convenience is even more appealing in cash-centric societies, predominantly developing countries, as demonstrated by [Liu et al. \(2019\)](#).

As consumers become more accustomed to mobile payment technologies, they increasingly perceive them as more convenient, which in turn strengthens their trust and engagement with these platforms ([Hu et al., 2023; Williams, 2021](#)). [Boden et al. \(2020\)](#) emphasize that mobile payments offer greater convenience and effectiveness when compared to conventional payment methods such as cash and credit cards, enhance user satisfaction, and drive higher adoption rates. These insights suggest that making mobile payments more user-friendly and seamlessly integrated into everyday transactions can foster trust and encourage widespread adoption ([Tan et al., 2025](#)).

Moreover, trust is highlighted as a crucial component in adopting new technologies like e-business and mobile wallet payments, as described by [Abu-Taieh et al. \(2022\); Al Nawayseh \(2020\)](#), and [Almaiah et al. \(2022\)](#). Without the perception of trust, users may hesitate to adopt even the most convenient payment methods. In the context of online payments, trust refers to the user's belief in the dependability and safety of the service, including concerns like privacy and transaction errors. This trust is seen as a vital element that enhances behavioral intentions in the mobile financial and fintech sectors ([Hu et al., 2023](#)). Based on the established importance of both convenience and trust in the adoption of

Table 1

Previous studies adopted TAM theory on mobile payment apps.

Author	Country	Context	Outcome
Raffinal and Senalasari (2021)	Indonesia	Mobile Payment Adoption During COVID-19	Perceived usefulness, trust, and attitude significantly impact customers' intentions to use mobile payment systems, especially during the COVID-19 pandemic.
Yang et al. (2023)	Taiwan	Investigating older adults' mobile payment adoption in Taiwan using advanced combined theoretical models and perceived risk factors	Usefulness, ease of use, observability, and trust, with performance and financial risks affecting trust
Kelly and Palaniappan (2023)	Ghana	Examining factors affecting continued use of mobile money in Ghana using TAM among users in Savannah and Bono regions.	Users' attitudes and continued usage are influenced by perceived risk, cost, social influence, usefulness, ease of use, and trust.
Ali et al. (2022)	Pakistan	Exploring factors affecting m-payment adoption and usage in Karachi, Pakistan	Facilitators, and barriers influencing customers' intentions and behaviors towards m-payment adoption
Ullah et al. (2022)	Pakistan	focusing on the role of financial skills and digital literacy using e-payment	Perceived usefulness, digital literacy directly impacts intention through perceived ease of use, offering insights for theory and practice in mobile financial services
Li et al. (2019)	China	This paper examines Alipay user attitudes using an extended TAM, focusing on risk perception, usefulness, and ease of use.	Ease of use and usefulness positively affect Alipay use intentions, while risk perception negatively influences these factors and user attitudes.

(Source: Authors' own work.)

mobile payments, it is hypothesized that:

H1. Perceived convenience positively influences users' perceived trust in mobile payment.

Regulatory compliance is a key factor in building trust in mobile payment adoption. When platforms adhere to security regulations and industry standards, users feel more confident that their financial transactions are safe and protected. [Shin \(2009\)](#) emphasizes that compliance enhances user confidence, while [Wu et al. \(2021\)](#) highlight how strong regulatory measures help mitigate security risks, ultimately boosting the credibility of mobile payment platforms. [Xue et al. \(2022\)](#) further support this by showing that compliance with industry standards improves transaction security, reinforcing customer trust. Additionally, [Al-Sharafi et al. \(2021\)](#) found that mobile payment apps with precise compliance mechanisms experience higher user trust and engagement. Similarly, [Bajwa et al. \(2023\)](#) state that efforts to prevent online fraud and ensure customer account security reassure users and strengthen digital payment systems. As financial transactions increasingly shift to digital platforms, ensuring adherence to security protocols and regulatory standards is crucial for fostering long-term trust and encouraging widespread adoption of mobile payments.

H2. Compliance positively influences users' perceived trust in mobile payments.

Perceived security is a crucial factor in building trust in mobile payment systems. Users need to feel confident that their financial data and transactions are protected against fraud, breaches, and unauthorized access. [Fan et al. \(2018\)](#) identify two fundamental security components—technology-based safeguards and security policies—that enhance user confidence in mobile payments by ensuring a safe transaction environment. Similarly, [Almaiah et al. \(2022\)](#) found that implementing strong encryption and multi-layered security measures significantly improves trust and adoption rates in NFC-based mobile payments.

Despite these advancements, privacy concerns and security risks continue to be major obstacles to widespread adoption ([Trinh et al., 2021](#); [Usman et al., 2022](#)). Consumers are particularly concerned about potential data leaks, identity theft, and cybersecurity threats, which can discourage them from fully embracing digital payment solutions. Additionally, [Shao et al. \(2019\)](#) suggest that perceived security affects different consumer groups in varying ways, with some users placing greater emphasis on security features before trusting digital payment systems. Given security's critical role in shaping user trust, mobile payment providers must invest in robust security frameworks, transparent privacy policies, and clear communication strategies to reassure users and encourage greater adoption.

H3. Perceived security positively influences users' perceived trust in mobile payments.

Perceived trust is a critical determinant of mobile payment usage, as it significantly influences users' willingness to engage with and rely on digital payment systems. [Chakraborty et al. \(2022\)](#) emphasize that trust in electronic transactions shapes consumer confidence, laying the groundwork for acceptance of new technologies like mobile payments. This sentiment is echoed by [Lazaroiu et al. \(2020\)](#) and [Wu and Tang \(2022\)](#), who argue that trust directly influences the adoption of e-commerce and mobile banking, where the absence of trust remains a primary barrier preventing users from engaging in e-commerce activities ([Lian & Li, 2021](#)). These studies highlight that trust, not only shapes consumer confidence but also directly impacts the acceptance and adoption of new technologies like mobile payments, which rely on secure and efficient digital transactions. [Alrawad et al. \(2023\)](#) and [Sleiman et al. \(2021\)](#) further reinforce this notion, emphasizing that perceived risk, coupled with trust, plays an important role in influencing consumers' choices, particularly in mobile commerce, where users prioritize the security of their transactions. Virtualized transactions carried

out over digital networks introduce significant uncertainties, particularly around anonymity and the potential for network failures during transactions ([Zhou, 2012](#)). These issues underscore the importance of trust in the credibility and reliability of mobile payment systems, as users must feel confident that their transactions will be processed smoothly and securely, without interruptions. However, users often question the reliability and stability of mobile networks. They worry that transactions might fail due to network connection issues during the process, which causes them to distrust mobile payment systems. Additionally, users are often in a weaker position during mobile payment transactions ([Xin et al., 2015](#)). The success and quality of these transactions depend heavily on the credibility and reliability of mobile service providers and payment systems, leaving users with little control over the process. Therefore, a strong trust relationship has been established with the user to reduce related risks and enable transactions via mobile payment ([Lian & Li, 2021](#)).

As trust mitigates concerns about security and transaction failure, it enhances user commitment to mobile payment platforms, directly affecting their willingness to persist in utilizing them. This evidence corroborates the claim that:

H4. Perceived trust positively influences the usage of mobile payments.

Mobile payment combines advanced payment systems and innovative technology solutions that enable transactions for products or services via mobile devices, thereby transforming how customers and businesses interact in today's economy ([Zhang et al., 2023](#)). While mobile payments revolutionize transaction methods, grasping the factors influencing customer loyalty in this context is key to ensuring long-term business success. Compared with the conventional method of payment (offline payments), the advent of mobile payment facilitates clients to execute diverse transactions on mobile devices at any location and at any time ([Qasim & Abu-Shanab, 2016](#)). Much of the current research centers on user adoption behaviors ([Bailey et al., 2022](#); [Chakraborty et al., 2022](#); [Yang et al., 2021](#)) and limited literature focuses on post-adoption behaviors ([Loh et al., 2022](#)) which are equally important. Since adoption alone does not guarantee continued use, understanding customer loyalty helps businesses address retention and improve long-term engagement with their services. Customer loyalty is relevant in this regard, particularly when intense competition and high customer turnover rates are considered ([Yuan et al., 2020](#)). Customer loyalty is also relevant to ensure business sustainability and staying competitive in a market with intense rivalry ([Ahmed et al., 2023](#)). In businesses, high loyalty increases the probability of repeat purchases as well as the probability of recommending the brand to others, hence assisting organizations in reducing marketing expenses and augmenting market share ([Zhang et al., 2023](#)). Moreover, trust in e-commerce is a key driver of customer loyalty ([Faraoni et al., 2019](#)). Empirical evidence suggests that customer trust has a significant positive effect on customer loyalty ([Mofokeng, 2023](#)). In general, the participation level in e-commerce has risen, which may be due to heightened interest in the construct of trust ([Urvashi et al., 2021](#)), such that the surge in online shopping is dependent on consumer trust in e-retailers ([Hossain et al., 2022](#)). As in other e-commerce sectors, establishing trust in mobile payment systems is very important for customer loyalty development. A trustworthy mobile payment platform reassures users that their financial data and transactions are secure. Recent studies demonstrate that consumer trust is pivotal in determining the usage of various internet services, including mobile payment and Fintech ([Al-Hattami et al., 2023](#)). This trust enhances customer loyalty towards mobile payment services. Given the critical role that trust plays in shaping customer behavior, especially in mobile payment systems, it is proposed that:

H5. Perceived trust positively influences customer loyalty towards mobile payments.

