

2024

## Modelling Security Factors Influencing E-Wallet Adoption in Malaysia

Adi Badiozaman Ruhani

*Department of Management and Information Technology, Politeknik Seberang Perai, Permatang Pauh, 13500, Malaysia AND Institute for Advanced and Smart Digital Opportunities, School of Computing, Universiti Utara Malaysia, Sintok, 06010, Malaysia*

Nur Suhaili Mansor

*Institute for Advanced and Smart Digital Opportunities, School of Computing, Universiti Utara Malaysia, Sintok, 06010, Malaysia, nursuhaili@uum.edu.my*

Hapini Awang

*Institute for Advanced and Smart Digital Opportunities, School of Computing, Universiti Utara Malaysia, Sintok, 06010, Malaysia*

Mohamad Fadli Zolkipli

*Institute for Advanced and Smart Digital Opportunities, School of Computing, Universiti Utara Malaysia, Sintok, 06010, Malaysia*

Khuzairi Mohd Zaini

Follow this and additional works at: <https://ijcsm.researchcommons.org/ijcsm>  
*Institute for Advanced and Smart Digital Opportunities, School of Computing, Universiti Utara Malaysia, Sintok, 06010, Malaysia*



[Digital Commons](https://ijcsm.researchcommons.org/ijcsm)

---

### Recommended Citation

See next page for additional authors

Ruhani, Adi Badiozaman; Mansor, Nur Suhaili; Awang, Hapini; Zolkipli, Mohamad Fadli; Zaini, Khuzairi Mohd; and Benlahcene, Abderrahmane (2024) "Modelling Security Factors Influencing E-Wallet Adoption in Malaysia," *Iraqi Journal for Computer Science and Mathematics*: Vol. 5: Iss. 4, Article 6.

DOI: <https://doi.org/10.52866/2788-7421.1205>

Available at: <https://ijcsm.researchcommons.org/ijcsm/vol5/iss4/6>

This Original Study is brought to you for free and open access by Iraqi Journal for Computer Science and Mathematics. It has been accepted for inclusion in Iraqi Journal for Computer Science and Mathematics by an authorized editor of Iraqi Journal for Computer Science and Mathematics. For more information, please contact [mohammad.aljanabi@aliraqia.edu.iq](mailto:mohammad.aljanabi@aliraqia.edu.iq).

---

## Modelling Security Factors Influencing E-Wallet Adoption in Malaysia

### Authors

Adi Badiozaman Ruhani, Nur Suhaili Mansor, Hapini Awang, Mohamad Fadli Zolkipli, Khuzairi Mohd Zaini, and Abderrahmane Benlahcene



## RESEARCH ARTICLE

# Modelling Security Factors Influencing E-Wallet Adoption in Malaysia

Adi Badiozaman Ruhani<sup>a,b</sup>, Nur Suhaili Mansor<sup>b,\*</sup>, Hapini Awang<sup>b</sup>,  
Mohamad Fadli Zolkipli<sup>b</sup>, Khuzairi Mohd Zaini<sup>b</sup>, Abderrahmane Benlahcene<sup>b,c</sup>

<sup>a</sup> Department of Management and Information Technology, Politeknik Seberang Perai, Permatang Pauh, 13500, Malaysia

<sup>b</sup> Institute for Advanced and Smart Digital Opportunities, School of Computing, Universiti Utara Malaysia, Sintok, 06010, Malaysia

<sup>c</sup> College of Commerce and Business Administration, Dhofar University, Salalah, Oman

## ABSTRACT

This study aims to develop an effective framework that addresses the security concerns and user behavior related to e-wallet adoption. The research methodology entails quantitative data collection through a literature review and surveys of e-wallet users using convenience sampling, and the proposed model is tested using the Partial Least Squares Structural Equation Modelling (PLS-SEM). The proposed security factors in this study include phone stolen protection, app security performance, secure authentication, data privacy protection, secure online transaction and banking info security. The online survey form was disseminated to Malaysian citizens, and 186 respondents participated in the survey. Using a two-step approach, this study employed a measurement model to assess indicator loadings, convergent validity, and reliability. Additionally, a structural model was utilized for path analysis. This study selects the measurement or dependent variable for e-wallet adoption as "usage behavior." The findings indicate a significant positive relationship between e-wallet adoption behavior and online trans-action security. The inclusion of secure online transactions in digital wallets reassures users, fostering confidence and promoting engagement in secure online transactions, thereby bolstering the efficacy of e-wallet services, especially for critical financial activities. The significance of the research project lies in its potential to overcome the barriers hindering e-wallet adoption by addressing the security concerns of potential users. By enhancing security measures and increasing user trust, the adoption of e-wallets can be accelerated. Through an in-depth analysis of these factors, the research may provide recommendations and contribute to the country's overall development and adoption of e-wallets.

**Keywords:** E-wallet, Security factors, Privacy concern, PLS-SEM, FinTech

## 1. Introduction

An electronic wallet, also referred to as a “digital wallet” or “e-wallet,” is a digital representation of a payment card that is authorized for use in online transactions [1–3] and enables anyone to do any e-commerce transaction and payments, which are currently considered one of the most popular transaction methods. A digital wallet transaction includes the advantages of convenience, flexibility, security [4, 5], cost savings, bill-splitting capability, and the opportunity to earn toll payment reductions [6].

The application enables customers to organize information about buying, loyalty and financial in a centralized location, similar to a real wallet [4, 7].

An E-wallet refers to an electronic card or application utilized for online transactions through a computer or smartphone, functioning similarly to a credit or debit card. To facilitate payments, an E-wallet must be linked to the user's bank account [6]. In Malaysia, e-wallets have gained significant traction due to their convenience and the government's initiative to promote a cashless society. Malaysia initiated a fintech initiative in 2011 as part of its Financial

Received 21 January 2024; accepted 19 November 2024.  
Available online 25 November 2024

\* Corresponding author.  
E-mail address: [nursuhaili@uum.edu.my](mailto:nursuhaili@uum.edu.my) (N. S. Mansor).

<https://doi.org/10.52866/2788-7421.1205>

2788-7421/© 2024 The Author(s). This is an open-access article under the CC BY license (<https://creativecommons.org/licenses/by/4.0/>).

Sector Blueprint 2011-2020 to modernize the financial sector and position Malaysia as a technologically advanced nation [8].

Based on the Malaysia FinTech Report 2021 [9], e-wallets are leading at 15% of the Malaysian FinTech space, with 38 over 233 companies providing e-wallet services. According to statistics from the BNM [10], e-payments and the utilization of e-wallets in Malaysia are emerging trends, but their progress is currently sluggish. In fact, Statista Research Department revealed that in the fourth quarter of 2022, 45 percent of Malaysian consumers had utilized digital wallets. However, this figure exhibited a decline compared to the previous quarter.

The peak usage of e-wallets in Malaysia was observed in the first quarter of 2022, with a recorded rate of 68 percent. The current circumstances could potentially impact the progress of initiatives aimed at transforming Malaysians into a cashless society, which offers numerous benefits, including economic efficiency, financial inclusion, reduced crime, improved transparency, technological advancement, and environmental sustainability.

However, there are various issues that have hindered Malaysia from attaining widespread e-wallet acceptance among its residents, and [6, 7], [11–17] noted that the security component is the biggest difficulty, including confidentiality, which is also seriously affected if the phones are lost or stolen [6, 7], [18–20]. Furthermore, they must contend with security threats such as hacking, malware, and phishing attempts in online transactions.

