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Unlocking e-commerce potential in SMEs: an integrative framework for adoption in emerging markets

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Although e-commerce is growing rapidly among consumers, its technological space is still primarily dominated by large enterprises, with small and medium-sized enterprises (SMEs) in emerging markets struggling to keep pace. In Indonesia and Malaysia, e-commerce adoption among SMEs remains limited, highlighting the critical need to understand factors that facilitate or hinder digital transformation. This study addresses this gap by developing and testing an integrative model that combines the technology-organization-environment (TOE) framework, innovation resistance theory (IRT), and the unified theory of acceptance and use of technology (UTAUT). Survey data collected from 357 SMEs were analyzed using partial least squares structural equation modeling. The results show that performance expectancy, facilitating conditions, and organizational readiness significantly enhance adoption intention, while effort expectancy, social factors, and technological context do not exert a meaningful effect. Among the barriers, value, usage, risk, and image concerns negatively impact adoption, whereas traditional barriers were not statistically supported. Notably, value barriers emerged as the most substantial deterrent, while facilitating conditions and organizational readiness were the most influential enablers. The integrated model explains 89.9% of the variance in e-commerce adoption intention, indicating a strong explanatory power. These findings suggest that improving digital infrastructure, building organizational capabilities, and addressing perceived value and usability concerns are critical for boosting SME participation in e-commerce. Policy and managerial implications include the importance of customized government initiatives, ecosystem support from platform providers, and targeted awareness programs to reduce perceived risks and increase digital engagement among SMEs. This study contributes to the e-commerce literature by offering a comprehensive framework for understanding adoption behavior and providing evidence-based recommendations for accelerating SME digital transformation in emerging markets.

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Introduction

Indonesia's and Malaysia's digital economies have experienced rapid expansion in recent years, mainly driven by the increasing accessibility of the Internet and mobile technologies. This digital transformation has paved the way for remarkable growth in online commerce across various sectors. The e-commerce sector in Indonesia has experienced significant growth over the past four years, demonstrating a robust market presence and high consumer engagement (Sastika et al. 2023). Although consumers are increasingly using e-commerce, large companies dominate e-commerce technologies. The adoption of e-commerce by SMEs lags that of large companies (Salah and Ayyash 2024). Research conducted by Boston Consulting Group and Blibli showed that only 20 percent of SMEs in Indonesia are digitized (Boston Consulting Group & Blibli, 2022).

In contrast, in Malaysia, most SMEs, which account for fifty-seven percent, have not started efforts toward digitalization (Azahar 2021). According to World Bank data, Malaysia's businesses have not performed as well as those of its ASEAN neighbors, including Thailand, the Philippines, Vietnam, and Singapore, in terms of digitalization (Azahar 2021). SMEs are expected to adopt e-commerce to expand market reach and increase sales, leading to increased business scale (Gao et al. 2023). Expanding the size of SMEs can significantly impact the Indonesian economy, as SMEs contribute approximately 61% of Indonesia's GDP and absorb approximately 97% of the nation's workforce (International Monetary Fund 2024). Meanwhile, in Malaysia, SMEs contribute approximately 38% of the overall GDP, accounting for about 48% of total employment (Yap 2023).

Research analyzing the driving factors and barriers to SMEs' embracing of e-commerce is essential in responding to this phenomenon. According to the literature, most studies analyzing the factors of e-commerce adoption by SMEs typically employ only one theoretical basis. No studies have analyzed this phenomenon from more than two theoretical perspectives. Studies utilizing the technology-organization-environment (TOE) framework include Hoang et al. (2021), Amornkitvikai et al. (2022), Abdulkarem and Hou (2022), Loo et al. (2024), Daoud and Kammoun (2024), Thaha et al. (2022) and Zabri (2024). Research based on the unified theory of acceptance and use of technology (UTAUT) was conducted by Aremu and Arfan (2023), Shahzad et al. (2023), Dutta and Shivani (2023), Alshourah et al. (2023) and Misra et al. (2022). The theory of planned behavior (TPB) has been employed in studies such as those by Awa et al. (2015) and Grandón and Ramírez-Correa (2018). The technology acceptance model (TAM) has been explored by Sarfo and Song (2021), Herzallah and Mukhtar (2016). Lastly, the innovation resistance theory (IRT) has been used in studies by Santoso et al. (2022), Cazabat et al. (2019), and Lee (2013).