Consumer behavior evolves from cognitive perceptions to emotional

attitudes and ultimately to behavioral results (Zheng et al., 2022). In mobile payments, perceived usage denotes the cognitive stage, illustrating the customer's conviction on the utility and ease of use of mobile payment systems (Huang & Chen, 2022). This positive perception fosters satisfaction (affective phase), by enhancing the emotional connection customers feel towards mobile payment systems, which in turn promotes loyalty (behavioral phase). Customers who accept the advantages and comfort of mobile payments are more inclined to experience satisfaction and subsequently exhibit loyalty, as these factors build trust and confidence in the technology (Zhang et al., 2023). Furthermore, customers perceive that mobile payment is more useful and reliable than conventional transactions. Mobile payment services are embraced when customers possess positive opinions and contentment about their usage. Research indicates that mobile payment usage is highly based on customer satisfaction and loyalty (Kar, 2021).

Rapid advancements in mobile payment technologies, and their increasing integration into daily transactions as explained by Migliore et al. (2022), have led to a substantial shift in the payment landscape, by redefining customer expectations and payment preferences. This evolution underscores the importance of understanding customer loyalty in the mobile payment sector, especially amidst growing competition and elevated customer turnover rates (Ahmed et al., 2023; Yuan et al., 2020). Existing research has extensively analyzed how quality, satisfaction, and loyalty interact in the context of mobile payments (Kim et al., 2022). However, there is a notable gap in understanding how perceived usage influences explicit customer loyalty, despite its critical role in shaping customer decision-making and retention strategies (Omigie et al., 2017; Yuan et al., 2020). According to Molinillo et al. (2020); Omar et al. (2021), usage experience and service quality significantly impact customer loyalty, aligning with the focus of this research, given the shift from traditional to mobile payment methods, which offer increased convenience and flexibility, by allowing seamless, secure, and faster transactions (de Luna et al., 2019; Mukhopadhyay & Upadhyay, 2022). The study hypothesizes that perceived usage of mobile payments positively influences customer loyalty, by creating a perception of superior value and reliability compared to conventional payment systems. This hypothesis seeks to enhance our understanding of customer behavior dynamics within the fast-changing mobile commerce industry. So, the study hypothesis is,

H6. Perceived usage of mobile payments positively influences customer loyalty.

The correlation between user trust and technology adoption has been a focal point in contemporary research. Trust is conceptualized as an emotional response, shaped by user satisfaction, and plays a pivotal role in system adoption and intention, by fostering confidence and reducing perceived risks associated with mobile payment systems (Liébana-Caballanas et al., 2021). Concerns about data privacy and trust issues have emerged, particularly in digital technology use within businesses (Lin et al., 2022). Recent studies underscore trust's influence on users' technology service adoption, linking it to increased service acceptance and highlighting trust as a key determinant of long-term usage and user loyalty (Huynh et al., 2021). During the COVID-19 outbreak, trust deficits hindered mobile payment adoption among retailers (Cao et al., 2017; To & Trinh, 2021).

Education is crucial to raising awareness about digital literacy; thus, it is the driving force behind informing users about using mobile payments effectively, by equipping them with the knowledge to navigate risks and optimize the benefits of mobile payment systems, leading to higher use and a wider variety of transactions and strengthening users' confidence in the security and reliability of these systems (Pal et al., 2021). Measuring perceived security is an incentive for real usage and intentions to use mobile payments (Ghasemaghahi, 2020). Users favor features such as password protection on their mobile and entering into two-factor authentication opportunities to ensure safe transactions, as these features enhance trust and reduce apprehensions regarding data

breaches or fraud (Zhou, 2011). Convenience, access to information, and history tracking are likely to encourage actual use of the mobile payment app because they simplify the user experience and provide transparency in transactions, while perceptions of risks and real constraints could act as a deterrent to adoption. Anything addressing digital literacy, thus indicating that it is one trait moving away from security-handling literacies due to trust in the security that is provided, will facilitate the continued use of payment systems in the mobile environment (Pal et al., 2021).

Park et al. (2019) suggest that advanced technology interaction necessitates certain educational levels, which may enhance users' ability to understand security measures and evaluate the reliability of payment systems, yet the link between education and mobile payment trust remains unclear (Donthu & Garcia, 1999). This study posits that education influences understanding and risk-benefit analysis of payment services, by enabling users to make informed decisions regarding the adoption and use of mobile payment systems and moderates the relationship between perceived trust and mobile payment usage, by strengthening the impact of trust on users' intention to embrace and sustain mobile payment practices. This leads to the hypothesis that participants' education level moderates the relationship between perceived trust and mobile payment usage, by shaping users' perceptions of trustworthiness, security, and overall system reliability. Therefore, the study hypothesis that,

H7. Participants' education level moderates the relationship between perceived trust and mobile payment usage.

Adopting new technologies, particularly mobile payment systems, varies significantly across different age groups. Older individuals generally exhibit more caution and emphasize trust, security, and credibility more than younger users, as these factors align with their concerns about financial and personal data security, who are more integrated with and dependent on mobile technology for daily tasks (Shankar et al., 2010). Another study by Wiese and Humbani (2020) identified that insecurity—a deficiency of trust in mobile technology—constitutes a substantial obstacle to accepting mobile payment solutions. Younger users (e.g., 18–29 years) demonstrate increased optimism and innovativeness regarding mobile technologies due to their familiarity and frequent engagement with digital platforms in their daily lives. In contrast, elderly users (e.g., 50+ years) frequently express heightened insecurity and discomfort from limited exposure to or understanding of advanced mobile technologies. This difference indicates that age may affect the influence of trust on the decision to utilize mobile payment applications. Therefore, trust is regarded as a significant determinant in mobile payments and Internet banking (Merhi et al., 2019; Sedigheh Moghavvemi et al., 2021), particularly among older persons (Yap et al., 2022), who exhibit heightened concerns regarding financial and performance risks, thereby influencing their perception of the use of payment applications in contrast to younger groups. This indicates that the correlation between trust and mobile payment use may differ among age groups, with older individuals prioritizing trust due to their specific apprehensions regarding security, reliability, and usability (Yang et al., 2023). However, other studies revealed that age did not significantly impact trust and mobile payment usage (Alrawad et al., 2023). While most studies have focused on the young and adolescent demographic their findings might not fully capture the challenges and motivations faced by older users, there's a growing need to examine a wider age range, especially with the increasing use of mobile shopping applications, to identify distinct behavioral patterns and trust dynamics across age groups (Natarajan et al., 2018). While age continues to be a crucial factor in predicting the adoption of emerging technologies, understanding how trust interacts with age-specific concerns can offer deeper insights into technology adoption behaviors (Yang & Shih, 2020). Therefore, analyzing the interaction between age and other characteristics, such as perceived trust, is crucial to comprehend the dynamics of technology adoption behaviors. Consequently, we propose

the following hypothesis to explore how age-specific trust perceptions influence the relationship between trust and mobile payment usage.

H8. Participant's age moderates the relationship between perceived trust and mobile payment usage.

3. Methodology

This paper used a quantitative research method and a survey questionnaire to collect the needed information regarding mobile payments. Further details on the methods employed are detailed in the subsequent sections of this paper.