E-wallets offer convenient and secure digital payment solutions, but security concerns hinder their widespread adoption in Malaysia. While the rise of COVID-19 has prompted Malaysians to embrace a cashless payment method, security concerns about e-wallet applications have been circulating, and most users are concerned [21]. According to Oppotus report [22], e-wallet usage declined quarterly, reaching 45% in Q1 2022, as consumers had more payment options with businesses operating normally, leading to a preference for cash (34%) and debit cards (19%) over digital wallets. Some small businesses still do not offer e-wallets as a payment choice.

The popularity of e-wallets is attributed to their seamless transactions, but the lack of awareness and knowledge, coupled with security concerns, remains a significant barrier. People hesitate to use e-wallets without trust in information system providers and the assurance of privacy and security features in place for transactions [23].

Despite the benefits and convenience of using e-wallets, user concerns persist due to fraud and secu-

rity issues. Some users are hesitant to use e-wallets as they do not see smartphones as secure payment methods. Additionally, linking financial information raises liability for potential losses from unauthorized transactions, causing inconvenience and time-consuming reconciliation processes for consumers seeking refunds [24]. Understanding and mitigating these risks is vital.

According to [8], Malaysia has a lot of potential for implementing the electronic wallet system; however, there are several challenges. Infrastructure, e-wallet complexity, cyber security, risk to personal information and fintech laws are just a few of them. Therefore, numerous studies have explored the factors influencing e-wallet adoption, including convenience [25], trust [19], perceived usefulness, and social influence [6]. However, the specific security factors that influence e-wallet adoption in Malaysia have not been comprehensively investigated. Understanding these factors is crucial for addressing user concerns and enhancing the security measures of e-wallet platforms [20].

Previous studies have identified security concerns as one of the key barriers to e-wallet adoption [6, 7, 11, 26, 27]. Security-related issues such as data breaches [28], unauthorized access [29], and fraudulent [8] activities may lead to skepticism and hesitation among potential users. Addressing security concerns is crucial for realizing the full potential of e-wallets in Malaysia, promoting financial inclusion and convenience. It is supported by [11], which states that concerns regarding security and privacy have arisen as significant obstacles to their widespread adoption.

This study aims to develop an effective framework that addresses the security concerns and user behavior related to e-wallet adoption. In pursuit of this goal, the research will determine the level of security concern among users and identify the security factors that impact the use of e-wallets in Malaysia. The focus of the study is solely on security factors due to the increasing concerns among smart technology users regarding security issues during transactions. Previous studies have only considered security as a general factor, making it essential to delve deeper into specific security aspects.

As it is commonly understood, the existing research on e-wallet adoption in Malaysia has overlooked specific security factors, hindering the industry's success. By analyzing the problem statement, this study may assist e-wallet providers in better understanding their customers' perspectives on e-wallet security issues, motivating providers to implement appropriately designed regulations that will increase e-wallet adoption in Malaysia.

## 2. Related work

This section will go into greater detail about the background and several important previous research efforts related to the security factors that influenced e-wallet adoption, which will help define the general model of this study.

### 2.1. E-WALLET services

In 1997, Coca-Cola allowed consumers in Helsinki to make payments via text message on vending machines, serving as a precursor to the development of digital payments and the eventual replacement of physical wallets with mobile phones for transactions and fund transfers [6, 12]. Digital payment does not entail the exchange of monetary notes; rather, the process of releasing and accepting money is carried out digitally [30, 31]. In the early days, electronic payment could be managed using several methods such as debit/credit cards, and the ACH network consisting of direct debit, e-check, and direct deposit [15, 32].

Besides, in 2011, Google pioneered the creation of a mobile m-wallet with NFC technology, enabling digital payments, loyalty points, discounts, and prizes. Apple Passbook emerged in 2012 for handling boarding passes, tickets, and coupons. Apple Pay, Android Pay, and Samsung Pay have since adopted NFC technology. These various types of e-wallets can be categorized based on themes due to the variable operationalization and usage of e-wallets.

In the meantime, digital payment systems are designed to appeal to a wider range of customers and to compete with market leaders [14, 27, 33]. These payment innovations can provide a wide range of alternative options, raising public awareness of the advantages of digital payment services [34]. Digital payments encompass a wide range of payments made with digital instruments, such as e-wallets, electronic payments, mobile payments and QR-based payments [16, 33, 35]. The e-wallet service comprises essential components: a smartphone, an e-wallet application, an e-wallet server, an Internet connection, merchant platforms, and the user's bank account, as illustrated in Fig. 1 [36].

E-wallets can be classified according to accessibility for three types of services which are closed e-wallet, semi-closed e-wallet, and open e-wallet [6, 20, 36, 37]. A closed e-wallet refers to an e-wallet provided by a company exclusively for the purpose of enabling consumers to buy goods and services directly from that company.

A semi-closed e-wallet enables the user to purchase goods and services, including financial services,



Fig. 1. Components in e-wallet service.

specifically at designated merchant locations and establishments with a contractual agreement with the e-wallet issuer. On the other hand, an open e-wallet allows users to purchase goods and services, including financial services, at any merchant location and withdraw cash from ATMs or authorized business correspondents.

Aside from that, e-wallet services vary in technological bases. Some operate solely online, while NFC and QR-code-based e-wallets enable over-the-counter transactions through smartphones. NFC-based wallets use radio frequencies for contact-based payments, while QR-code wallets process payments through scanned QR images, allowing contactless transactions. E-wallets also can be classified as network-based or card-based. Both types can issue electronic money and perform transactions with merchants (open loop). However, only the card-based e-wallet is linked to a specific card scheme [6].

### 2.2. E-wallet landscape in malaysia

In 2015, e-wallets made their debut in Malaysia, but their adoption was still at an early stage. These payment methods have grown in popularity in Malaysia, particularly during the COVID-19 outbreak [21, 37, 38]. The COVID-19 pandemic has prompted an increased adoption of e-wallets by consumers as they seek contactless transaction methods to comply with social distancing measures. As consumers' lifestyles and needs evolve with the changing times, merchants are compelled to rethink and reformulate their customer services accordingly [39].

During the Covid-19 epidemic, especially in Asia, data reveals a 30–40% rise in online shopping spending and a 60 percent increase in contactless payments

[27]. In fact, the advent of e-wallets has caused significant disruptions within the FinTech industry, leading to a fundamental transformation in the financial services sector operations. Southeast Asia has emerged as the fastest-growing region globally in terms of the rapid expansion of mobile wallets [38, 40].

According to [41], in the year 2021, mobile banking witnessed a significant surge, attracting three million new customers and driving the adoption of e-wallets to unprecedented levels, largely influenced by the Malaysian Government's Movement Control Order (MCO). Responding promptly to the trend, merchants embraced digital payments, with over 400,000 new businesses registering for QR code payments—a remarkable 164% increase compared to the previous year.

Despite the significant increase in e-wallet usage in Malaysia, it is evident that the transaction volume of e-wallets is not as desirable as that of online banking [41]. Additionally, there is a lack of comprehensive sources available on the factors influencing users' behavior to adopt e-wallets in Malaysia.

The adoption of e-wallets in Malaysia has proven beneficial, contributing to national income, enhancing business competitiveness, and fostering growth in the digital economy [42]. To capitalize on these advantages, the Malaysian government introduced the E-Tunai Rakyat initiative to encourage e-wallet adoption among citizens. The response from the public has been positive, with the E-Tunai and E-Penjaja applications gaining popularity and significantly increasing e-wallet usage among Malaysians.

In the meantime, the pandemic led to a surge in e-wallet usage in Malaysia, with 68% of Malaysian respondents reporting e-wallet payments in Q1 2022. However, this percentage declined compared to the previous quarter [43]. The usage of e-wallet services remains low in Malaysia, primarily due to the fact that many Malaysian users are unaware of the numerous benefits offered by e-wallets and have limited knowledge about their usage. According to an industry report, Malaysian users often prefer debit cards or online banking over e-wallets for non-cash payment transactions [6].