The TOE framework comprises three key aspects: technology, organization, and environment. Technology factors refer to aspects related to technology itself, such as perceived benefits and compatibility (Abdulkarem and Hou 2022; Hoang et al. 2021), IT system integration and website capabilities (Ding et al. 2008), and technical infrastructure (Amornkitvikai et al. 2022; Chong 2008).

Organizational factors encompass an organization's internal components, including owner demographics (Amornkitvikai et al. 2022), employee and organizational readiness (Hoang et al. 2021), and marketing strategies (Eid and Trueman 2004). Other key aspects include strategy type and manager commitment (Abdulkarem and Hou 2022; Ding et al. 2008), business scale (Abdulkarem and Hou 2022; Amornkitvikai et al. 2022), SMEs readiness (Chong 2008), and human resource factors, along with business infrastructure (Abdulkarem and Hou 2022; Jennex et al. 2004).

Environmental factors include external influences, such as external support and pressure (Hoang et al. 2021), external e-commerce factors (Amornkitvikai et al. 2022), pressure from suppliers and consumers and government support (Abdulkarem and Hou 2022; Chong 2008). Other environmental considerations include legislation (Abdulkarem and Hou 2022; Jennex et al. 2004) as well as broader external factors such as public awareness, government activities, economic conditions, geographic conditions, technological infrastructure, sociocultural conditions, and political situations (Adeniran et al. 2022).

Numerous studies have analyzed the upstream scope of SME e-commerce adoption by examining various factors that facilitate or impede this process. However, these studies primarily relied on single or dual theoretical frameworks, limiting their ability to capture the full spectrum of influencing factors. While previous research has explored the TOE framework, UTAUT, and IRT separately, integrative approaches that combine these perspectives to provide a more comprehensive understanding of SME e-commerce adoption are lacking. The absence of a multi-theoretical perspective results in fragmented insights, as individual frameworks only address specific aspects of the adoption process, whether technological, organizational, environmental, or behavioral. Given the dynamic and multifaceted nature of e-commerce adoption, an integrative framework is essential to overcome the limitations of prior studies and offer a holistic analysis of the driving forces and barriers influencing SMEs.

The difference between the previous study and the current research lies in the fact that the current research analyzes the determinants of e-commerce adoption by SME from three perspectives: the TOE framework, innovation resistance theory, and UTAUT. However, the integration of this theory has not been explored in previous studies. Mensah et al. (2023) integrated the TOE framework with UTAUT to investigate e-commerce adoption among SMEs in China. Similarly, Nguyen et al. (2024) combined the TOE framework with the Theory of Planned Behavior (TPB) to assess cross-border e-commerce adoption in Vietnamese SMEs. Haces et al. (2024) integrated the TOE model with the Technology Acceptance Model (TAM) and Rogers' Innovation Diffusion Theory (IDT) to analyze e-commerce adoption in Mexican SMEs. In Indonesia, Muslim and Sandhyaduhita (2016) employed a combination of the TOE framework and UTAUT, termed the I-TOE framework, to identify supporting and inhibiting factors for SME e-commerce adoption.

