Advances in Consumer Research
https://acr-journal.com/

Volume-2 | Issue-6 | Nov 2025

Original Researcher Article

Mobile Usability Among Malaysian Consumers: An Extended TAM

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Received: 01/09/2025
Revised: 03/10/2025
Accepted: 19/11/2025
Published: 28/11/2025

ABSTRACT

As an innovative monetary payment method, mobile payment has become popular in developed economies, providing users with a convenient and efficient payment experience for economic activities. However, mobile payment in Malaysia remains at a critical development stage, and current studies have not fully unveiled the underlying pathway influencing its mobile usability. The objective of this study is to evaluate the key factors affecting mobile payment usability among Malaysian users. In the emerging field of mobile payment, the applicability of the Technology of Acceptance Model (TAM) is examined in specific scenarios of mobile payment. The methodology adopted for this research comprises a quantitative, cross-sectional study involving 280 Touch 'n Go users from Kuala Lumpur and Selangor. Data were collected via an online survey and were analyzed using SEM-AMOS. The results indicate that system quality, information quality, and service quality significantly positively affect mobile usability. Furthermore, the relationship between mobile usability, system quality, information quality, and service quality is mediated by perceived value. Additionally, perceived risk moderates the relationship between perceived value and mobile usability. The extended TAM constructed in this study was fully validated and consistent with the core logic of TAM and confirms the theoretical pathway that external variables (system quality, information quality, and service quality) influence technology acceptance outcomes (mobile usability) through the user perception (perceived value). This study offers original insights by extending the TAM to integrate system, information, and service quality with perceived value and perceived risk in explaining mobile payment usability among Malaysian users.

Keywords: Mobile Payment Usability, Technology Acceptance Model (TAM), Perceived Value, System, Information, and Service Quality, Perceived Risk

INTRODUCTION:

The popularity of smartphones and mobile Internet has laid a solid foundation for users to make mobile payments. In addition, the integration of innovative technologies such as near field communication (NFC) has also promoted the prosperity and development of mobile payments (Huang & Mohamad, 2025). Mobile payment refers to a method in which a mobile client uses electronic devices such as mobile phones to make electronic currency payments (Balachandran et al., 2024). It is characterized by mobility, timeliness, customization, and integration (Mohamad et al., 2024). Compared to traditional payment methods, mobile payment utilizes smartphones as the primary carrier, enabling users to complete payments, query transactions, manage accounts, and perform other operations without being restricted by time and space (Ma et al., 2024). Despite the various advantages of mobile payment, the application of multiple devices and technologies has made mobile payment information security a focus of users' attention. The binding of mobile payment platforms with users' bank cards and real-name information stores a large amount of personal privacy data (Huang et al., 2024). Once this information is leaked, it may not only lead to users' personal property loss but also interfere with the mobile payment ecosystem balance, thereby weakening the mobile usability (Qiu & Dwyer, 2023). These challenges are particularly evident in Malaysia.

Despite its relatively late popularization in Malaysia, mobile payment has rapidly gained popularity and is currently experiencing rapid growth. According to the 2024 annual report of Bank Negara Malaysia (BNM),

the volume of electronic payment transactions in Malaysia reached 14.7 billion in 2024, with the annual per capita transaction volume increasing from 343 in 2023 to 409 in 2024, underscoring the growing adoption of digital payment methods (Bank Negara Malaysia, 2025). Current studies have begun to explore factors that influence mobile payment usability, but there are still some research gaps. Previous studies have focused on countries with higher payment rate adoption, such as China, the United States, and Singapore (Xu et al., 2024; Shaw et al., 2022; Ong & Chong, 2022). While the emerging mobile payment market has garnered increasing scholarly attention, systematic research focusing specifically on the Malaysian context remains scarce (Pal et al., 2021). Existing studies are not only limited in number but also fragmented in scope, lacking a comprehensive theoretical framework.