### 2.3. Hypothesis development and proposed research model

An E-wallet is a digital representation of a payment card used for online transactions and e-commerce payments. Due to the proliferation of cyber threats targeting the financial sector, security has emerged as an indispensable element in banking [44]. In a previous study, it was concluded that security plays a significant role in influencing the adoption of

**Table 1.** Proposed security factors.

Component	Proposed security factor
Smartphone	Phone stolen protection
E-wallet app	App security performance, secure authentication
E-wallet server	Data privacy protection
Internet connection	Secure online transaction
User's banks account	Banking info security

e-wallets in general. Nevertheless, there is a scarcity of research focused specifically on identifying security factors related to the adoption of e-wallets, with limited or almost non-existent existing studies in this area [20].

As widely understood, this service requires a smartphone, an e-wallet app, an e-wallet server, an internet connection, merchant platforms, and the user's bank account. Each of these components carries its own set of security risks. According to the previous studies [20], they have proposed six security factors that have been identified as affecting e-wallet customer satisfaction. Those security factors are transaction speed, authentication, encryption mechanisms, software performance, privacy details and information provided. However, in this study, the author also suggests six security factors that are related to e-wallet service components, as shown in Table 1.

The proposed security factors include phone stolen protection, app security performance, secure authentication, data privacy protection, secure online transaction and banking info security. Only two factors—data privacy and authentication—are used once more in this study. While the three other factors—online transactions, banking information, and app performance—have been re-justified, particularly in terms of scope. One new variable or factor is put forth in this study that has to do with smartphone security concerns [6, 18, 19]. Each of the suggested factors is considered as a variable in this research. The next section outlines the variables' description and the proposed hypotheses for the study.

**Secure Online Transaction.** The number of online transactions has experienced a tremendous surge, witnessing a significant expansion in the e-commerce industry with numerous players rapidly expanding their businesses [28]. The term online transaction refers to a method of completing financial transactions through the internet. This online transaction is a way to potentially steal money [26] since it contains credit card and payment account credentials [45] as well as personal information [46]. As a result, clients must feel safe in terms of their personal privacy issues [26, 47]. Previous research indicates that consumer hesitation in online transactions stems from security concerns. However, when security features are

present, consumers feel more confident and able to engage in secure online transactions [26]. As a result, the following hypothesis is put forward:

**H1.** *The e-wallet adoption behavior and online transaction security are significantly related.*

**Secure Authentication.** Authentication is the process of validating a user's identity to ensure that the action being done is being carried out by a trustworthy and actual person. It functions as a deterrent, reducing the chances of identity theft. Authentication has a tremendous impact on the consumer's experience, which influences their decision to use a digital wallet [25, 48]. In the meanwhile, authentication plays a critical role in safeguarding e-wallets, requiring installation on dedicated devices and utilizing multifactor operations in today's digital era [3]. According to the findings of the [25] study, the priority of importance among factors is led by authentication methods, with usability and convenience concerns following closely behind. Because client confidence is so important, digital wallet providers must ensure that important components like authentication are properly controlled to establish user trust [49]. Consequently, the subsequent hypothesis is put forth:

**H2.** *The e-wallet adoption behavior and secure authentication are significantly related.*

**Data Privacy Protection.** In this sense, data privacy refers to the information collected from clients by digital services. Private information is usually provided for registration purposes. Customer satisfaction with digital wallets is greatly impacted by their capacity to safeguard their privacy, according to several past research [50, 51]. Consumers are concerned about the confidentiality of their personal information, which they fear will be abused by the merchant [52]. Ensuring customer privacy and security is crucial for digital payment applications to build customer trust and protect against vulnerabilities like identity theft and information exploitation [11]. Therefore, the following hypothesis is proposed:

**H3.** *The e-wallet adoption behavior and data privacy protection are significantly related.*

**App Security Performance.** If users are concerned about the security of e-wallet apps, they will typically avoid using them. The app, for example, might contain malicious code that can monitor users' identities and collect sensitive information [53]. A comprehensive examination of 693 banking apps found to have numerous vulnerabilities, revealing inadequate secu-

urity measures [54]. Performance expectation is one of the most important factors that directly determine acceptance intention for digital wallets [55, 56]. Consumers may be concerned about incorrect functional use circumstances and software defects. Therefore, the following hypothesis is proposed:

**H4.** *The e-wallet adoption behavior and app security performance are significantly related.*

**Banking Info Security.** Banking information refers to all information regarding the Bank's clients and their affairs that is subject to banking secrecy, is not accessible to the general public, and is kept in the Bank's information system. Consumers are concerned that their personal financial information may be released, leaving them vulnerable to fraud and scams [6, 28]. As a result, the following hypothesis is made:

**H5.** *The e-wallet adoption behavior and banking information security are significantly related.*

**Phone Stolen.** Private information is stored on smartphones and other technological gadgets. Digital wallets eliminate the necessity for consumers to carry their wallets or purses. They must, however, have at least one electronic device, such as a smartphone, with them at all times [20]. The user risks losing personal and private information if his or her gadget is stolen or misplaced [7, 19]. Therefore, the following hypothesis is proposed:

**H6.** *The e-wallet adoption behavior and phone stolen are significantly related.*

This study adopts usage behavior as the primary measurement instead of customer satisfaction, considering its higher significance in the context of the research to show the degree of e-wallet adoption. Customer satisfaction with e-wallets is determined by how effectively the services meet or surpass consumer expectations [57]. In fact, merely being satisfied does not ensure action; the offerings of service significantly influence behavioral decisions [58]. Moreover, the ongoing utilization of online services may not always be linked to customer satisfaction in particular application contexts. Customer satisfaction is a distinct outcome that is contingent on the specific experience during the evaluation of pre-consumption attitudes [59].

The selection of usage behavior as a dependent variable is seen in line with what is stated in [60], which is the behavioral factor represents an emotional element that motivates individuals to embrace mobile payment methods. And even more clearly, according

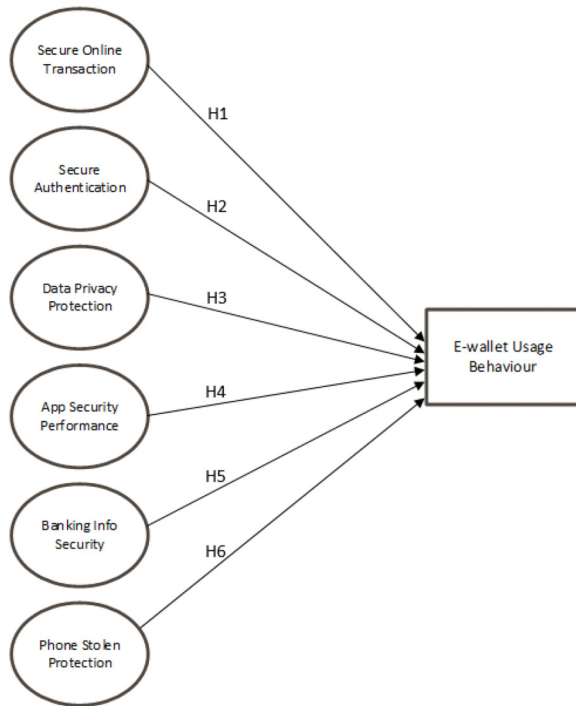


Fig. 2. The proposed research conceptual model.

to [59], as a certain behavior becomes more habitual, its predictability by intention decreases. However, usage intention is a fundamental approach for predicting human behavior towards possible technology adoption or rejection, and the intention is commonly used simply to explain how attitude can impact consumer behavior [21]. The suggested model for this research is depicted in Fig. 2.