The decision to adopt a multi-theoretical approach in this study is grounded in the explanatory power (R^2) of existing models in prior research on e-commerce adoption in SMEs. For instance, studies utilizing UTAUT have demonstrated robust explanatory power, with R^2 values ranging from 58% to 65% for behavioral intention. Notable studies in this area include (Ayaz and Yanartaş 2020; Azubuike et al. 2023; Chauhan and Jaiswal 2016; Haces et al. 2024; Kwarteng et al. 2024; Pobee 2021; Rafinda et al. 2024; Shahzad et al. 2020; Sombultawee 2020; Soong et al. 2020). Extended models incorporating additional factors such as organizational support, competitive dynamics, and perceived risk tend to exhibit higher explanatory power, further strengthening the predictive capabilities of UTAUT.

Similarly, research employing the TOE framework has demonstrated a strong predictive capability, with R^2 values ranging from 57% to 70%. The predictive strength of TOE is particularly evident when integrated with complementary models, such as the Technology Acceptance Model (TAM) or the Resource-Based View (RBV). Additionally, incorporating industry-specific dimensions, such as sustainable human capital, has been shown to yield even higher R^2 values. Notable studies include (Badghish and Soomro 2024; Gomes et al. 2024; Hasani

et al. 2023; Lestari et al. 2024; Praswati et al. 2024; Pu et al. 2024; Salah and Ayyash 2024; Ta and Lin 2023; Triandini et al. 2023). These findings underscore the need to integrate multiple theoretical lenses to more effectively capture the multifaceted drivers of e-commerce adoption.

Likewise, studies examining IRT have reported R^2 values ranging from 54% to 70%. Key studies in this domain include (Dwivedi et al. 2023; Harsasi et al. 2023; Himawan et al. 2024; Jin et al. 2022; Kinkani et al. 2024; Migliore et al. 2022; Musyaffi et al. 2022; Nazir and Roomi 2021; Ray et al. 2022).

Models that incorporate moderators or mediators, such as communication campaigns and managerial capabilities, as well as those integrating IRT with other frameworks, such as UTAUT2, TAM, or TOE, tend to achieve higher R^2 values, demonstrating enhanced explanatory power. Furthermore, the inclusion of contextual and organizational dimensions strengthens the explanatory capacity of IRT, particularly in diverse sectors, such as digital payments, e-commerce, and blockchain.

By integrating UTAUT, TOE, and IRT, this study aimed to achieve a more comprehensive explanatory framework. TOE's focus on environmental factors (e.g., regulatory policies and infrastructure) is crucial for understanding SME adoption in emerging markets, where external barriers often dominate. IRT's insights into resistance address cultural and psychological nuances, such as traditional mindsets and perceived risks, which are particularly relevant in conservative or low-resource environments. UTAUT's behavioral predictors are indispensable for understanding individual decision-making within SMEs, especially in contexts where organizational leaders or key employees drive adoption. The combined approach addresses the limitations of standalone models by incorporating organizational, technological, environmental, and individual-level factors, thereby enhancing the overall R^2 value. This integrative approach not only aligns with best practices in the literature, but also underscores the novelty of this research in advancing our understanding of SME e-commerce adoption.

This study offers significant theoretical and managerial contributions to understanding e-commerce adoption among SMEs. Theoretically, the integrative framework offers a multidimensional lens to examine the drivers of and barriers to technology adoption. These findings provide actionable insights for policymakers, platform providers, and SME leaders. By addressing critical barriers such as value and risk perceptions, and leveraging facilitators such as government support and infrastructure, this study informs targeted strategies to promote digital transformation. For instance, SMEs can focus on enhancing their technological capabilities and adapting their organizational culture, whereas policymakers can design incentives and training programs to mitigate resistance and drive adoption. These contributions enhance scholarly discourse and provide practical tools to foster e-commerce adoption in emerging markets.

Literature review and hypotheses development

UTAUT. Venkatesh et al. (2003) introduced the UTAUT framework, a widely used model for understanding technology adoption. Performance expectancy, effort expectancy, social influence, and facilitating factors are the four main components identified by this model that impact behavioral intention and use behavior. These constructs have been validated across various settings, including the adoption of information systems and e-commerce in SMEs (Ayaz and Yanartaş 2020).