Although the technology acceptance model has been extensively employed to explain consumers' adoption behavior of information systems (Chen & Tsai, 2019) and has also been applied in mobile payment research (Bailey et al., 2017), few studies have leveraged TAM to systematically examine the relationship between mobile payment quality characteristics and mobile usability within the Malaysian market. To address this research gap, this study adopts and extends TAM to determine the influencing factors of mobile usability in Malaysia.

LITERATURE REVIEW AND UNDERPINNING THEORY

Mobile Payment Studies

As one of the main payment methods in the digital economy era, mobile payment has been favored by scholars for its implications on usability. Relevant studies have used a variety of theoretical frameworks for exploration. These can be categorized into two dimensions: research topics and theoretical applications. In terms of research topics, existing studies present multidimensional characteristics but mainly focus on the empirical analysis of mobile payment intention and loyalty. For instance, Al-Qudah et al. (2024) examined the Apple Wallet application in the United Arab Emirates to evaluate the relationship between the willingness to use mobile payment and its various antecedent variables. Some scholars have explored the influencing factors of mobile payment loyalty from the perspectives of perceived value and the extended information system success model (ISSM), the cognitive-affective-behavioral (C-A-B) model, and consumer value theory (Zhong & Chen, 2021; Zhang et al., 2023).

Additionally, prior studies also involve technical risk prevention and control, such as the mobile payment fraud detection system developed by Hajek et al. (2023). Some scholars have also conducted cross-national comparative analysis, such as Kumar et al. (2021), on the differentiated impact of mobile payment platforms in 30 countries or regions. Migliore et al. (2022) conducted a comparative exploration of the antecedents of mobile payment in the two countries, as well as the heterogeneous impact on availability among different populations, including the elderly (Cham et al., 2022; Wong et al., 2022) and Generation Z (Lisana, 2024).

In terms of theoretical application, TAM (Venkatesh et al. 2003), ISSM (Delone & Mclean, 2003), and Unified Technology Acceptance and Use Theory (UTAUT, Venkatesh et al., 2003) are the three most widely used theoretical frameworks. Among them, TAM is the most widely used in mobile payment research. In recent years, several studies have incorporated variables related to mobile payment usability, such as self-efficacy, new technology anxiety, and mobile payment privacy issues, based on TAM to more accurately explain user behavior mechanisms. In addition, scholars have further expanded the applicability of TAM in mobile payment scenarios by integrating variables such as perceived quality, trust, values, and sacrifices (Tian & Chan, 2024; Park et al., 2025).

The initial ISSM was developed through theoretical analysis and had not been empirically validated (Delone & Mclean, 1992). The revised ISSM comprises six constructs: system quality, information quality, service quality, willingness to use, user satisfaction, and net values. The revised ISSM is suitable for explaining mobile payments in the digital economy (Delone & Mclean, 2003). In the field of mobile payments, scholars have mainly expanded their applications from the aspects of mediating effects and moderating effects.

Through empirical research, previous studies have verified the mediating transmission mechanism of trust, perceived security, and perceived value between system quality, information quality, service quality, and mobile payment availability, revealing the internal logic of how quality characteristics affect user perception and then act on behavior (Chang et al., 2025; Almaiah et al., 2022; Kumari & Biswas, 2023). Combining the quality characteristics and mobile payment scenario, the model introduces perceived risk as a moderating variable to explore its influence on the relationship between quality dimension and usability, to further enhance the model's explainability for complex payment scenarios (Huang et al., 2024).

UTAUT offers distinct advantages in its ability to integrate multiple theoretical frameworks. It demonstrates strong explanatory power in the mobile payment scenario. The UTAUT model is composed of eight models: Task Technology Fit Model (TTF), Diffusion of Innovation Theory (IDT), Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), Motivational Model (MM), Composite TAM and TPB Model (C-TAM-TPB), PC Utilization Model (MPCU), and Social Cognitive Theory (SCT) elucidate the mechanisms and factors influencing the acceptance and utilization of new technology. Scholars have expanded on the moderate effect and model integration in the mobile payment scenario. For example, some scholars have verified the influence of age and mobile payment knowledge as moderating variables on the usability of mobile payment (Sobti, 2019; Slade et al., 2015). In addition, the model has gradually evolved into

UTAUT2 and UTAUT3 with the changes of time and experience (Migliore et al., 2022; Aliu, 2024).