### 3. Methodology

This section focuses on techniques that have already been completed or existing solutions identified in earlier literature but with the addition of new thoughts to the solution. Since data analysis is quantitative and hypotheses and relationships must be tested, a conclusive research design was used for this study [61–63].

#### 3.1. Research design

In this research, quantitative methods are employed to test the theory and draw conclusions that can be generalized from the findings. A conceptual model (Fig. 2) has been developed, informed by an extensive literature review. Through the use of quantitative methods, the research aims to numerically and mathematically depict the relationships between variables,

enabling a comprehensive analysis of their associations.

#### 3.2. Data collection

In order to ensure the model's realistic testing, the study opted for an online survey as it facilitated reaching a large and diverse participant pool while efficiently gathering data for multiple questions within a limited timeframe [64]. The data collection process involved distributing a self-administered online questionnaire to a wide range of Malaysian citizens who met the criteria of using any digital wallet platform, and the survey was shared on various social networks. Due to the absence of a sampling frame encompassing all e-wallet users, convenience sampling was employed to gather the data [65]. The chosen method was based on the study's relatively large sample size, which necessitated the use of the Slovin formula to gather a minimum sample of 100 respondents (with a 10% error rate) [17].

The method was selected to ensure a broader and more diverse coverage of respondents, encompassing a wider range of demographics. The survey facilitated the acquisition of extensive information and validation of the models by utilizing closed-ended questions in the questionnaire to standardize the responses [21]. The research framework involved adapting statements to assess eight constructs. Each item was rated on a seven-point Likert scale. The questionnaire was divided into three parts: the first for respondents' demographic information, the second for e-wallet usage, and the third for the constructs in the proposed model. Additionally, the questionnaire was available in both English and Malay versions.

The online Microsoft Form was distributed to the users of various social media platforms, and data collection took place from 1st July to 29th July 2023. The survey yielded a total of 186 responses. After evaluating the data for missing values and outliers, one response was removed during the data-cleaning process. Consequently, a total of 185 usable responses remained for analysis. The demographic information of the respondents was then analyzed to provide an overview of their profiles.

#### 3.3. Data analysis

The proposed model is tested using the Partial Least Squares Structural Equation Modelling (PLS-SEM) method. Even this method has been widely adopted by researchers in various fields, including mobile wallets, internet banking, mobile shopping, and ride-sharing [48].



In recent times, [65] stated Partial Least Squares Structural Equation Modelling (PLS-SEM) has gained popularity among social scientists and researchers across various disciplines, including hospitality, tourism, and Fintech studies. Its application has expanded due to its capacity to handle complex models and reflective measurement in quantitative research. Notably, PLS-SEM does not rely on normal distributional assumptions and does not demand large sample sizes, making it a versatile tool for both explanatory and predictive analysis in Fintech studies.

## 4. Result and discussion

### 4.1. Profiles of respondents

The research encompasses mobile wallet customers' profiles distributed across various analytics. Table 2 below shows the characteristics of the respondents in this study. The data underwent descriptive analysis using Microsoft Excel. Overall, 66% of the respondents are female and 34% male. Meanwhile, in terms of education, the majority are undergraduate (49%) and postgraduate (23%). The respondents' age distribution appears to be relatively balanced, with 30% belonging to Gen Z (11–26 years old), 37% to Millennials (27–42 years old), and 32% to Gen X (43–58 years old). The majority of them were from the North Region (41%), followed by the Central Region of Malaysia (32%).

According to the findings, 86% of the respondents reported having over ten years of Internet experience, while 65% used an Android smartphone as their e-wallet platform device. Furthermore, the respondents' top choices for frequently used digital wallets were Touch n Go e-wallet (44%) and MAE (30%). Consequently, more than three-quarters of the respondents (76%) utilize the e-wallet app for financial transactions more than six times a month, and 71% of responses report transaction amounts exceeding RM400 per month.

### 4.2. Measurement model

In order to validate the proposed hypotheses, they need to undergo rigorous testing using appropriate methods and analyses. For this research, Structural Equation Modeling (SEM) with Partial Least Squares (PLS) was employed as the data analysis approach. SEM with PLS is chosen as the preferred method for examining the relationships between variables and validating the research hypotheses. PLS is employed to assess the suitability of the built model in theory and practice, encompassing stages such as measurement model analysis to evaluate data validity and

**Table 2.** Demographics of the participants.

Respondents' characteristics	Frequency	Percentage
<b>A1: Gender</b>		
Male	63	34%
Female	122	66%
<b>A2: Age (years old)</b>		
11–26	56	30%
27–42	69	37%
43–58	59	32%
> 59	1	1%
<b>A3: Region</b>		
North region	76	41%
Central region	59	32%
South region	28	15%
East coast region	15	8%
East malaysia	7	4%
<b>A4: Education level</b>		
Secondary school	13	7%
Certificate	8	4%
Diploma	25	14%
Bachelor's degree	91	49%
Master's degree	43	23%
PhD	5	3%
Others	0	0%
<b>A5: Years of internet experience</b>		
Less than 1 year	1	1%
1–5 years	8	4%
6–10 years	16	9%
> 10 years	160	86%
<b>A6: Type of smartphone</b>		
Android smartphone	121	65%
iPhone	64	35%
Not using any smartphone	0	0%
<b>A7: E-wallet app frequently used</b>		
Touch'n go eWallet	81	44%
Maybank2u (MAE)	56	30%
Grab pay	10	5%
CIMB QRPay	13	7%
Boost	4	2%
Shopee pay	16	9%
BigPay	0	0%
AEON wallet	0	0%
FavePay	0	0%
KiplePay	0	0%
Other	5	3%

reliability, followed by structural model analysis to determine the model's appropriateness and concluding with statistical analysis and hypothesis evaluation [16].

The initial step involved calculating the outer loadings of the model. Each indicator's loading was thoroughly examined to ensure that the constructs met the prescribed criteria. Specifically, it was recommended that all factor loadings should be at least 0.7 [17, 48, 65]. Upon analyzing the data, it was observed that all the findings exceeded the required threshold of 0.7, except for three items within the C6 construct. However, the findings from the reliability

**Table 3.** Reliability and validity measures constructs.

Descriptions	Constructs	Item	OL	CA	CR (rho_a)	CR (rho_c)	AVE
Frequency of usage	B1	B1a < – B1	0.894	0.905	0.926	0.934	0.779
		B1b < – B1	0.903				
		B1c < – B1	0.789				
		B1d < – B1	0.938				
Transaction amount	B2	B2a < – B2	0.888	0.931	0.950	0.951	0.829
		B2b < – B2	0.855				
		B2c < – B2	0.953				
		B2d < – B2	0.944				
Secure online transaction	C1	C1a < – C1	0.911	0.914	0.925	0.939	0.794
		C1b < – C1	0.849				
		C1c < – C1	0.907				
		C1d < – C1	0.896				
Secure authentication	C2	C2a < – C2	0.955	0.974	0.976	0.981	0.928
		C2b < – C2	0.966				
		C2c < – C2	0.975				
		C2d < – C2	0.957				
Data privacy protection	C3	C3a < – C3	0.867	0.915	0.927	0.940	0.796
		C3b < – C3	0.885				
		C3c < – C3	0.924				
		C3d < – C3	0.892				
Apps security performance	C4	C4a < – C4	0.927	0.946	0.958	0.961	0.859
		C4b < – C4	0.907				
		C4c < – C4	0.940				
		C4d < – C4	0.933				
Banking info security	C5	C5a < – C5	0.932	0.960	0.970	0.971	0.892
		C5b < – C5	0.930				
		C5c < – C5	0.964				
		C5d < – C5	0.952				
Phone stolen	C6	C6a < – C6	0.659	0.723	0.775	0.818	0.532
		C6b < – C6	0.678				
		C6c < – C6	0.868				
		C6d < – C6	0.694				

Note: Outer Loading (OL) (>0.7); Average Variance Extracted (AVE) (>0.5); Composite Reliability (CR) (>0.7); Cronbach's Alpha (CA) (>0.7).

and validity analysis indicate that all three items meet the required criteria for Average Variance Extracted (AVE) (>0.5), Composite Reliability (CR) (>0.7), and Cronbach's Alpha (CA) (>0.7), then the item is retained. The detailed results are presented in Table 3.