Performance expectancy refers to the extent to which a person believes that utilizing technology will enhance their ability to perform their job, and is a critical predictor of the intention to adopt e-commerce. Studies on SMEs have demonstrated that owners and managers are more likely to adopt technology when they perceive tangible improvement in business efficiency or competitive advantage (Soong et al. 2020). The convenience, speed, and access to a broader customer base through e-commerce drive higher intentions among SMEs to adopt digital solutions (Haryanti and Subriadi 2020).

Effort expectancy, the perceived ease of use associated with technology, is another significant factor that influences adoption. Research indicates that SMEs often lack the necessary resources and technical expertise required to implement complex systems, making ease of use a priority for e-commerce technology (Chauhan and Jaiswal 2016). When technology is perceived as user-friendly, SMEs demonstrate a greater willingness to adopt it, as minimal training and reduced time for onboarding become feasible advantages (Mapeshoane and Pather 2016).

Social influence, or the extent to which individuals perceive that essential others believe they should use the new system, has been identified as a significant factor, particularly in SMEs where external perceptions can impact decision-making. Social factors, including competitive pressure and customer expectations, are often cited as strong motivators for e-commerce adoption (Najib et al. 2021). The literature suggests that SMEs may adopt technology if they perceive that their peers or competitors also adopt similar solutions, thus emphasizing the role of social influence in the adoption process (Moghawemi et al. 2012).

The degree to which a person believes that organizational and technological infrastructure is in place to facilitate technology use is called the facilitating condition. For SMEs, essential resources such as Internet access and technical support are necessary for successful e-commerce adoption (Awa et al. 2017). Studies suggest that when SMEs have access to reliable support systems and training resources, their likelihood of adopting e-commerce technology increases significantly (Mapeshoane and Pather 2016). Building on the UTAUT framework and the existing literature, the following hypotheses are proposed:

H1: Performance expectancy positively affects intentions to adopt e-commerce technology.

H2: Effort expectancy positively affects intentions to adopt e-commerce technology.

H3: Social factors positively affect intentions to adopt e-commerce technology.

H4: Facilitating conditions positively affect intentions to adopt e-commerce technology.

Technology-organization-environment (TOE) framework. To explore the adoption of e-commerce technology within the TOE framework, several studies underline the factors influencing adoption across technological, organizational, and environmental contexts. Technological factors, including perceived ease of use, compatibility, and relative advantage, are essential for enhancing adoption intention. Previous studies have demonstrated that perceived ease of integration with existing systems and the compatibility of new technologies positively impact adoption rates (Badghish and Soomro 2024; Yoon 2024). Additionally, companies view technologies that offer competitive advantages as beneficial for long-term adoption, thus supporting higher adoption rates among SMEs (Shahzad et al. 2023).

In addition to technological considerations, organizational factors also play a pivotal role in shaping SMEs' adoption decisions. Organizational readiness encompassing top management support, resource availability, and IT infrastructure is crucial for successful technology adoption. Managerial support and organizational commitment to fostering a culture of technology adoption are significant drivers in adopting new digital tools (Almashawreh et al. 2024; Hasani et al. 2023).

Evidence also suggests that organizational readiness, through financial resources and skilled human capital, encourages positive intentions toward adoption (Subramaniam et al. 2024).

In addition to internal organizational readiness, external environmental factors shape SMEs' adoption decisions. The external environment, including market competition, customer demand, and government regulations, is a significant factor in the adoption decisions. Studies highlight how competitive pressures and government policies, such as subsidies or regulatory incentives, can foster adoption by reducing perceived risk and increasing confidence in technology implementation (Ta and Lin 2023; Zian et al. 2024). External pressures from market demand and customer expectations also push organizations toward digital transformation (Praswati et al. 2024). In summary, these hypotheses draw on the TOE framework to propose a comprehensive model for understanding how technological, organizational, and environmental factors collectively influence e-commerce adoption intentions.