3.1. Population and sampling

The population of this study encompassed the users of mobile payment apps such as Apple Pay and STC Pay and business entrepreneurs in the Kingdom of Saudi Arabia. Though the use of mobile payment apps has significantly increased in recent years in Saudi Arabia, the exact population of the users is not available. Due to the unavailability of a sampling frame, this study adopted snowball sampling, a non-probability technique for sampling and data collection. In the absence of a sampling frame, it was hard to reach out to the desired number of participants. In such situations, snowball sampling is a useful technique that involves identifying an initial set of participants, usually acquaintances or personal or professional relations, who help recruit additional participants from their contacts, creating a snowball effect.

Hair et al. (2017) advised obtaining 10 responses per item in the questionnaire (10:1) in a multivariate analysis to determine the minimum sample size for a study where a sampling frame is unavailable. This study contains six latent variables and 25 associated items, leading to a minimum size of 250 responses. In addition, following the recommendation of Memon et al. (2020), we used G*power to determine the sample size for the study specifications, which resulted in a minimum of 103 samples.

The final dataset of 290 responses exceeds the minimum threshold of 250, ensuring sufficient statistical power for analysis. In addition to Hair et al. (2017) guideline of 10 responses per item, we used G*Power analysis (Memon et al., 2020), which suggested a minimum of 103 responses, further validating the adequacy of our sample size. Prior studies in FinTech and payment app adoption, such as Balakrishnan and Lay Gan (2023) and Slade et al. (2015), have achieved robust findings with comparable or even smaller sample sizes, confirming that our sample is well within an acceptable range. Additionally, previous research highlights that PLS-SEM performs well even with moderate sample sizes, as long as they meet the complexity requirements of the model (Chin, 1998; Wong, 2013). Given these considerations, our sample of 290 provides robust analytical capability while maintaining model reliability.

Several steps were taken to reduce potential response bias further. First, participation was voluntary and anonymous, helping to minimize social desirability bias (Podsakoff et al., 2003). Second, the survey was made available in both English and Arabic to ensure accessibility for a wider audience, following best practices for cross-cultural research (Brislin, 1980). Third, we actively sought diversity in our sample by working with industry organizations like Fintech Saudi Authority and expanding outreach beyond personal referrals, as recommended for improving representativeness in non-probability sampling (Etikan et al., 2016). Lastly, to check for any bias over time, we compared responses from early and late participants using *t*-tests, which showed no significant differences, further confirming that response bias did not affect the study's findings (Armstrong & Overton, 1977).

3.2. Questionnaire development

Following the guidelines by Zikmund et al. (2013) on business

research methods, the questionnaire was developed with due diligence. The questionnaire consisted of six constructs intended to assess the research model (See Fig. 1). The items of these constructs were adopted from the available published works where their reliability and validity were well established. The measurement scales of security, compliance, convenience, trust, usage, and loyalty were adopted from Kim et al. (2010) and Parasuraman and Colby (2015) in the context of payment apps. Participants were asked to respond using a five-point Likert scale, where 1 represented "strongly agree," 2 was "agree," 3 stood for "neutral," 4 was "disagree," and 5 indicated "strongly disagree." We used a five-point Likert scale due to its widespread use in research, its reliability and validity in capturing responses, and its simplicity, which facilitates higher response rates. This scale aligns with our study's objectives and the need for straightforward, easily interpretable responses, minimizing respondent burden and potential inconsistencies.

The initial part of the survey gathered demographic details from respondents, ensuring their confidentiality and stressing that participation was voluntary. The subsequent part probed respondents' familiarity with existing payment applications in Saudi Arabia, their usage frequency, and the kind of transactions they conducted using these apps. The final section delved into their perceptions regarding convenience, adherence to rules, security, trustworthiness, actual usage, and loyalty to the payment apps. The survey, available in both English and Arabic (see Appendix A), was designed on the Question-Pro platform. To ascertain its clarity and relevance, three academic experts reviewed the questionnaire. Based on their feedback, necessary refinements were made before proceeding with the pilot test.

3.3. Data collection and analysis

The initial step in the data collection process for academic research is conducting a pilot study. This preliminary study aims to pinpoint potential issues in the research design and refine the methods for selecting a representative sample. Hence, a test run was carried out with 25 participants from the target demographic. Based on the feedback from this pilot test, refinements were made to the questionnaire, which was then rolled out for the primary data collection. Participants could access the survey through a link shared via email or social media platforms. Applying the snowball sampling technique, we applied two strategies to maximize the response: (1) individuals familiar to the researchers and who used mobile payment apps were approached to complete the survey and were also encouraged to share the link within their network, and (2) the Fintech Saudi Authority and the Fintech Saudi Society were approached to help disseminate the survey to the relevant audience.

Over the four months from March to June 2024, we contacted approximately 900 targeted respondents to participate in the survey. Of them, 411 participants attempted the survey, generating a response rate of 46 %, which is acceptable in online surveys. In the screening process, a total of 121 responses were excluded from the database due to incomplete or lack of engagement. The final data set remained at 290, which is above the minimum requirement of 250. The survey period was carefully chosen to balance both seasonal factors and a steady period. While Ramadan and Eid took place during this time, mobile payments are a routine part of daily life in Saudi Arabia, making it unlikely that these events significantly affected consumer behavior, especially since they lasted only a month. Moreover, collecting data over four months also ensured a more diverse mix of user experiences and helped smooth out any short-term fluctuations.

To ensure a diverse and representative sample, we initially invited around 900 potential respondents via email, social media, student clubs, and professional networks, focusing on mobile payment users and business entrepreneurs in Saudi Arabia. Of those, 411 attempted the survey, resulting in a 46 % response rate, which is acceptable for online surveys. To broaden participation and reduce potential bias in snowball sampling, we collaborated with industry organizations like Fintech Saudi Authority while also leveraging personal and professional

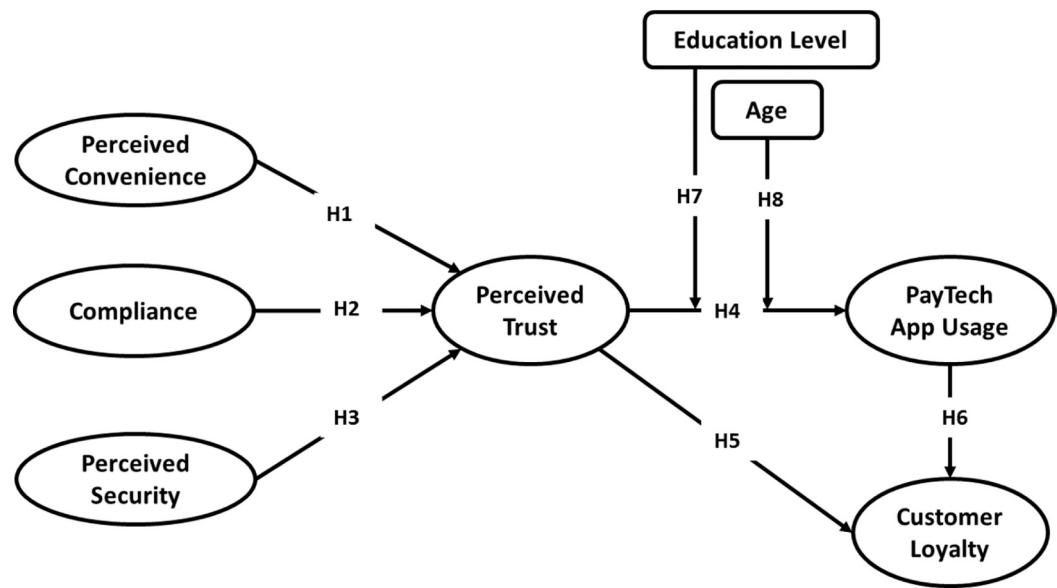


Fig. 1. Conceptual structure.
(Source: Authors’ own work.)

networks. These efforts helped reach participants from different age groups, professions, and regions, ensuring a more varied and inclusive sample. While snowball sampling can sometimes lead to a more homogeneous respondent pool, these proactive measures helped mitigate this limitation and provide valuable insights into mobile payment adoption.

While snowball sampling can sometimes lead to a more homogeneous respondent pool, efforts were made to minimize this by reaching out to participants from diverse professional backgrounds, age groups, and regions.