In summary, TAM, ISSM, and UTAUT have their own strengths in mobile payment research, providing a solid theoretical framework for understanding mobile payment user behavior. Among these models, TAM stands out for its effectiveness in explaining mobile usability with its accurate capture of user perception mechanisms. Given the established status and advantages of TAM in the mobile payment scenario, this study adopts the TAM framework to underpin the in-depth analysis of the impact pathways through which quality characteristics of mobile payment systems influence mobile usability. This study aims to elucidate how TAM provides a robust theoretical foundation for understanding mobile usability.

Technology Acceptance Model

TAM is a model developed by American scholar Venkatesh et al. (2003) to describe the user's information technology acceptance behavior. TAM has been extensively utilized in fields such as information technology management and e-commerce for its simplicity, ease of operation, and strong explanatory power, especially in the study of mobile payment adoption behavior, providing a robust foundation for studying technology-related behavioral decisions (Park et al., 2025; Azman et al., 2024). It is one of the classic models for studying information systems and new technology user behavior at this stage. This model posits that the primary factors influencing computer system users are perceived utility and perceived usability. It provides a clear analytical path for understanding information system usage behavior while establishing its fundamental position in the technology acceptance domain.

In the emerging field of mobile payment, the applicability of TAM has also been verified. Compared with complex models, TAM is easier to flexibly adapt to different research situations through variable expansion (Persico et al., 2014). This also makes it show obvious advantages in more research fields. Therefore, based on the TAM framework, this study incorporates perceived value and perceived risk as mediating variables and moderating variables, respectively, and expands the TAM, aiming to comprehensively analyze the influencing mechanism of mobile usability in specific scenarios of mobile payment. This extended model addresses both the quality dimension and the attitude cognitive dimension of user experience, thus providing a deeper insight into the antecedents of mobile usability. Figure 1 presents a model of mobile usability.