The study assessed discriminant validity by calculating the Heterotrait-Monotrait (HTMT) ratio for correlations. Table 4 presents the results, indicating that all constructs' values were below 0.90 [16, 35, 39, 66]. These findings demonstrate strong reliability and validity in the study.

The comprehensive adaptation model in Smart-PLS aims to identify each indicator's significance. SRMR (Standardized Root-Mean-Square Residual) serves as an absolute adaptation indicator, assessing the accuracy of hypotheses [67]. An SRMR value below 0.10 indicates a better fit. Additionally, the Normed Fit Index (NFI), with values between 0 and 1, reflects the fit quality, where an NFI above 0.80 signifies an

**Table 4.** Discriminant validity using the HTMT.

	B1	B2	C1	C2	C3	C4	C5	C6
B1								
B2	0.735							
C1	0.469	0.557						
C2	0.282	0.396	0.779					
C3	0.320	0.296	0.659	0.688				
C4	0.325	0.386	0.762	0.782	0.772			
C5	0.308	0.374	0.681	0.719	0.785	0.886		
C6	0.154	0.281	0.483	0.527	0.539	0.547	0.572	

Note: Heterotrait-Monotrait (HTMT) (<0.9).

acceptable fit [68]. In this research, the structural model's fit was assessed with SRMR (Standardized Root Mean Residual) at 0.058 and NFI (Normed Fit Index) at 0.819. As per Smart-PLS regulations for model estimation, the fit indices met the required criteria, indicating a good fit of the structural model. Therefore, it can be inferred that the adaptation model is appropriate for this study.

**Table 5.** Collinearity Statistics (VIF) - Inner Model.

	VIF	VIF
C1 -> B1	2.449	C4 -> B1 4.895
C1 -> B2	2.449	C4 -> B2 4.895
C2 -> B1	2.956	C5 -> B1 4.205
C2 -> B2	2.956	C5 -> B2 4.205
C3 -> B1	2.489	C6 -> B1 1.426
C3 -> B2	2.489	C6 -> B2 1.426

Note: Variance inflation factor (VIF) (<5.0).

**4.3. Structural model**

In the subsequent phase, the assessment of the structural model involves examining collinearity concerns and assessing the statistical significance and relevance of the path coefficients [65]. The research must ensure freedom from collinearity issues, as it is essential to assess whether the constructed model is devoid of collinearity. The presence of high levels of multicollinearity in the formative measurement model can lead to redundancy in indicator information, rendering certain indicators statistically nonsignificant [68]. A construct is considered free of collinearity if its value is below 5 [39].

According to [68], Variance inflation factor (VIF) values of 5 or higher indicate possible collinearity issues. However, the findings presented in Table 5 show all constructs' internal VIF values ranged from 1.426 to 4.895, which are below 5. Consequently, based on the collinearity assessment results, there are no concerns regarding collinearities between the variables in the current research framework.

The structural model depicts the hypothesized relationships between the latent variables in this study. Table 6 presents the path coefficients ( $\beta$ ), t-statistics, and p-values for each hypothesis. The analysis reveals that only one hypothesis is significant and supported. Specifically, H1 ( $\beta = 0.495$ ,  $t = 4.263$ ,  $p = 0.000$ ) and ( $\beta = 0.533$ ,  $t = 5.273$ ,  $p = 0.000$ ) show a positive and significant relationship between secure online transactions and usage behavior (frequency of usage and transaction amount), representing e-wallet adoption (B1/B2). This finding aligns and is consistent with prior studies concerning online transactions [2, 15, 20, 48].

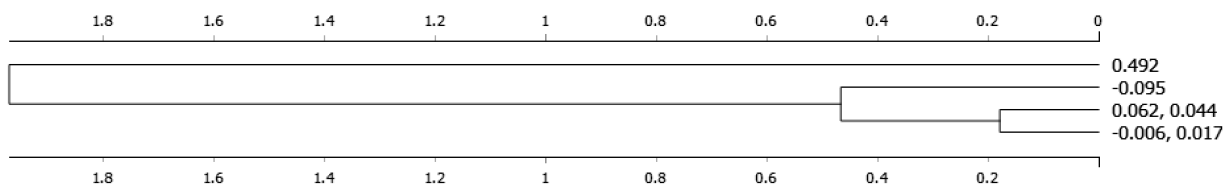
**Table 6.** Hypothesis testing.

Hypothesis	Path	$\beta$	T-stats	p-value	Decision
H1	C1 -> B1	0.495	4.263	0.000	Supported
	C1 -> B2	0.533	5.273	0.000	
H2	C2 -> B1	-0.147	1.055	0.292	Rejected
	C2 -> B2	0.003	0.026	0.979	
H3	C3 -> B1	0.095	0.838	0.402	Rejected
	C3 -> B2	-0.117	1.027	0.304	
H4	C4 -> B1	-0.012	0.080	0.936	Rejected
	C4 -> B2	-0.057	0.369	0.712	
H5	C5 -> B1	0.056	0.387	0.699	Rejected
	C5 -> B2	0.124	0.945	0.345	
H6	C6 -> B1	-0.072	0.807	0.420	Rejected
	C6 -> B2	0.051	0.619	0.536	

On the other hand, no significant relationships were found between C2, C3, C4, C5, and C6 with either B1 or B2 ( $t < 1.96$ ,  $p > 0.05$ ), leading to the rejection of H2, H3, H4, H5, and H6, respectively. These results indicate that perceived secure authentication, data privacy protection, app security performance, perceived banking information security, and the perceived risk of phone theft do not significantly influence e-wallet adoption behavior in this study.

The assessment of security concern levels, based on the proposed construct, involves categorizing them into three tiers: High, Moderate, and Low. Clustering is determined based on the mean values of each construct. The findings are presented in Fig. 3, indicating that secure online transactions are rated at the High level, followed by secure authentication at the Moderate level. On the other hand, data privacy protection, app security performance, banking information security, and phone theft protection are ranked at the Low level.

The coefficient of determination ( $R^2$ ) was utilized to evaluate the predictive accuracy of the dependent variables. The model accounted for 21.1% of the variance in frequency of usage (B1) and 28.5% of the variance in transaction amount (B2). These  $R^2$  values, 0.211 and 0.285, respectively, exceeded the recommended threshold of 0.13, as proposed by [69], indicating a moderate predictive power. The evaluation of a high  $R^2$  level is contingent on the particular research discipline, with disciplines like consumer behavior regarding  $R^2$  results of 0.20 as high [68].



**Fig. 3.** Security level concern.

Overall, the analysis supports the positive relationship between secure online transactions and e-wallet adoption, while the other factors do not show a significant impact on the adoption behavior. Indeed, the primary concern for e-wallet users in this study is the security of online transactions. Based on the survey findings, the presence of secure online transactions in digital wallets helps alleviate security concerns among users. Users perceive that the existence of robust security features instills confidence and encourages engagement in secure online transactions, thereby enhancing the effectiveness of digital e-wallet services. This aspect holds particular significance for critical transactions, especially those involving financial activities.