The final data were analyzed using the partial least squares equation modeling (PLS-SEM). This method was chosen primarily due to the non-normal distribution of the data, the complexity of the model involving multiple moderators, the existence of reflective constructs, and the capability of PLS-SEM to assess validity, reliability, and robust hypothesis testing. We used a one-tailed test as our hypothesis specifically predicts a positive impact of IVs on DV. Since our theoretical framework and prior literature suggest a directional relationship, a one-tailed test allows us to assess whether the effect occurs in the expected direction with greater statistical power.

Based on Hair Jr et al. (2017) guidelines, the data were analyzed in two stages. In the first stage, the measurement model was assessed for the reliability and validity of latent variables. The measurement model assessment ensures the quality of the measurement scales of latent variables that allow the structural model to undergo assessment in the second stage. The structural model assessment includes testing hypotheses and analyzing the moderation effect. This two-stage assessment method was applied by numerous similar studies such as Eltayeb and Ahmad (2021), Syed et al. (2020), and Ahmad et al. (2020), to name a few.

4. Results and findings

4.1. Respondents’ demographics

The descriptive analysis provided in Table 2 below presents the participants’ background information and how it affects their choices and decisions.

The study encompassed a cohort of 290 individuals, characterized by a gender composition of 22.07 % male and 77.93 % female participants. Age demographics were distributed as follows: 10.00 % were under 20

Table 2
Demographic information of respondents.

Variable	Category	Frequency	Percentage
Gender	Male	64	22.070 %
	Female	226	77.930 %
Age	<20 years	29	10.000 %
	21–25	114	39.310 %
	26–30	72	24.830 %
	31–40	60	20.690 %
	41–50	12	4.140 %
	>50 years	3	1.030 %
Qualification	No Formal Qualification	2	0.690 %
	Primary	0	0.000 %
	Secondary	44	15.170 %
	Graduate	196	67.590 %
Monthly Income	Masters and Above	48	16.550 %
	No Formal Income	135	46.550 %
	SR 5000–10,000	88	30.340 %
	SR 11,000–20,000	43	14.830 %
	SR 21,000–30,000	13	4.480 %
Occupation	SR ≥31,000	11	3.790 %
	Business Professionals	109	37.590 %
	Doctor or Engineer	19	6.550 %
	Students	19	6.550 %
	Finance and Accounting	41	14.140 %
	Lawyer	2	0.690 %
	Industry and Technician	1	0.340 %
	Academician	19	6.550 %
	Other	80	27.590 %
	Total	290	100 %

(Source: Authors’ own work.)

years, 39.31 % aged between 21 and 25 years, 24.83 % within the 26–30 year range, 20.69 % between 31 and 40 years, 4.14 % falling in the 41–50 year bracket, and 1.03 % exceeding 50 years of age. Educational backgrounds varied, with 0.69 % having no formal qualifications, 15.17 % possessing secondary education, 67.59 % being university graduates, and 16.55 % holding master’s degrees or higher qualifications. In terms of income distribution, 46.55 % reported no formal income, 30.34 % earned between SR 5000–10,000, 14.83 % fell into the SR 11,000–20,000 income bracket, 4.48 % were in the SR 21,000–30,000 category, and 3.79 % earned above SR 31,000. Occupational diversity was notable, with 37.59 % engaged in business professions, 6.55 % as doctors or engineers, 6.55 % being students, 14.14 %

in finance/accounting roles, 0.69 % practicing law, 0.34 % in industrial/technical positions, 6.55 % in academia, and 27.59 % occupied in various other professions such as teaching, banking, and manual labor.

4.2. Data distribution analysis

To assess the distribution characteristics of the data, this study employed measures of skewness and kurtosis, complemented by the Shapiro–Wilk tests, as detailed in Table 3. A data set is generally considered to be normally distributed if the values of skewness and kurtosis fall within the range of -1.96 and $+1.96$ (George & Mallery, 2019). Furthermore, a non-significant result ($p > 0.05$) in the Shapiro–Wilk test implies that the data is normally distributed. For this study, the skewness value observed for the ‘perceived convenience’ variable was 3.357. The Shapiro–Wilk test further reinforced these findings, revealing significant values for all variables. Based on these results, the data was determined to be non-normally distributed.

4.3. Evaluation of measurement model

The first stage in the path model analysis is the assessment of the measurement model, where the reliability and validity of latent variables are established before hypothesis testing. The reliability of the underlying constructs was verified by the substantial outer loadings of their indicators. Internal consistency was measured using composite reliability (CR). Furthermore, convergent validity was assessed by calculating the average variance extracted (AVE) and comparing it to CR. Whereas, the discriminant validity was established through the Fornell and Larcker (1981) criterion as well as the Heterotrait–Monotrait Ratio of Correlations (HTMT) which is considered more accurate and reliable than the former.

4.3.1. Reliability assessment

To assess the reliability of the measurement model, composite reliability and higher outer loading values were used. Composite reliability is used to assess the internal consistency of the measurement scale of each latent variable (Hair et al., 2017). It evaluates the items of each variable to be steady and uniform in their results. As presented in Table 4, all the values of composite reliability were >0.70 representing internally consistent measurement scales of the latent variables and establishing the reliability of all six measurement models.

On the other hand, the indicator reliability was evaluated using the outer loadings as given in Table 4. The indicator reliability illustrates the amount of variation in the items of a latent variable. Higher outer loading suggests that the associated measure is significantly related to the variable. Hair et al. (2017) recommended the retention of the items with an outer loading of 0.70 and higher. However, before deciding on the retention or exclusion of any item the impact on Average Variance Extracted (AVE) and CR should then be examined. As appeared in Table 4, all the values of outer loading appeared to be higher than 0.70. Following Hair et al. (2017) guidelines, in this study, a cut-off criterion (>0.70) was set for the factor loading, Cronbach Alpha, rho_A, and composite reliability. In the initial run, two items (one from perceived

Table 3
Data distribution analysis.

Latent variables	Descriptive		Shapiro-Wilk		
	Skewness	Kurtosis	Statistics	Df	Sig.
Perceived Convenience	1.502	3.357	0.795	290	0.000
Compliance	0.379	-0.479	0.946	290	0.000
Perceived Security	0.036	0.045	0.974	290	0.000
Perceived Trust	0.449	0.411	0.953	290	0.000
Usage	0.846	0.343	0.877	290	0.000
Loyalty	0.432	-0.092	0.929	290	0.000

(Source: Authors' own work.)

Table 4

Reliability and convergent validity analysis of the measurement model.

Item	Loadings	Cronbach Alpha	rho_A	Composite reliability	AVE
Compliance		0.847	0.845	0.873	0.633
Comp1	0.825				
Comp2	0.713				
Comp3	0.756				
Comp4	0.878				
Customer Loyalty		0.844	0.859	0.896	0.683
Conv1	0.868				
Conv2	0.831				
Conv4	0.780				
PayTech App Usage		0.796	0.802	0.881	0.712
Loyl1	0.882				
Loyl2	0.882				
Loyl3	0.808				
Loyl4	0.723				
Perceived Convenience		0.770	0.781	0.867	0.684
Secu1	0.792				
Secu2	0.862				
Secu3	0.813				
Secu5	0.723				
Perceived Security		0.809	0.812	0.876	0.638
Trust1	0.789				
Trust2	0.796				
Trust3	0.838				
Trust4	0.851				
Trust5	0.802				
Perceived Trust		0.874	0.877	0.909	0.665
Usag1	0.807				
Usag2	0.903				
Usag3	0.819				

Bold values represent the highest loadings for each construct.

(Source: Authors' own work.)

convenience and one from perceived security) were loaded below the cut-off criterion and were excluded from further analysis. The second analysis returned the loadings for each indicator above the cut-off criterion and indicated satisfactory reliability statistics as shown in Table 4.

4.3.2. Validity assessment

The validity of the measurement model was examined by assessing convergent and discriminant validity. Construct validity measures the degree to which two theoretically related latent variables or measurement scales correlate. This validation ensures that the constructs properly represent the intended phenomena within the study's scope. According to Hair et al. (2017) convergent validity of the latent variables can be established if it satisfies three conditions, i.e. (a) composite reliability scores are higher than 0.70, (b) average variance extracted scores are higher than 0.50, and (c) composite reliability scores are greater than average variance extracted scores of the same variable. As demonstrated in Table 4, the scores of CR and AVE exceeded the cut-off values and the CR scores of all the latent variables were above the corresponding AVE scores; thus, confirming the convergent validity of the measurement models.