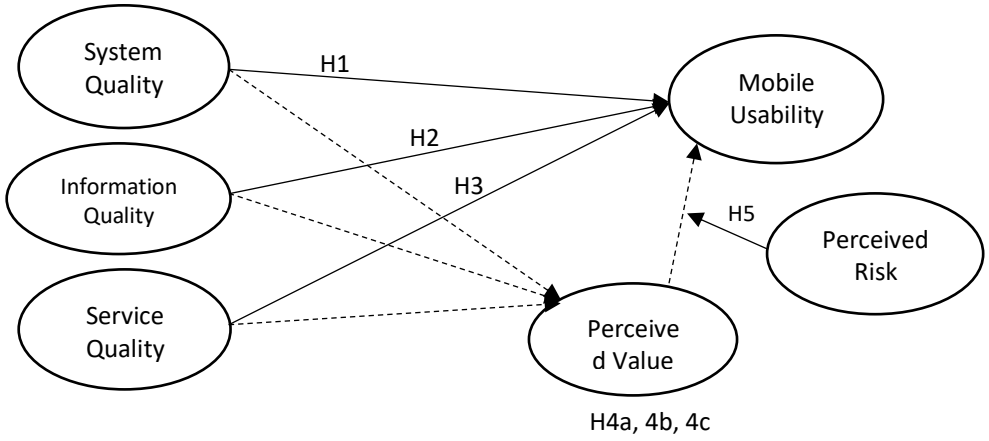

Figure 1. Research framework

Effect pf System Quality

DeLone and McLean (2003) define system quality as the measurement of the system's design attributes. Common indicators include availability, reliability, response time, etc. In mobile commerce, high-quality mobile system design can better meet user needs and is a prerequisite for winning mobile payment availability (Zheng & Pulli, 2007). Mobile usability refers to the extent to which mobile applications or websites help users achieve their goals efficiently, quickly, and satisfactorily in a mobile environment (Huang & Benyoucef, 2023). From the perspective of TAM perception, high-definition pictures and perfect mobile system functions can reduce users' operating costs and make users feel the ease of operation of the system design (Ahmed et al., 2021). When the mobile payment system responds quickly and the payment process is smooth, it can save users time to the maximum extent, and users will make positive comments on mobile availability (Lee & Kang, 2024). Prior studies have shown that the interface design and compatibility of mobile systems affect consumers' positive emotions (Rahardja et al., 2023b). Thus, based on the above findings, this study proposes the following hypothesis:

- H1: System quality significantly influences mobile usability.

Effect of Information Quality

According to DeLone & McLean (2003), information quality measures the information characteristics of the system output, including relevance, comprehensibility, accuracy, simplicity, completeness, timeliness, and usefulness. In the mobile payment scenario, information quality is not only related to the output presentation of transaction information but also directly affects the user's experience of operation on mobile devices (Hasbiah & Hasdiansa, 2025). Mobile payment systems provide clear and timely transaction record information, making it easier for users to complete operations and payment management on mobile devices, thereby improving the mobile usability experience (Isaac & Sherali, 2014). Franque et al. (2021) emphasized that interesting, reliable, and useful information content can affect users' willingness to continue using mobile payments. In contrast, defects in information quality pose challenges to information quality retrieval. Highly relevant information quality affects users' willingness to use (Frondelius et al., 2024). Systems with poor information quality will affect user satisfaction, and users will find it difficult to quickly obtain the information they want, thereby reducing the mobile usability of the system (Al-Okaily et al., 2023). In addition, studies have shown that information quality affects loyalty to social commerce sites (Molinillo et al., 2021). Drawing on this, this study posits that information quality is an important antecedent variable affecting mobile usability. Hence, this study proposes the following hypothesis:

- H2: Information quality significantly influences mobile usability.

Effect of Service Quality

DeLone and McLean (2003) pointed out in their research that service quality measures the quality of assistance users receive from information system departments and technical support staff, such as responsiveness, accuracy, technical ability, and empathy. When using mobile payments, users require fast and professional technical support to deal with problems that may arise in the process of system usage (Amro et al., 2025; Zhao & Bacao, 2021). If the service provider responds slowly or the service is unprofessional, users may have usage barriers in mobile operations, thereby affecting their perceived ease of use of the mobile payment system (Rahardja et al., 2023a). Some scholars have evaluated the continued intention based on mobile payments after the COVID-19 pandemic, and the results indicate that service quality constitutes a pivotal influencing factor in the continued use of mobile payments (Hijazi et al., 2023). In addition, existing studies have shown that service quality is an important factor affecting the willingness to continue using mobile payment systems (Raman & Aashish, 2021). Based on the above observations, this study proposes the following hypothesis:

- H3: Service quality significantly influences mobile usability.

Effect of Perceived Value

Perceived value is an overall assessment of the utility of a product or service after evaluating the customer's perceived values against the cost of receiving the product or service (Zeithaml, 1988). Perceived value reflects the customer's perception of the value offered by the company's products or services, as opposed to the objective value of those items or services. In the mobile payment scenario, the user's overall view of system usability is influenced by system quality, information quality, and service quality (DeLone and McLean, 2003). These factors often indirectly affect their willingness to use it by improving the user's perceived value (Ali et al., 2023). When the mobile payment system runs smoothly, features a user-friendly interface, delivers accurate information, and provides prompt and personalized service support, users are more likely to perceive high value, thereby enhancing their mobile usability (Lee & Kang, 2024). Perceived value is believed to play a bridging role between quality characteristics and user behavior decisions (Molinillo et al., 2021), and its role as a mediating variable has been verified in previous studies (Sinha et al., 2024). This study believes that perceived value mediates the relationship between system quality, information quality, service quality, and mobile usability. Based on this, the following hypotheses are proposed:

H4a: Perceived value mediates the relationship between system quality and mobile usability.
H4b: Perceived value mediates the relationship between information quality and mobile usability.
H4c: Perceived value mediates the relationship between service quality and mobile usability.