## 5. Limitations and future works

This section has addressed the limitations of the present study and offered recommendations for future research. Firstly, it acknowledges the small sample size and potential outliers, suggesting that future investigations should involve a larger and more diverse respondent pool spanning various generational profiles. Secondly, the empirical study included 66% female respondents, indicating an asymmetric gender distribution. As a consequence, the study's results may be biased towards modeling the behavior of women rather than capturing the overall customer behavior. Prior evidence has highlighted gender differences' potential to influence the effects of attitude, perceived behavioral control, and subjective norm on a user's behavioral intention [59].

Thirdly, the study successfully identified and examined security factors impacting e-wallet application usage, but it proposes enhancing the instruments for each construct in future studies. Lastly, it emphasizes the necessity of testing the proposed model to optimize its effectiveness in capturing the relationships between security factors and e-wallet adoption behavior. Implementing these recommendations will contribute to a more comprehensive and robust understanding of security influences on e-wallet adoption.

## 6. Conclusion

In conclusion, this research introduces a comprehensive six-factor security framework that impacts e-wallet adoption behavior. Among the proposed factors, only secure online transactions emerge as the sole significant positive influence on usage behavior. This finding suggests that users' confidence in transaction security plays a pivotal role in driving

broader adoption of e-wallet applications, elevating them from being solely utilized for receiving government aid funds.

In this study, it is worth noting that the results may be subject to the respondents' demographics, as 86% of them possess over a decade of Internet usage experience. This implies the need for further investigation to explore potential variations in security perceptions among diverse user groups. Nonetheless, the study contributes valuable insights for stakeholders seeking to enhance e-wallet adoption rates by prioritizing robust security measures to foster user trust and engagement.

## Acknowledgement

This study was conducted under Institute for Advanced and Smart Digital Opportunities (IASDO), School of Computing, Universiti Utara Malaysia (UUM). As a part of Master of Science (Cybersecurity) final project, authors would like to acknowledge all personnel who involved and contributed in this study.

## Funding

Not provided

## Conflicts of interest

The authors declare no conflict of interest.

## References

1. M. A. Hassan and Z. Shukur, "Review of digital wallet requirements," in *2019 International Conference on Cybersecurity (ICoSec)*, pp. 43–48, 2019. doi: [10.1109/ICoSec47621.2019.8970996](https://doi.org/10.1109/ICoSec47621.2019.8970996).
2. M. A. Hassan, Z. Shukur, M. K. Hasan, and A. S. Al-Khaleefa, "A review on electronic payments security," *Symmetry (Basel)*, vol. 12, no. 8, 2020. doi: [10.3390/sym12081344](https://doi.org/10.3390/sym12081344).
3. M. A. Hassan and Z. Shukur, "Device identity-based user authentication on electronic payment system for secure e-wallet apps," *Electron.*, vol. 11, no. 1, 2022. doi: [10.3390/electronics11010004](https://doi.org/10.3390/electronics11010004).
4. M. Salah Uddin and A. Yesmin Akhi, "E-wallet system for Bangladesh an electronic payment system," *Int. J. Model. Optim.*, vol. 4, no. 3, pp. 216–219, 2014. doi: [10.7763/ijmo.2014.v4.376](https://doi.org/10.7763/ijmo.2014.v4.376).
5. Md W. Karim, A. Haque, M. A. Ulfy, Md A. Hossain, and Md Z. Anis, "Factors influencing the use of E-wallet as a payment method among Malaysian young adults". doi: [10.37227/jibm-2020-2-21](https://doi.org/10.37227/jibm-2020-2-21).
6. F. A. A. Ramli and M. I. Hamzah, "Mobile payment and e-wallet adoption in emerging economies: A systematic literature review," *J. Emerg. Econ. Islam. Res.*, vol. 9, no. 2, p. 1, 2021. doi: [10.24191/jeeir.v9i2.13617](https://doi.org/10.24191/jeeir.v9i2.13617).