Discriminant validity, on the other hand, ensures that any two constructs in the measurement models are not so highly correlated that they measure the same variable. The discriminant validity of the scales confirms whether theoretically unrelated constructs are distinct and separate. Among numerous methods, Fornell and Larcker (1981) standard and the Heterotrait–Monotrait Ratio of Correlations (HTMT) method are predominantly used to verify the discriminant validity of the measurement model. According to Fornell and Larcker (1981) criterion, the square root of AVE (the bold values along the diagonal in Table 5) should be higher than the corresponding squared correlation coefficients in the same row and column (off-diagonal values in Table 5). As

Table 5
Fornell and Larcker's statistics of discriminant validity.

	1	2	3	4	5	6
1 Compliance	0.796					
2 Customer Loyalty	0.163	0.827				
3 Pay Tech App Usage	−0.020	0.510	0.844			
4 Perceived Convenience	0.042	0.525	0.542	0.827		
5 Perceived Security	0.207	0.430	0.230	0.211	0.799	
6 Perceived Trust	0.093	0.596	0.463	0.402	0.559	0.816

^a Grey cells represent the square root of AVE, which should exceed the corresponding squared correlations.

(Source: Author's own work.)

illustrated in Table 5, the AVE values surpassed the squared correlation coefficients for their respective rows and columns. This indicates a robust discriminant validity within the data set.

The Heterotrait–Monotrait Ratio of Correlations (HTMT) represents a contemporary method in structural equation modeling, as introduced by Henseler et al. (2015). This innovative technique is recognized for its heightened accuracy and dependability in evaluating discriminant validity. According to this method, latent variables should not have a correlation coefficient ≥ 0.85 . Referring to Table 6, the most substantial correlation coefficient observed was 0.694 between Pay Tech App Usage and Perceived Convenience. Nevertheless, this was within the recommended range, staying below the stipulated cut-off. Therefore, the discriminant validity of the construct was established. Given the satisfactory results of both reliability and validity tests, it was deemed suitable to progress to the structural model analysis.

4.4. Structural model assessment

Upon establishing the reliability and validity of every measurement framework, the focus shifted to assessing the structural model, particularly the interplay between dependent and independent factors. This assessment encompassed gauging the model's collinearity statistics through the Variance Inflation Factor (VIF), the determination coefficient (R^2), and evaluating research hypotheses through the pathway coefficient.

4.4.1. Multicollinearity assessment

The VIF is a statistical measure used to detect multicollinearity between the study variables in regression analysis. Ideally, multicollinearity occurs if the VIF value exceeds 5.0, indicating a high correlation between the independent and dependent variables. As

shown in Table 7, all the VIF values of the dependent variables at a 95 % confidence interval to their corresponding dependent variables remained fairly below the threshold.

4.4.2. Explanatory power analysis

The determination coefficient (R^2) indicates how well the model elucidates and forecasts outcomes. Though Craney and Surles (2002) stated that an R^2 value above 0.10 should be considered significant for a parsimonious model, Henseler et al. (2009) established that R^2 values of 0.25, 0.50, and 0.75 are considered weak, moderate, and strong, consecutively. This study consists of three endogenous variables (customer loyalty, payment app usage, and perceived trust) and five exogenous variables (payment app usage, perceived trust, perceived convenience, compliance, and perceived security). The findings, as presented in Table 8, demonstrate that payment app usage and perceived trust explain 42.5 % ($R^2 = 0.425$) of the variance in consumer loyalty. However, this value underlines the high effect of these factors on explaining customer loyalty, it also suggests that other factors not included in the present model may contribute to customer loyalty. For

Table 7
Multicollinearity statistics.

	1	2	3	4	5	6
1. Compliance						1.045
2. Customer Loyalty						
3. PayTech App Usage		1.273				
4. Perceived Convenience						1.047
5. Perceived Security						1.092
6. Perceived Trust		1.273	1.017			

Criteria: VIF < 5.0.

(Source: Author's own work.)

Table 6
HTMT statistics for discriminant validity.

	1	2	3	4	5	6
1 Compliance						
2 Customer Loyalty	0.158					
3 Pay Tech App Usage	0.053	0.620				
4 Perceived Convenience	0.070	0.645	0.694			
5 Perceived Security	0.238	0.515	0.285	0.268		
6 Perceived Trust	0.082	0.683	0.551	0.490	0.659	

Criterion: Correlation coefficients for latent variables should remain under 0.85.

Grey cells in the table represent correlation values between constructs. Blank diagonal cells indicate self-correlations, which are not applicable.

(Source: Author's own work.)

Table 8
Explanatory power of the research model.

Endogenous constructs	R ²	t-value	p-values	Corresponding exogenous construct
Customer Loyalty	0.425	9.108	0.000	Pay Tech App Usage
Pay Tech App Usage	0.234	4.141	0.000	Perceived Trust
Perceived Trust	0.397	9.366	0.000	Perceived Convenience Compliance Perceived Security

Criteria: R² = 0.25 (weak); R² = 0.50 (moderate); R² = 0.75 (Moon & Armstrong, 2020).

(Source: Author's own work.)

example, user experience, brand reputation, and peer influence may also account for unexplained variance. Perceived trust explains 23.4 % (R² = 0.234) of the variance in payment app usage. Whereas perceived convenience, compliance, and perceived security explain a 39.7 % (R² = 0.397) variance in perceived trust.

While some R² values in this study may seem modest, this is common in behavioral research, where human decision-making is influenced by many external factors beyond what any single model can capture. In the case of PayTech adoption and customer loyalty, aspects like user experience, social influence, brand reputation, and marketing may also play a role but these factors were not the focus of this study. Still, the model provides meaningful insights, as shown by the strong statistical significance of the predictors (p < 0.001), confirming their actual impact. Similar studies on digital payment adoption, such as Balakrishnan and Lay Gan (2023), have reported comparable R² values, reinforcing the credibility of these findings. Rather than focusing on higher R² values, this study prioritizes identifying the most influential factors driving trust and loyalty. These insights are valuable for both PayTech firms and policymakers. Future research can build on this by incorporating additional behavioral and technological elements to strengthen predictive power further.

4.4.3. Effect size analysis

Apart from the coefficient of determination assessment, there is a need for the effect size (f^2) measurement, which computes the proportion of variation attributable to every exogenous variable influencing the R² of the respective endogenous variable. This is accomplished by sequentially excluding the exogenous constructs from the structural model and tracking the change in R² of the endogenous construct with each omission. According to Hair et al. (2017) guidelines, f^2 of 0.02, 0.15, and 0.35 represent a small, medium, and large effect size, respectively. According to Table 9, the dependent variable customer loyalty was predicted by PayTech app usage ($f^2 = 0.121$) and perceived trust ($f^2 = 0.287$), giving a medium effect. Likewise, perceived trust has a medium impact on PayTech app usage. However, perceived trust was predicted by compliance, perceived convenience, and perceived security, with no effect ($f^2 = 0.001$), a small effect ($f^2 = 0.140$), and a

Table 9
Assessment of effect size.

Exogenous constructs	Endogenous constructs		
	Customer Loyalty	PayTech App Usage	Perceived Trust
Compliance			0.001
PayTech App Usage	0.121		
Perceived Convenience			0.140
Perceived Security			0.381
Perceived Trust	0.287	0.278	

Criteria: $f^2 = 0.02$ (small); $f^2 = 0.15$ (medium); $f^2 = 0.35$ (large).

(Source: Author's own work.)

significant effect ($f^2 = 0.381$), respectively.

4.4.4. Predictive relevance analysis

To strengthen the predictive accuracy of the model, Hair et al. (2017) recommend the use of Stone-Geisser's Q² value. Stone-Geisser's Q² measure is a criterion for assessing the predictive relevance of a model. It employs the blindfolding method to test the ability of the model and its parameters to predict observed values. The blindfolding procedure is used to obtain Q² values of endogenous constructs. Blindfolding is a sample reuse method that removes data points from the indicators of the endogenous construct in a systematic way and provides an estimation of their original values. Hair et al. (2017) recommend an omission distance between 5 and 12 with 5000 subsamples. The predictive validity of the model is assessed based on Q² values, with thresholds as follows: 0 > Q² < 0.02 indicates the existence of predictive relevance, 0.02 ≥ Q² < 0.15 indicates low predictive relevance, 0.15 ≥ Q² < 0.35 indicates moderate predictive relevance, and Q² ≥ 0.35 indicates high predictive relevance (Fig. 2).