Effect of Perceived Risk

Perceived risk was originally derived from psychology. It refers to the degree of uncertainty consumers perceive about possible adverse consequences when using a product or service (Dowling & Staelin, 1994). Risk is inevitable. Xie et al. (2021) defined it as uncertainty perceived by consumers. In a mobile payment scenario, users are often concerned about privacy leakage, a usable network environment, and account or mobile device theft. These risk perceptions may weaken their technology adoption intention (Ahmed et al., 2021). Past studies have demonstrated that perceived risk weakens the mobile payment intention during the pandemic (Al-Qudah et al., 2024). With the development of advanced technologies such as artificial intelligence, the security of mobile payments has brought unprecedented challenges. In the mobile payment environment, even if users can perceive value from the quality characteristics of the system, users will abandon mobile payment if security cannot be guaranteed (Fang et al., 2021). Therefore, drawing upon the above observations, the following hypothesis is proposed:

- H5: Perceived risk moderates the relationship between perceived value and mobile usability.

METHODOLOGY

This study consists of six main constructs: system quality, information quality, service quality, perceived value, perceived risk, and mobile usability. This study measured the above constructs with 28 items modified from earlier empirically tested relevant studies (DeLone & McLean, 2003; Zhong & Chen, 2023). The initially developed scale was reviewed by three experts in the field of management for content validity and contextual appropriateness. A 5-point Likert scale running from "1 = strongly disagree" to "5 = strongly agree" was used to measure the items. In addition, the questionnaire also contained some questions about the demographic characteristics of Malaysian users, such as gender, age, education level, location, and frequency of using mobile payments. The survey was conducted in two stages. First, a pilot test of 40 users with Touch' n Go experience was conducted to check the suitability of the questionnaire and refine the wording of items based on the feedback. The questionnaire was then distributed through a combination of online methods. This study conducted an online survey on the electronic questionnaire platform Google Forms. The questionnaire was distributed to users who had used mobile payment through various online channels (such as WhatsApp). The participants of this study were adult mobile payment users in Kuala Lumpur and Selangor, Malaysia. Kuala Lumpur and Selangor are among the most economically active, densely populated, and internet-penetrating regions in Malaysia. Conducting surveys in these two regions will facilitate obtaining high-quality data.

Table1. Descriptive statistics of respondents (n = 280)

Measure	Value	Frequency	Percentage
Gender	Male	120	42.9
	Female	160	57.1
Age	21 - 30	15	5.4
	31 - 40	150	53.6
	41 - 50	58	20.7
	Over 50	57	20.4
Education level	High school	16	5.7
	Diploma	45	16.1
	Bachelor	121	43.2
	Master's or PhD	98	35.0
Usage frequency	< 3 times/week	78	27.9
	3 - 5 times/week	134	47.9
	6 - 10 times/week	34	12.1
	＞10 times/week	34	12.1
Location	Kuala Lumpur	135	48.2
	Selangor	145	51.8

This study employs the Maximum Likelihood Estimation (MLE) method within the AMOS software to test the proposed theoretical model. AMOS is a powerful statistical analysis tool specifically designed for the development and evaluation of structural equation models (Bessadok & Hersi, 2025). In total, 345 questionnaires were distributed to the target population. The researchers carefully reviewed the responses of all respondents and removed invalid samples based on the following criteria: (1) individuals with no experience in using mobile payment; (2) individuals whose answers to all questions were the same; and (3) individuals who answered the questionnaire in a short time. After careful screening, finally 280 valid questionnaires were obtained for subsequent data analysis. The required sample size for the survey was determined using G*Power software. The software's effect size (f2) was set to 0.15, with 6 predictors, a statistical power of 0.80, and a significance level of 0.05 (Faul et al., 2007). According to the model shown in Figure 1, at least 97 valid samples are required. Therefore, the 280 (https://zenodo.org/records/17355211) valid samples in this study are sufficient to support the subsequent analysis.