H5: Technology aspect positively affects intentions to adopt e-commerce technology.

H6: Organization aspect positively affects intentions to adopt e-commerce technology.

H7: Environment aspect positively affects intentions to adopt e-commerce technology.

Innovation resistance theory (IRT). Ram and Sheth's (1989) innovation resistance theory (IRT) provides a framework for understanding why individuals and organizations are hesitant to adopt new technologies. This theory identifies five primary barriers to adoption: usage, value, risk, tradition, and image barriers. Each barrier introduces unique challenges that can negatively impact adoption intentions, especially among SMEs (Migliore et al. 2022).

Usage barriers refer to the perception that new technology might disrupt current workflows, leading to implementation difficulties. Many SMEs resist adopting e-commerce due to perceived integration challenges with existing systems, particularly when the technology requires significant adjustments to daily operations (Moorthy et al. 2017; Musyaffi et al. 2022). This barrier is prevalent in traditional settings where businesses often view technological shifts as cumbersome due to limited infrastructure and technical expertise (Jin et al. 2022).

Value barriers arise when potential adopters perceive minimal or no added value from the innovation. SMEs may view e-commerce as unnecessary if it does not directly contribute to their core business activities or provide straightforward returns (Ray et al. 2022). Research shows that these value perceptions can significantly hinder adoption, as many SMEs are reluctant to invest in technologies without a noticeable impact on profitability (Migliore et al. 2022).

Risk barriers, including security, data privacy, and reliability concerns, pose significant challenges for SMEs, particularly those with limited resources to manage cybersecurity effectively (Mapeshoane and Pather 2016; Musyaffi et al. 2022). Studies suggest that transaction security concerns and potential data breaches may lead SMEs to perceive e-commerce adoption as financially and reputationally risky, deterring their willingness to engage in online business (Dwivedi et al. 2023; Moorthy et al. 2017). Similar concerns exist in consumer adoption of e-commerce, where trust plays a crucial role in purchase decisions. Uncertainty regarding security and privacy has negatively impacted online purchasing behavior (Indiani et al. 2024). Given that SMEs interact directly with consumers in digital transactions, their reluctance to adopt e-commerce may stem from similar concerns about transaction security and financial exposure. Thus, perceived risk barriers are expected to influence SMEs' intention to adopt e-commerce negatively.

Tradition barriers relate to the preference for established processes, where SMEs may view e-commerce as a threat to long-standing business practices and customer relationships. This barrier is solid among businesses with deep-rooted traditional approaches, as they often see digital transformation as unnecessary or disruptive to their business culture (Jin et al. 2022; Migliore et al. 2022). Tradition-oriented resistance can be a significant hurdle, particularly in family-owned or locally oriented enterprises that rely heavily on personal interactions (Musyaffi et al. 2022).

Image barriers involve concerns that adopting e-commerce might misalign the business's established identity or values. SMEs may resist adopting online platforms if they believe e-commerce conflicts with their desired brand image, often rooted in community-based relationships and personal customer interactions (Dwivedi et al. 2023; Musyaffi et al. 2022). This resistance is notable among businesses that prioritize brand consistency and worry about losing customer connection. Drawing on the Innovation Resistance Theory, we propose the following hypotheses:

H8: Usage barriers negatively affect intentions to adopt e-commerce technology.

H9: Value barriers negatively affect intentions to adopt e-commerce technology.

H10: Risk barriers negatively affect intentions to adopt e-commerce technology.

H11: Tradition barriers negatively affect intentions to adopt e-commerce technology.

H12: Image barriers negatively affect intentions to adopt e-commerce technology.