As indicated in Table 10, Q² values for the endogenous constructs of customer loyalty and perceived trust exhibited a moderate predictive relevance, whereas PayTech app usage had a small predictive relevance. These results showed that the model has satisfactory predictive relevance, as Q² values for all the endogenous constructs are well above the threshold value.

4.4.5. Hypotheses testing

Path coefficient analysis is a key component of structural equation modeling, employed to evaluate the causal relationships among hypothesized constructs. The importance of a path coefficient (β) is ascertained through the t-values and p-values for the respective path, as indicated in Fig. 3. In this study, hypotheses were tested at a 95 % confidence interval. The criterion for a hypothesis to be statistically significant is that the t-value must be larger than ± 1.96 and that the p-value must be less than ± 0.05 for a path coefficient at a 95 % confidence interval. The standardized path coefficient (β), t-values, p-values, and confidence interval for all hypotheses of this study are listed in Table 11. The result revealed that H1, H3, H4, H5, and H6 are statistically supported whereas H2, H7, and H8 are statistically insignificant. Among the unsupported hypotheses, H2 was a direct effect, whereas H7 and H8 were moderating relationships. Hence, it is concluded that perceived convenience and perceived security help organizations in winning customer trust. However, compliance does not significantly impact customers' perceived trust. Whereas perceived trust plays an important role in pay tech app usage and building customer loyalty. Pay tech app usage, in addition, plays a vital role in winning customer loyalty. Moreover, it was hypothesized that customer education level and age would affect the association between perceived trust and the use of pay tech apps. However, the results did not support these hypotheses, and therefore, they were rejected.

4.4.6. Importance-performance map analysis

Importance-Performance Map Analysis (IPMA) is a PLS-SEM tool used to enhance the interpretation of results by providing insights into the relative importance and performance of predictor variables on a target construct (Carranza et al., 2018). The IPMA analysis helps identify the most important predictor variable that should be prioritized to achieve better outcomes. It utilizes path coefficient values of the corresponding latent variables as importance and average latent variable scores as performance and eventually draws a scatter diagram (See Fig. 4).

In this study, following (Carranza et al., 2021) IPMA for customer loyalty is conducted to assess the importance-performance of perceived user trust and PayTech app usage. The analysis reveals that perceived user trust has a high performance (40.40) and importance (0.459) in developing customer loyalty, whereas app usage has a comparatively lower performance (34.83) and lower importance (0.299). This

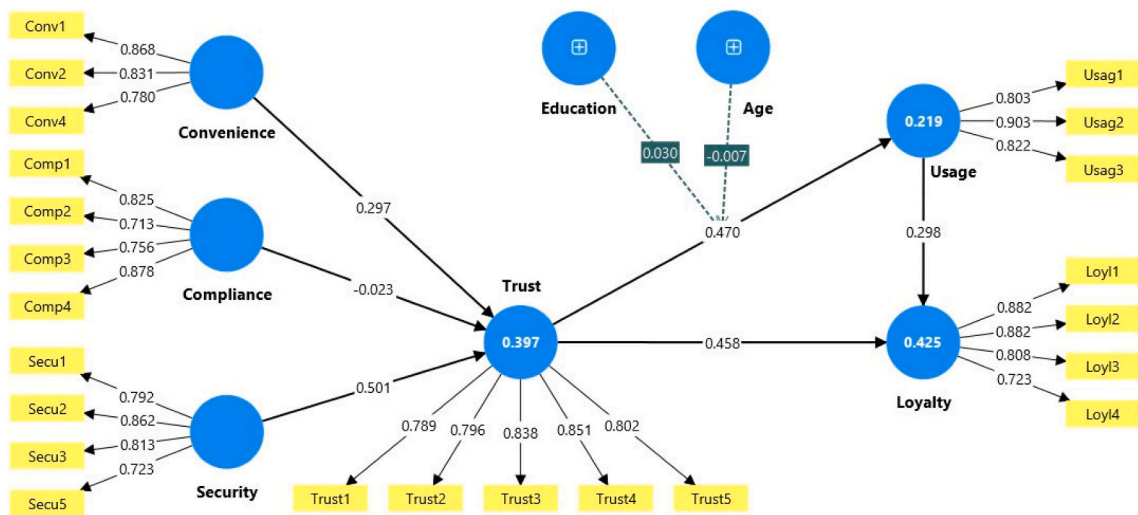


Fig. 2. Path model with path coefficient and R² values. (Source: Author's work.)

Table 10
Predictive relevance of endogenous constructs.

Endogenous constructs	Q ²
Customer Loyalty	0.273 (Medium)
PayTech App Usage	0.141 (Low)
Perceived Trust	0.231 (Medium)

Criteria: 0 < Q² < 0.02 (existence); 0.02 ≥ Q² < 0.15 (low); 0.15 ≥ Q² < 0.35 (low); Q² ≥ 0.35 (high).
(Source: Author's own work.)

indicates that in the context of the PayTech app, perceived trust is essential in building customer trust.

As shown in Fig. 4, user trust has a strong influence on customer loyalty, with relatively high importance (0.51) and moderate performance (35). This suggests that while trust is already contributing positively, further improvements, such as enhancing security measures could strengthen loyalty even more. In contrast, usage rate has a moderate impact (0.31) but relatively low performance (15), indicating that customers are not engaging as frequently as expected. Addressing this gap through strategies like improving user experience, offering

incentives, or increasing convenience could enhance both usage and overall customer loyalty.

5. Discussion section

This research delves into the complex factors influencing the adoption of mobile payment systems within Saudi Arabia, a developing market. It unveils key factors such as perceived convenience, security, compliance, and trust and their profound impact on user loyalty and usage frequency. This nuanced understanding is vital in the nation's rapidly evolving digital transaction landscape. Moreover, the study's results build on a growing body of literature that explores similar themes, providing new insights into the evolving area and validating the results of previous studies.

One of the study's most important findings is the strong link between perceived convenience and trust in payment apps. This result aligns with Yi et al. (2024a) findings, which emphasize ease of use as a feature and as the basis of users' trust. The TAM proposed by Davis (1989) also emphasizes the importance of perceived usefulness and ease of use in the adoption of technology. For Saudi Arabia, where mobile technology has already become a significant part of our regular lifestyle, these findings

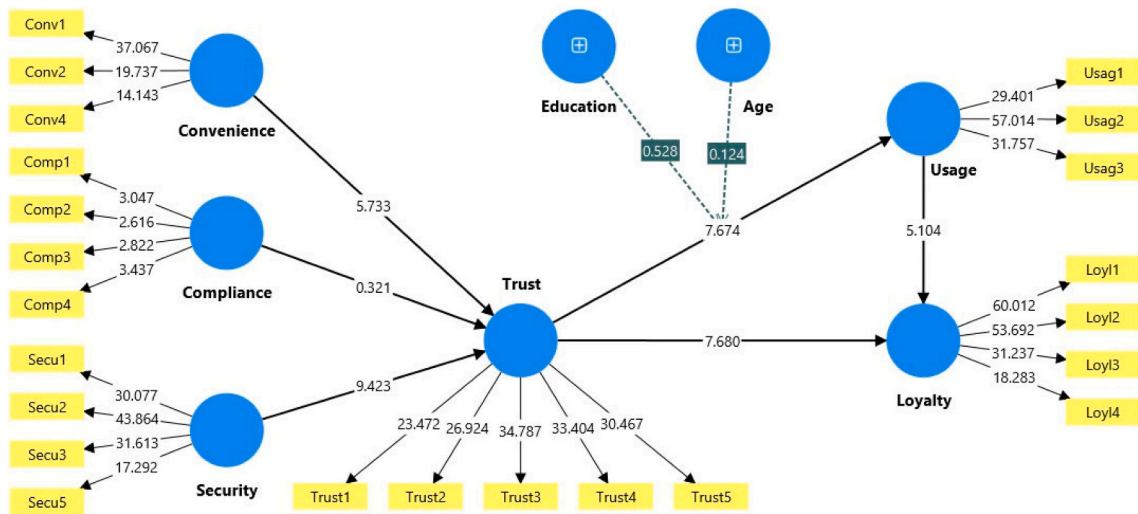


Fig. 3. Path model with t-values. (Source: Authors' own work.)

Table 11
Results of structural model and hypotheses testing.