The demographic characteristics of the respondents are displayed in Table 1. 42.9% were males, while females accounted for 57.1%. Additionally, the 31 to 40-year-old group accounted for the highest proportion, reaching 53.6%. More than 43.2% of the respondents had a bachelor's degree. 47.9% said they used mobile payment more than 10 times a week. In terms of geographical distribution, 48.2% of the respondents were from Kuala Lumpur and 51.8% were from Selangor.

RESULTS AND DISCUSSIONS

Measurement Model

The measurement model was assessed for reliability, convergent validity, and discriminant validity.

Table 2. Reliability and validity of constructs

Construct	Scale Item	Factor loadings	AVE	CR
System Quality	SQ1	0.743	0.529	0.820
	SQ2	0.712		
	SQ3	0.677		

	SQ4	0.773		
Information Quality	IQ1	0.853	0.672	0.891
	IQ2	0.821		
	IQ3	0.807		
	IQ4	0.791		
Service Quality	SERQ1	0.821	0.727	0.841
	SERQ2	0.665		
	SERQ3	0.682		
	SERQ4	0.731		
Perceived Value	PV1	0.680	0.673	0.858
	PV2	0.713		
	PV3	0.672		
	PV4	0.833		
Perceived Risk	PR1	0.877	0.693	0.920
	PR2	0.881		
	PR3	0.810		
	PR4	0.762		
Mobile Usability	MU1	0.751	0.514	0.762
	MU2	0.747		
	MU3	0.682		
	MU4	0.649		

Note: SQ=Service quality; IQ=Information quality; SERQ=Service quality; PV=Perceived value; PR=Perceived risk; MU=Mobile usability.

Firstly, this study assessed the measurement model. To ensure the measurement model fits well, the following requirements must be met: the standardized Chi-square value per degree of freedom (X2/df) should be less than 3, the goodness of fit index (GFI) should exceed 0.9, the adjusted goodness of fit index (AGFI) should exceed 0.8, the Tucker–Lewis Index (TLI) should exceed 0.9, the comparative fit index (CFI) should exceed 0.9, and the root mean squared error (RMSEA) should be less than 0.08 (Lv et al., 2025). The results of the assessment showed X2/df = 2.66, GFI = 0.886, AGFI = 0.837, CFI = 0.935 and TLI = 0.910, all of which exceeded the threshold. Furthermore, RMSEA = 0.065, which was less than the threshold, suggesting a good model fit.

Secondly, all items with factor loadings greater than 0.5 were deemed significant (Cheung et al., 2024). This study assessed convergent validity, which measures the degree of consistency among multiple items on the same construct. Hair et al. (2019) proposed using factor loadings, average variance extracted (AVE), and composite reliability (CR) to determine convergent validity. To meet the convergent validity criterion, they recommended factor loadings > 0.5, AVE > 0.5, and CR > 0.7. The analysis results (Table 2) indicated all loadings for the model were greater than 0.6, the AVEs were greater than 0.5, and the CRs were above 0.7. Thus, convergent validity was confirmed.

Discriminant validity is the degree to which items distinguish between various constructs or measure differences across concepts (Rönkkö & Cho, 2022). It is assessed by examining the correlations between measurements of potentially overlapping constructs. Items should have higher factor loadings on the constructs in the model, and the average variance extracted between each construct and its measures should exceed the variance between the construct and others (Compeau et al., 1999; Ramayah et al., 2011). As presented in Table 3, the squared correlations for each construct are less than the average variance recovered by the indicators assessing that construct, indicating adequate discriminant validity. In conclusion, the measurement model revealed sufficient convergent validity and discriminant validity.