7. F. Nizam, H. J. Hwang, and N. Valaei, "Measuring the effectiveness of E-wallet in Malaysia," in *Studies in Computational Intelligence*, vol. 786, Springer Verlag, pp. 59–69, 2019. doi: [10.1007/978-3-319-96803-2\\_5](https://doi.org/10.1007/978-3-319-96803-2_5).
8. M. M. Alam, A. E. Awawdeh, and A. I. Bin Muhamad, "Using e-wallet for business process development: challenges and prospects in Malaysia," *Bus. Process Manag. J.*, vol. 27, no. 4, pp. 1142–1162, 2021. doi: [10.1108/BPMJ-11-2020-0528](https://doi.org/10.1108/BPMJ-11-2020-0528).
9. Fintech News Malaysia, "Malaysia FinTech Report 2021," *Fintech News Malaysia*, p. 92, 2021.
10. M. A. Mustafa, J. Singh, K. Singh, and N. B. Ahmad, "The adoption of E-wallet by generation Z in Kuala Lumpur, Malaysia," *Electron. J. Bus. Manag.*, vol. 7, no. 2, pp. 51–67, 2022.
11. A. M. Sahi, H. Khalid, A. F. Abbas, K. Zedan, S. F. A. Khatib, and H. Al Amosh, "The research trend of security and privacy in digital payment," *Informatics*, vol. 9, no. 2, 2022. doi: [10.3390/informatics9020032](https://doi.org/10.3390/informatics9020032).
12. J. V. Andrew, S. N. A. Ambad, and K. E. Tan, "A model of factors influencing consumers' intention to use e-wallet system in Malaysia: A systematic review," Online, 2019.
13. M. D. Visakha and K. Keni, "The impact of security and perceived ease of use on reuse intention of e-wallet users in Jakarta: The mediating role of e-satisfaction," 2022.
14. Y. M. Tang, K. Y. Chau, L. Hong, Y. K. Ip, and W. Yan, "Financial innovation in digital payment with wechat towards electronic business success," *J. Theor. Appl. Electron. Commer. Res.*, vol. 16, no. 5, pp. 1844–1861, 2021. doi: [10.3390/jtaer16050103](https://doi.org/10.3390/jtaer16050103).
15. M. A. Hassan, Z. Shukur, M. K. Hasan, and A. S. Al-Khaleefa, "A review on electronic payments security," *Symmetry*, vol. 12, no. 8. MDPI AG, pp. 1–24, Aug. 2020. doi: [10.3390/sym12081344](https://doi.org/10.3390/sym12081344).
16. R. J. Johari *et al.*, "Digital payment during pandemic: An extension of the unified model of QR code," *Acad. J. Interdiscip. Stud.*, vol. 10, no. 6, pp. 213–223, 2021. doi: [10.36941/ajis-2021-0166](https://doi.org/10.36941/ajis-2021-0166).
17. W. C. Hoo, J. O. K. Yan, T. P. Liang, and A. H. H. Ng, "Age as moderator between factors influencing and adoption of e-wallet in Malaysia," *Rev. Int. Geogr. Educ. Online*, vol. 11, no. 8, pp. 1143–1153, 2021. doi: [10.48047/rigeo.11.08.96](https://doi.org/10.48047/rigeo.11.08.96).
18. S. V. R. Rao, "E-wallet – A 'Pay'volution," no. February, 2020.
19. N. Abdullah, F. Redzuan, and N. A. Daud, "E-wallet: Factors influencing user acceptance towards cashless society in Malaysia among public universities," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 20, no. 1, pp. 67–74, 2020. doi: [10.11591/ijeeecs.v20.i1.pp67-74](https://doi.org/10.11591/ijeeecs.v20.i1.pp67-74).
20. D. A. Muhtasim, S. Y. Tan, M. A. Hassan, M. I. Pavel, and S. Susmit, "Customer satisfaction with digital wallet services: An analysis of security factors," *Int. J. Adv. Comput. Sci. Appl.*, vol. 13, no. 1, pp. 195–206, 2022. doi: [10.14569/IJACSA.2022.0130124](https://doi.org/10.14569/IJACSA.2022.0130124).
21. F. O. Edeh *et al.*, "Impact of COVID-19 pandemic on consumer behavior towards the intention to use e-wallet in Malaysia," *Int. J. Account. Financ. Asia Pasific*, vol. 4, no. 3, pp. 42–59, 2021. doi: [10.32535/ijafap.v4i3.1205](https://doi.org/10.32535/ijafap.v4i3.1205).
22. "How COVID-19 shaped The e-wallet landscape in Malaysia," 2023.
23. M. Y. Adults, "Factors influencing the use of e-wallet as a payment method among Malaysian young adults," *J. Int. Bus. Manag.*, vol. 3, no. 2, pp. 1–11, 2020. doi: [10.37227/jibm-2020-2-21/](https://doi.org/10.37227/jibm-2020-2-21/).
24. R. Kolandaisamy, S. L. Lie, I. Kolandaisamy, A. Bin Jalil, and G. Muthusamy, "The impact and effectiveness of e-wallet usage for Malaysian male and female," *Spec. Ugdydym.*, vol. 1, no. 43, pp. 4102–4109, 2022.
25. C. S. Weir, G. Douglas, M. Carruthers, and M. Jack, "User perceptions of security, convenience and usability for ebanking authentication tokens," *Computers and Security*, vol. 28, no. 1–2, pp. 47–62, 2009. doi: [10.1016/j.cose.2008.09.008](https://doi.org/10.1016/j.cose.2008.09.008).
26. S. S. Kim, "Purchase intention in the online open market: Do concerns for e-commerce really matter?," *Sustain.*, vol. 12, no. 3, 2020. doi: [10.3390/su12030773](https://doi.org/10.3390/su12030773).
27. E. Susanto, I. Solikin, and B. S. Purnomo, "A review of digital payment adoption in Asia," *Adv. Int. J. Business, Entrep. SMEs*, vol. 4, no. 11, pp. 01–15, Mar. 2022. doi: [10.35631/ajjbes.411001](https://doi.org/10.35631/ajjbes.411001).
28. A. Vaz, R. T. Fernandez, S. Mansori, and D. Rao, "Individual awareness of e-wallet and bank staff related fraud in Malaysia, in the face of widespread global digitalization."
29. T. Hukama, "An empirical analysis of consumers' behaviour in selecting and adopting e-wallet services in Indonesia," *Int. J. Adv. Manag. Technol. Eng. Sci.*, 2022.
30. I. Dimitrova, P. Öhman, and D. Yazdanfar, "Barriers to bank customers' intention to fully adopt digital payment methods," *Int. J. Qual. Serv. Sci.*, vol. 14, no. 5, pp. 16–36, 2022. doi: [10.1108/IJQSS-03-2021-0045](https://doi.org/10.1108/IJQSS-03-2021-0045).
31. A. M. F. and D. S. Sahayaselvi, "An overview on digital payments," *Glob. J. Res. Anal.*, no. October 2017, pp. 1–2, 2019. doi: [10.36106/gjra/8906567](https://doi.org/10.36106/gjra/8906567).
32. J. Hord, "How electronic payment works," 2005.
33. W. A. Alkhowaiter, "Digital payment and banking adoption research in Gulf countries: A systematic literature review," *International Journal of Information Management*, vol. 53, no. September 2019, p. 102102, 2020. doi: [10.1016/j.ijinfomgt.2020.102102](https://doi.org/10.1016/j.ijinfomgt.2020.102102).
34. A. Iradianty and B. R. Aditya, "Student awareness of digital payment services (case study in Indonesia)," *Journal of Physics: Conference Series*, vol. 1823, no. 1, 2021. doi: [10.1088/1742-6596/1823/1/012036](https://doi.org/10.1088/1742-6596/1823/1/012036).
35. S. Chaveesuk, B. Khalid and W. Chaiyasoonthorn, "Digital payment system innovations: A marketing perspective on intention and actual use in the retail sector," *Innov. Mark.*, vol. 17, no. 3, pp. 109–123, 2021. doi: [10.21511/im.17\(3\).2021.09](https://doi.org/10.21511/im.17(3).2021.09).
36. J. Singh, "Offline transactions functionality in eWallets," *Indian J. Sci. Technol.*, vol. 10, no. 16, pp. 1–4, 2017. doi: [10.17485/ijst/2017/v10i16/110781](https://doi.org/10.17485/ijst/2017/v10i16/110781).
37. S. Mahmudul, H. Masum, F. Kasirye and S. M. Mahmudul, "The effects of e-wallet among various types of users in Malaysia: A comparative study assessing the relationships between information seeking, motives of using social media and information sharing on haze and air pollution among IUM students view project," 2021.
38. L. Hiew, C. M. Leong, and C. Y. Liew, "Do they really intend to adopt e-wallet? Prevalence estimates for government support and perceived susceptibility," no. May, 2022. doi: [10.14707/ajbr.2](https://doi.org/10.14707/ajbr.2).
39. Y. Y. Lee, C. L. Gan, and T. W. Liew, "Do e-wallets trigger impulse purchases? An analysis of Malaysian Gen-Y and Gen-Z consumers," *J. Mark. Anal.*, vol. 11, no. 2, pp. 244–261, 2023. doi: [10.1057/s41270-022-00164-9](https://doi.org/10.1057/s41270-022-00164-9).
40. Y. Lee, "Report: South-East Asia is world's fastest-growing mobile wallet market," *The Star*, 2021.
41. K. Boon, S. Fern, X. Yee, and C. Ling, "Investigating the e-wallet usage continuance intention in Malaysia post-covid 19 pandemic," *Int. J. Bus. Technol. Manag.*, vol. 5, no. 1, pp. 333–350, 2023. doi: [10.55057/ijbtm.2023.5.1.26](https://doi.org/10.55057/ijbtm.2023.5.1.26).
42. B. Boon-Hui Chai, J. Yee Choy, Y.-O. Choong, and T. Tzen- Vun Yap, "Zoomers e-wallet end-users' satisfaction in