Hypothesis	β	t-value	p-value	5 % CI	95 % CI	Decision
H1: Perceived convenience positively influences perceived trust.	0.299	5.748	0.000	0.215	0.386	Supported
H2: Compliance positively influences perceived trust.	−0.009	0.326	0.372	−0.151	0.091	Not Supported
H3: Perceived security positively influences perceived trust.	0.497	9.568	0.000	0.409	0.579	Supported
H4: Perceived trust positively influences pay tech app usage.	0.462	7.743	0.000	0.359	0.559	Supported
H5: Perceived trust positively influences customer loyalty.	0.459	7.839	0.000	0.359	0.554	Supported
H6: Pay tech usage positively influences customer loyalty.	0.299	5.184	0.000	0.205	0.392	Supported
H7: Participant's Education level moderates the relationship between perceived trust and pay tech app usage.	−0.007	0.857	0.196	−0.153	0.151	Not Supported
H8: Participant's age moderates the relationship between perceived trust and pay tech app usage.	0.037	0.943	0.173	−0.159	0.184	Not Supported

Statistical significance: $n = 5000$ subsamples; $t(0.05; 4999) = 1.960$; $t(0.01; 4999) = 2.577$; $t(0.001; 4999) = 3.292$ * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. (Source: Author's own work.)

imply that technology providers ought to concentrate on creating handy, intuitive, and seamless apps. A difficult-to-use or poorly designed app may quickly disturb the trust of the user, irrespective of the advanced features of this app (Harrison et al., 2013).

Similarly, the importance of security in building trust was reaffirmed in this study using hypothesis (H3). These findings substantiate the work of Gull et al. (2022), who also found that robust security measures like multi-factor authentication and encryption are important in earning customers' trust, particularly in e-commerce and digital payment platforms. Furthermore, the broader literature on fintech, like Ismail et al. (2018); Mashatan et al. (2022) also support this view on trust. Literature highlights that visible and effective security features are critical to driving adoption. In countries like Saudi Arabia, where cybersecurity threats are an ever-present concern, ensuring secure digital transactions is not just a technical requirement but is of utmost importance for retaining users.

The impact of compliance on trust has interestingly unexpected results. Contrary to what might be anticipated, regulatory compliance (H2) did not significantly impact perceived trust in this study. This result differs from previous studies, such as Hosain and Kamal (2024), which suggested that compliance enhances user confidence in digital payment

systems. Similarly, the study of Al-Sharafi et al. (2022) also emphasizes the critical role of compliance in fostering trust and sustainability in using mobile payment technologies. However, considering the Saudi context, the user may take compliance for granted. Users might be assuming that government regulations and oversight ensure app reliability. This highlights a critical gap indicating that the compliance measures must be more visible and relatable to users. It suggests that policymakers and app developers should better communicate compliance in ways that resonate with end users. That may be through certification, notifications, or user-friendly explanations of the existing regulations.

This study also confirms trust's pivotal role in influencing both app usage and customer loyalty (H4 and H5). The findings of this study are in line with those of previous studies. For example, Almaiah et al. (2022) highlighted that trust is the cornerstone of sustained user engagement in technology adoption. Trust also serves as a link between users' initial engagement and their long-term commitment to our platforms. Similarly, Le (2021) also suggested that a significant factor affecting users' loyalty is their level of trust in the fintech service. Therefore, for Fintech companies, trust-building strategies must go beyond addressing functionality and security alone. They must also foster a sense of reliability and transparency that keeps users returning to the platform.

Furthermore, the link between app usage and customer loyalty (H6) supports the findings of Al-Okaily (2023), who suggested that frequent interaction with the platform strengthens users' emotional and functional connections to it. This creates a feedback loop where higher engagement enhances loyalty, which, in turn, encourages sustained usage. FinTech firms can leverage this insight by offering personalized features, rewards programs, and seamless integrations with other financial services to drive continuous engagement.

This study also incorporates Importance-Performance Map Analysis (IPMA) to assess key customer loyalty factors. The Importance-Performance Map Analysis (IPMA) highlights trust as the key driver of customer loyalty, with both high importance (0.459) and performance (40.40). In contrast, PayTech app usage, though relevant, has lower importance (0.299) and performance (34.83), suggesting that trust matters more for retention than just frequent usage. FinTech firms should focus on building trust through clear security measures, data protection, and customer engagement while encouraging app usage with rewards, gamification, and seamless integrations.

While demographic factors like age and education (H7 and H8) were included in this study, their moderation effect was insignificant. This result aligned with the findings of Migliore et al. (2022), who conducted the study in the context of Italy and China and found that user experience factors often outweighed demographic variables in influencing mobile app payment adoption. Moreover, these findings differ from those reported in several earlier studies, such as Hwang et al. (2016); Peltonen et al. (2018). These findings also suggest exploring other variables, such as cultural attitudes, socioeconomic factors, and personality traits, which may provide a deeper understanding of user behavior in different contexts. Moreover, the results of these studies are well aligned with the ongoing developments in fintech, especially the growing impact of artificial intelligence, big data management, and cloud computing on building user trust and loyalty. Advanced technologies like blockchain-based systems and IoT-enhanced payment platforms create better customer experience, improve security, and deliver more personalized services. All these play a vital role in the adoption of mobile payment apps (Andronie et al., 2023; Lăzăroiu et al., 2023).

Overall, the results of this study contribute to the growing literature on mobile payment adoption by validating and extending the results of previous studies. It confirms the critical importance of convenience, security, and trust while shedding new light on the nuanced role of compliance. For countries like Saudi Arabia, which are on a fast emerging and developing path, it offers a road map for the fintech sector. Developers and policymakers should design user-centric solutions that meet the needs of a digitally savvy population while also

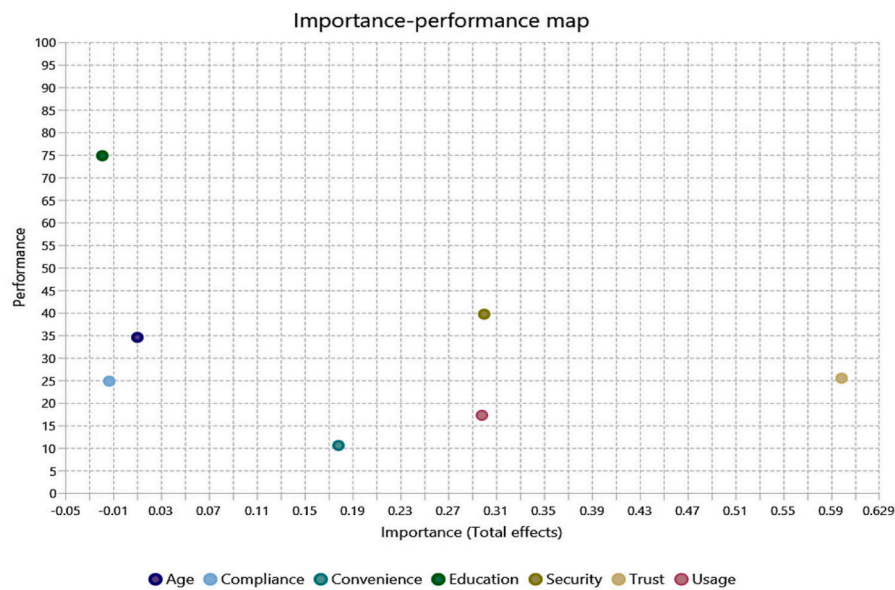


Fig. 4. IPMA for customer loyalty.
(Source: Author's own work.)

focusing on the security angle of these applications.

6. Conclusion

This study explores the factors that drive people to use and stay loyal to payment apps in Saudi Arabia. Data were collected from 290 participants through a questionnaire from March to June 2024, and responses were included from business enterprises and mobile payment users in Saudi Arabia. The analysis revealed that key factors like convenience, security compliance, and trust influence how often users engage with these apps and how loyal they remain to them.

Drawing on the Technology Acceptance Framework, this study's results indicate how crucial convenience and security are for building trust in these payment apps, which in turn keep users loyal to these payment apps. In a country like Saudi Arabia, where mobile usage and digital transport transformation are rising, these elements play a vital role in enhancing financial technology and payment app solutions. Regulatory compliance plays a crucial role in building trust for payment apps. However, our findings in the context of Saudi Arabia suggest a different dynamic, underscoring the need for well-designed regulatory strategies and app features that actively foster user confidence.