Table 3. Discriminant validity.

Construct	System Quality	Information Quality	Service Quality	Perceived Value	Perceived Risk	Mobile Usability
System Quality	0.727					
Information Quality	0.453	0.834				
Service Quality	0.520	0.325	0.821			
Perceived Value	0.337	0.201	0.271	0.716		
Perceived Risk	0.412	0.571	0.224	0.362	0.730	
Mobile Usability	0.525	0.340	0.467	0.261	0.334	0.731

Note: The bolded values on the diagonal are square roots of AVEs, the off-diagonals represent correlations.

Structural Model

Before evaluating the structural model, this study assessed its fit. The hypotheses were tested, and the path coefficients, significance levels, and determination coefficients were obtained. The relevant results are illustrated in Table 4. The X2/df = 2.231, GFI = 0.851, AGFI = 0.816, CFI = 0.910, TLI = 0.885, and RMSEA = 0.071 suggesting good model fit. The R2 for the prediction between independent variables to mobile usability was 0.42, perceived value was 0.27, and mobile usability was 0.36. H1 posited a significant positive relationship between system quality and mobile usability, supporting H1, indicating system quality significantly positively affects mobile usability (ß = 0.530, p < 0.001). H2 posited a significant positive relationship between information quality and mobile usability. Information quality significantly positively affects mobile usability (ß = 0.269, p < 0.001), thus H2 was accepted. H3 posited a significantly positive relationship between service quality and mobile usability. Service quality significantly positively impacts mobile usability (ß = 0.540, p < 0.001). Therefore, H3 is supported. Thus, the significant effect of system quality, information quality, and service quality on mobile usability was determined.

Next, the mediating role of perceived value in the effect of system quality, information quality, and service quality on mobile usability was analyzed using a bias-corrected bootstrap approach with 5000 bootstrap samples and a 95% confidence level. Mobile usability has a significant indirect effect on system quality, information quality, and service quality via perceived value are significant (system quality indirect effect = -.136, 95% bootstrap CI [-.188, -.088], p < .01; information quality indirect effect = -.211, 95% bootstrap CI [-.264, -.168], p < .01, and service quality indirect effect = -.142, 95% bootstrap CI [-.203, -.132], p < .01), respectively. Consequently, hypotheses H4a, H4b, and H4c were supported. Perceived value partially mediates the relationship between system quality, information quality, service quality, and mobile usability.

Table 4: Hypothesis testing results.

Hypothesis	Relationships	β	S.E.	CR	Results
H1	SQ →MU	0.530**	0.059	7.050	Supported
H2	IQ →MU	0.269**	0.072	3.676	Supported
H3	SERQ → MU	0.540**	0.078	5.891	Supported
H5	PR → PV → MU	-0.107**	0.046		Supported
		Direct effect	Indirect effect	Total effect	Degree of mediation
H4a	SQ → PV →MU	-0.157**	-0.136**	-0.293**	Partial
H4b	IQ → PV → MU	-0.170**	-0.211**	-0.381**	Partial
H4c	SERQ → PV → MU	-0.162**	-0.142	-0.321**	Partial

Note: ** p < 0.01; MU=Mobile usability; SQ=Service quality; IQ=Information quality; SERQ=Service quality; PV=Perceived value; PR=Perceived risk.

Finally, the moderating role of perceived risk was analyzed. The interactions between perceived values and mobile usability were analyzed. The results in Table 3 indicated that the perceived risk has a moderated relationship with perceived values and mobile usability (β = -0.107, p < 0.001). Therefore. H5 was accepted.