- Malaysia via service quality,” in *2022 MAG Scholar Conference in Business, Marketing & Tourism*, no. March, pp. 29–32, 2023.
43. S. Nair, N. Jayabalan, and I. Perumal, “E-wallet usage intention in selangor, Malaysia,” *J. Hunan Univ. Nat. Sci.*, vol. 50, no. 4, 2023. doi: [10.55463/issn.1674-2974.50.4.2](https://doi.org/10.55463/issn.1674-2974.50.4.2).
  44. C. Kathiravan, A. Rajasekar, S. Velmurgan, P. Mahalakshmi, and E. Chandramouli, “Sentiment analysis and text mining of online customer reviews for digital wallet apps of Fintech industry,” vol. 12, no. 03, 2021.
  45. M. N. Ardiansah, A. Chariri, and S. Rahardja, “The effect of electronic payments security on e-commerce consumer perception: An extended model of technology acceptance,” *Manag. Sci. Lett.*, vol. 10, pp. 1473–1480, 2020. doi: [10.5267/j.msl.2019.12.020](https://doi.org/10.5267/j.msl.2019.12.020).
  46. G. Argimbayeva, I. Menasria, E. Elshareif, and A. Lewis, “The impact of e-wallet on ADNOC’s customer satisfaction,” in *Proceedings of the 2020 11th International Conference on E-Education, E-Business, E-Management, and E-Learning*, pp. 364–368, 2020.
  47. L. Xiao, Q. Lu, and F. Guo, “Mobile personalized recommendation model based on privacy concerns and context analysis for the sustainable development of M-commerce,” *Sustain.*, vol. 12, no. 7, 2020. doi: [10.3390/su12073036](https://doi.org/10.3390/su12073036).
  48. N. N. Duy Phuong, L. T. Luan, V. Van Dong, and N. Le Nhat Khanh, “Examining customers’ continuance intentions towards e-wallet usage: The emergence of mobile payment acceptance in Vietnam,” *J. Asian Financ. Econ. Bus.*, vol. 7, no. 9, pp. 505–516, 2020. doi: [10.13106/JAFEB.2020.VOL7.NO9.505](https://doi.org/10.13106/JAFEB.2020.VOL7.NO9.505).
  49. R. Thakur, “Customer adoption of mobile payment services by professionals across two cities in India: An empirical study using modified technology acceptance model,” *Bus. Perspect. Res.*, vol. 1, no. 2, pp. 17–30, 2013. doi: [10.1177/2278533720130203](https://doi.org/10.1177/2278533720130203).
  50. C. Mombeuil, “An exploratory investigation of factors affecting and best predicting the renewed adoption of mobile wallets,” *J. Retail. Consum. Serv.*, vol. 55, no. April, p. 102127, 2020. doi: [10.1016/j.jretconser.2020.102127](https://doi.org/10.1016/j.jretconser.2020.102127).
  51. E. D. Matemba and G. Li, “Consumers’ willingness to adopt and use WeChat wallet: An empirical study in South Africa,” *Technol. Soc.*, vol. 53, pp. 55–68, 2018. doi: [10.1016/j.techsoc.2017.12.001](https://doi.org/10.1016/j.techsoc.2017.12.001).
  52. M. S. M. Ariff, M. Sylvester, N. Zakuan, K. Ismail, and K. M. Ali, “Consumer perceived risk, attitude and online shopping behaviour; Empirical evidence from Malaysia,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 58, no. 1, 2014. doi: [10.1088/1757-899X/58/1/012007](https://doi.org/10.1088/1757-899X/58/1/012007).
  53. X.-J. Lim, P. Ngew, J.-H. Cheah, T. H. Cham, and Y. Liu, “Go digital: can the money-gift function promote the use of e-wallet apps?,” *Internet Res.*, 2022. doi: [10.1108/INTR-06-2021-0406](https://doi.org/10.1108/INTR-06-2021-0406).
  54. S. Chen *et al.*, “Are mobile banking apps secure? what can be improved?,” in *ESEC/FSE 2018 - Proceedings of the 2018 26th ACM Joint Meeting on European Software Engineering Conference and Symposium on the Foundations of Software Engineering*, pp. 797–802, 2018. doi: [10.1145/3236024.3275523](https://doi.org/10.1145/3236024.3275523).
  55. N. N. Mohd Razif, M. Misiran, H. Sapiri, and Z. M. Yusof, “Perceived risk for acceptance of E-wallet platform in Malaysia among youth: Sem approach,” *Manag. Res. J.*, vol. 9, p. 1, 2020.
  56. S. S. Alam, M. H. Ali, N. A. Omar, and W. M. H. W. Hussain, “Customer satisfaction in online shopping in growing markets: An empirical study,” *Int. J. Asian Bus. Inf. Manag.*, vol. 11, no. 1, pp. 78–91, 2020. doi: [10.4018/IJABIM.2020010105](https://doi.org/10.4018/IJABIM.2020010105).
  57. G. Ilieva, T. Yankova, Y. Dzhabarova, M. Ruseva, D. Angelov, and S. Klisarova-Belcheva, “Customer attitude toward digital wallet services,” *Systems*, vol. 11, no. 4, 2023. doi: [10.3390/systems11040185](https://doi.org/10.3390/systems11040185).
  58. K. Gupta and D. W. Stewart, “Customer satisfaction and customer behavior: The differential role of brand and category expectations,” *Mark. Lett.*, vol. 7, no. 3, pp. 249–263, 1996. doi: [10.1007/BF00435741](https://doi.org/10.1007/BF00435741).
  59. C. Liao, J. L. Chen, and D. C. Yen, “Theory of planning behavior (TPB) and customer satisfaction in the continued use of e-service: An integrated model,” *Comput. Human Behav.*, vol. 23, no. 6, pp. 2804–2822, 2007. doi: [10.1016/j.chb.2006.05.006](https://doi.org/10.1016/j.chb.2006.05.006).
  60. M. F. Putri, B. Purwandari, and A. N. Hidayanto, “What do affect customers to use mobile payment continually? A systematic literature review,” *2020 5th Int. Conf. Informatics Comput. ICIC 2020*, 2020. doi: [10.1109/ICIC50835.2020.9288590](https://doi.org/10.1109/ICIC50835.2020.9288590).
  61. G. Aisaiti, L. Liu, J. Xie, and J. Yang, “An empirical analysis of rural farmers’ financing intention of inclusive finance in China: The moderating role of digital finance and social enterprise embeddedness,” *Ind. Manag. Data Syst.*, vol. 119, no. 7, pp. 1535–1563, 2019. doi: [10.1108/IMDS-08-2018-0374](https://doi.org/10.1108/IMDS-08-2018-0374).
  62. J. Lappeman, S. Marlie, T. Johnson, and S. Poggenpoel, “Trust and digital privacy: willingness to disclose personal information to banking chatbot services,” *J. Financ. Serv. Mark.*, no. 0123456789, 2022. doi: [10.1057/s41264-022-00154-z](https://doi.org/10.1057/s41264-022-00154-z).
  63. N. K. Malhotra and M. Peterson, *Basic marketing research: A decision-making approach*. Prentice hall, 2006.
  64. N. N. D. Phuong and N. T. Dat, “The effect of country-of-origin on customer purchase intention: A study of functional products in Vietnam,” *J. Asian Financ. Econ. Bus.*, vol. 4, no. 3, pp. 75–83, 2017. doi: [10.13106/jafeb.2017.vol4.no3.75](https://doi.org/10.13106/jafeb.2017.vol4.no3.75).
  65. A. T. Esawe, “Understanding mobile e-wallet consumers’ intentions and user behavior,” *Spanish J. Mark. - ESIC*, vol. 26, no. 3, pp. 363–384, 2022. doi: [10.1108/SJME-05-2022-0105](https://doi.org/10.1108/SJME-05-2022-0105).
  66. K. C. Chung and S. W. J. Liang, “Understanding factors affecting innovation resistance of mobile payments in taiwan: An integrative perspective,” *Mathematics*, vol. 8, no. 10, pp. 1–18, 2020. doi: [10.3390/math8101841](https://doi.org/10.3390/math8101841).
  67. J. Henseler, C. M. Ringle, and M. Sarstedt, “A new criterion for assessing discriminant validity in variance-based structural equation modeling,” *J. Acad. Mark. Sci.*, vol. 43, no. 1, pp. 115–135, 2015. doi: [10.1007/s11747-014-0403-8](https://doi.org/10.1007/s11747-014-0403-8).
  68. J. F. Hair, C. M. Ringle, and M. Sarstedt, “PLS-SEM: Indeed a silver bullet,” *J. Mark. Theory Pract.*, vol. 19, no. 2, pp. 139–152, 2011. doi: [10.2753/MTP1069-6679190202](https://doi.org/10.2753/MTP1069-6679190202).
  69. J. Cohen, *Statistical Power Analysis for the Behavioral Sciences*, 2nd ed. New York: Lawrence Erlbaum Associates Publishers, 1988.