The study's findings also highlight the critical importance of creating app features and service quality that resonate with users' preferences and smooth the functionality of apps. With the increasing adoption of digital payment platforms, the importance of visible and clear security measures and compliance practices are required. This will enable fintech companies to strengthen customer loyalty and emotional connection to the platforms.

Interestingly, routine demographic factors like age and education have an insignificant impact on user experience. This reinforces the crucial importance of focusing on user-friendly design, strong security, and seamless functionality for gaining customers' trust and encouraging sustained loyalty. Therefore, the insights of this study provide valuable guidance for fintech companies in an emerging country like Saudi Arabia, where developers and policymakers must create an environment for better user experience and innovation in payment apps.

6.1. Theoretical implications

This study provides valuable insights into the theoretical understanding of user behavior within mobile payment systems. It expands

existing literature by examining how key factors like convenience, security, and trust shape mobile payment apps' adoption and loyalty dynamics. The research enriches theoretical models of Technology Acceptance and user behavior by providing empirical evidence, offering a deeper exploration of the interplay between these factors. Moreover, the study provides a deeper perspective on how these drivers collectively influence user engagement and retention, paving the way for refining existing frameworks in technology adoption, e-commerce, and FinTech-related user behavior. This work bridges a critical gap in the literature by addressing the unique behavioral patterns within the evolving FinTech landscape.

6.2. Practical implications

This study provides valuable insights for FinTech companies and policymakers in Saudi Arabia. The findings emphasize the need to focus on convenience, security, and trust to encourage more people to adopt and stay loyal to mobile payment apps. For FinTech companies, this means developing user-friendly, secure, and transparent payment solutions that meet customer expectations while ensuring a seamless experience. On the other hand, policymakers have a vital responsibility in shaping policies that encourage innovation while keeping user protection at the forefront. A well-balanced approach between regulation and technological advancement is essential for the continued growth and adoption of digital financial services.

The results of IPMA highlight that trust plays the most significant role in driving loyalty. FinTech companies should focus on enhancing security transparency, making compliance measures more visible, and improving customer support to build confidence. While app usage has a lower impact, engagement tactics like personalized rewards, seamless integrations, and user-friendly designs can encourage more frequent interactions, indirectly strengthening loyalty. FinTech firms can create a more sustainable and loyal customer base by balancing trust-building with user engagement. Focusing on both regulatory and user needs, this research provides a roadmap for the future of FinTech and digital payment solutions in Saudi Arabia and beyond.

6.3. Limitations and opportunities for future research

Though the study offers applicable findings regarding the determinants that affect the usage and loyalty of payment apps in the Saudi

Arabia context, it also raises limitations that indicate the area of potential future research. First, using the cross-sectional data design in PLS-SEM settings may lead to potential methodological biases. It requires a cautious interpretation of causality among the variables. Future studies should focus on longitudinal research examining how the relationship among these variables evolves. Secondly, the study focuses mainly on the users of payment apps inside Saudi Arabia, which may limit the generalizability of the findings to other regions and contexts. Future researchers may target diverse geographical users and cultural settings to attain more generalized results, which help us better understand the markets and the factors behind the trust and loyalty of payment apps.

Thirdly, since the study focused on only one methodological approach, it limited the depth of user insights. Future research may adopt mixed-method approaches integrating qualitative and quantitative analysis to understand better user behavior, trust, and long-term engagement with payment apps. Fourthly, this research mainly emphasizes convenience, trust, and security. It does not consider the environmental and economic impacts of digital payment solutions. Future studies could investigate how payment app solutions contribute to sustainability goals by reducing the number of paper-based transactions and their role in enhancing or increasing the country's financial inclusion and overall economic growth.

Finally, and probably the most important aspect of future research, is integrating the impact of evolving technologies such as blockchain, artificial intelligence, and biometric authentication concerning the digital payment ecosystem. This will open new avenues and bring new insights into the domain. By addressing these methodological, contextual, and technological limitations, future research can provide a more holistic and forward-looking perspective on the adoption and loyalty of digital payment app solutions.

Appendix A. Measurement scales

Compliance	Comp1	I always look for security assurances on the App website before adopting it for transactions. أبحث دائماً عن ضمانات أمنية على موقع التطبيق قبل اعتماده للمعاملات.
	Comp2	I always read Payment App solutions Guidelines for cyber security risk etc. أقرأ دائماً إرشادات تطبيقات الدفع لمخاطر الأمن السيبراني إلخ
	Comp3	I always follow Cyber-security instructions offered by Payment App تتبع دائماً تعليمات الأمان عبر الإنترنت التي يوفرها تطبيق الدفع
	Comp4	I always follow the security procedures provided by payment App providers before doing any transaction. أتبع دائماً إجراءات الأمان التي يقدمها تطبيقات الدفع قبل إجراء أي معاملة.
Customer Loyalty	Conv1	Payment apps makes my purchases easier. تطبيقات الدفع تجعل مشترياتي أسهل
	Conv2	Payment apps makes my purchases faster. تطبيقات الدفع تجعل مشترياتي أسرع
	Conv4	Payment apps are convenient since these are cash free. تطبيقات الدفع تعتبر مريحة بما أنها تخلو من الأوراق النقدية
PayTech App Usage	Loyl1	I recommend this payment App to those who ask for my advice. أوصي بتطبيقات الدفع لأولئك الذين يطلبون نصيحتي
	Loyl2	I give positive feedback about this Payment App to other persons. أعطي ردود فعل إيجابية حول تطبيق الدفع الذي استخدمه للآخرين
	Loyl3	I consider this payment App company my first choice. أعتبر هذه الشركة الممولة عن تطبيق الدفع خياراً الأول
	Loyl4	I also use or intend to use other products from this App provider. أنا أيضاً أستخدم أو أنوي استخدام منتجات أخرى من موفر التطبيق ذات
Perceived Convenience	Secu1	Payment App solutions are free from Malware and viruses. تطبيقات الدفع تعتبر خالية من البرامج الضارة والفيروسات
	Secu2	Payment App solutions are free from transaction frauds. تطبيقات الدفع تعتبر خالية من عمليات الاحتيال في المعاملات
	Secu3	Payment App Solutions are impossible to be intercepted due to high security measures, تطبيقات الدفع من المستحيل اعتراضها بسبب الإجراءات الأمنية المشددة
	Secu5	Payment App solutions will not leak my personal information, such as bank accounts, ID number, and address etc. لن تسرب تطبيقات الدفع معلوماتي الشخصية ، مثل الحسابات المصرفية ورقم الهوية والعنوان وما إلى ذلك
Perceived Security	Trust1	I trust most of the parties involved in Payment apps system. أثق في معظم الأطراف المشاركة في نظام تطبيقات الدفع
	Trust2	I trust the transaction mechanisms of Payment apps. أثق في الآليات تحريك الأموال المتبعة في تطبيقات الدفع

(continued on next page)

CRedit authorship contribution statement

Farooq Ahmad Bajwa: Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization. **Jingtao Fu:** Supervision, Methodology, Investigation, Conceptualization. **Ishtiaq Ahmad Bajwa:** Writing – review & editing, Software, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Shabir Ahmad:** Writing – review & editing, Validation, Software, Formal analysis, Data curation, Conceptualization. **Faiq Mehmood:** Writing – review & editing, Supervision, Project administration, Data curation, Conceptualization.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author(s) used QuillBot and Grammarly to enhance the grammar. Upon using this tool/service, the author(s) thoroughly assessed and revised the material as necessary and assumed (s) complete accountability for the publication's content.

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(continued)

Perceived Trust	Trust3	I trust overall mobile app payment services. بشركل عام أشق في الخدمات المقدمة من تطبيقات الدفع عن طريق الهاتف المحمول
	Trust4	I trust the information provided during the Payment apps registration process. أشق في المعلومات المقدمة خلال عملية التسجيل في تطبيقات الدفع
	Trust5	I feel more comfortable with available Payment app companies. أشعر بالراحة تجاه شركات تطبيقات الدفع المتوفرة حالي
	Usag1	I use payment apps more often than bank/cash payments. أستخدم تطبيقات الدفع أكثر من استخدامي للخدمات المصرفية أو الأوراق النقدية
	Usag2	I will continue to use Payment Apps in future. سوف أداوم على استخدام تطبيقات الدفع في المستقبل
	Usag3	I believe my Payment Apps usage will increase in future. أتوقع أن يزيدي استخدامي لتطبيقات الدفع في المستقبل

Data availability

Data will be made available on request.

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