CONCLUSIONS

Findings and Implications

Based on TAM, this study explores how system quality, information quality, and service quality influence mobile usability, with perceived value as the mediating role and perceived risk as the moderating role. Through data analysis of the sample, the extended TAM constructed in this study was fully validated, with all hypotheses supported, providing empirical evidence for understanding the antecedents of mobile usability. The findings reveal that system quality, information quality, and service quality significant positively affect mobile usability, with perceived value partially mediating the relationship. High-quality systems, information, and services enhance users' perceived value, which in turn strengthens their perception of mobile service usability. These findings are consistent with the core logic of TAM and confirm the theoretical pathway that external variables (system quality, information quality, and service quality) influence technology acceptance outcomes (mobile usability) through the user perception (perceived value). This demonstrates the strong adaptability and robustness of the TAM in mobile payment research.

Furthermore, the significant moderate effect of perceived risk on the relationship between perceived value and mobile usability was verified. When user-perceived risk is low, system quality, information quality, and service quality have a stronger positive impact on mobile usability through perceived value. However, when users perceive high risk, the positive impact of system quality, information quality, and service quality on mobile usability through perceived value is weakened.

Theoretically, this study expands the application scenarios of TAM by incorporating system quality, information quality, and service quality as antecedent variables in the model. This clarifies the mediating role of perceived value and the moderating role of perceived risk, enriching the TAM theoretical framework and providing valuable insights for future research exploring the complex mechanisms of technology acceptance.

Practically, the findings offer important guidance for mobile payment service providers and policymakers. Mobile payment service providers should prioritize optimizing system stability, information accuracy, and service timeliness. They should enhance service efficiency by improving the responsiveness of mobile payment systems, establishing information security assurance systems, and improving customer service systems, thereby enhancing user perceived value. Secondly, they should prioritize security and risk management. This can be achieved by strengthening the system security of risk warning education, addressing technical vulnerabilities and failures, and improving information security capabilities to safeguard user funds and information. For the policymakers, in the context of rapid growth and increasing complexity of mobile payments, to ensure the healthy development of the financial market, protect consumer rights and interests, and prevent financial risks, it should introduce and continuously improve the mobile payment regulatory system, urge mobile service providers to improve their internal control systems, enhance data security protection capabilities, and strengthen user privacy safeguards.

Limitations and Future Directions

This study has certain limitations and needs to be further improved in future research. First, the sample selection is limited in scope. The samples of this study are mainly concentrated in the middle-aged and young mobile payment user groups in Kuala Lumpur and Selangor, Malaysia. This concentration of age and geographical distribution may limit the universality of the research conclusions, especially since the usage characteristics of elderly users and users in other regions are not fully covered. Future research can focus on specific elderly groups and users in other regions to conduct an in-depth analysis of their usage behaviors and influencing mechanisms.

Second, this study did not subdivide the availability differences of different types of mobile payment services. For example, the differences in different forms, such as scan code payment, face payment, and touch payment, have not been included in the investigation. In the future, researchers can better capture the heterogeneity of the impact of system quality, information quality, and service quality on mobile usability by comparing different types of mobile payment services horizontally.

Finally, the applicable scenarios of the research model can be further expanded. The current study is mainly based on mobile payment service scenarios. In the future, the model can be extended to specific mobile payment application fields (such as mobile medical payment and mobile online shopping) to comprehensively evaluate the universality of the model.

ACKNOWLEDGEMENTS

This work was supported by Management and Science University as part of the MSU International Research Grant entitled “Model of Intention to Use E-Wallet for Gen-Z: Study on New Technology Adoption” with contract number MIRG-004-022024-FBMP and contract date 30th July 2026.

AUTHOR CONTRIBUTIONS

Siti Hajar Mohamad contributed to the conceptualization, data curation, investigation, writing of the original draft, project administration, and funding acquisition. Doni Purnama Alamsyah, Nurhidayah Shamsudin, Iylia Dayana Mohamed Izwan, and Yi Huang contributed to supervision and writing, review, and editing.

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