This study integrates UTAUT, TOE, and IRT to analyze e-commerce adoption among SMEs comprehensively. UTAUT focuses on individual behavioral predictors, TOE addresses organizational and environmental factors, and IRT highlights psychological barriers. By combining these frameworks, the study addresses their limitations, including TOE's lack of individual-level insights, UTAUT's omission of resistance behaviors, and IRT's limited systemic perspective, thereby creating a robust, multidimensional model for understanding adoption dynamics. In this study, the constructs from the TOE, IRT, and UTAUT frameworks were combined into a unified research model to provide a comprehensive analysis of e-commerce adoption in SMEs. Each construct was represented by carefully selected measurement items sourced from established literature. The selection process for these measurement items was guided by three key criteria: quantity, quality, and relevance. Quantity referred to the frequency with which specific items appeared in previous studies, ensuring that widely accepted and frequently used indicators were incorporated. Quality was assessed based on the measurement item's ability to effectively define its construct, with preference given to items that demonstrated high loading factors in prior research, signifying their robustness and reliability. Relevance ensured that the selected items were appropriate for the SME context and aligned with the objectives of this study. By adhering to these criteria, the study ensured the validity, reliability, and applicability of the research model, thereby strengthening its ability to capture the multifaceted dynamics of e-commerce adoption.

As observed in this study, the integration of theoretical frameworks may introduce conceptual overlaps between constructs between organizational readiness (TOE) and facilitating conditions (UTAUT). While these constructs share similarities in

addressing resource availability and preparedness, they serve distinct purposes in the unified model, contributing unique insights into e-commerce adoption among SMEs. Organizational readiness reflects an enterprise's strategic and systemic preparedness to adopt e-commerce technologies. The indicators used to measure this construct include the SME's eagerness to explore new online marketing media, the managerial support provided through financial and non-financial contributions, and the workforce's ability to manage online marketing activities. This construct captures an enterprise-wide perspective, focusing on the strategic intent, leadership commitment, and internal capabilities required for successful e-commerce integration.

In contrast, facilitating conditions emphasize the operational-level resources and supports that enable technology adoption in practice. This construct encompasses the availability of financial and infrastructure resources, the necessary knowledge for online marketing, and external support from individuals or organizations. These indicators assess the practical enablers that ease adoption by addressing operational constraints and providing the necessary infrastructure. Both constructs intersect in their focus on financial resources and capability-building. For example, while organizational readiness evaluates financial contributions as a reflection of managerial commitment, facilitating conditions consider the immediate availability of financial resources for operational implementation. Similarly, both constructs address workforce skills; however, organizational readiness views this as a systemic capability, while facilitating conditions assess the knowledge required for day-to-day usage of e-commerce technologies. Despite these overlaps, the constructs diverge in their scope and emphasis. Organizational readiness takes a macro-level view, encompassing strategic intent and systemic capability, whereas facilitating conditions focus on micro-level, practical usability. By maintaining this distinction, the unified model captures the strategic and operational dimensions of e-commerce adoption, ensuring a comprehensive analysis of SME behavior.

Research method

This study examines the relationship between dependent and independent variables using a quantitative approach and survey methodology. By evaluating a theory based on multiple aspects, quantified and statistically analyzed, the quantitative approach investigates a social or humanitarian issue and verifies the veracity of the theory's projected generalizations (Creswell 2003). Information is gathered by surveying a sample of people and using their answers (Check and Schutt 2012). The objectives of survey research include a thorough analysis of the characteristics of a target population, an understanding of their attitudes, perceptions, motives, and beliefs, as well as a comprehensive collection of their viewpoints on a topic of interest to the researcher (Chrysochou 2017). The survey method was chosen for this study because it was suitable for determining the target group's attitudes towards adopting e-commerce technology. The quantitative approach with the survey method is also the most suitable method to use when the study's objectives include testing hypotheses, identifying statistical relationships between variables, making predictions, and generalizing research findings to the study population (Chrysochou 2017), which is what this study aims to do.

A structured data collection method was necessary to implement this approach effectively, leading to the use of a questionnaire as the primary survey tool. Thirty respondents were the subjects of a preliminary survey to evaluate measurement instrument construction. The results showed that the research constructs were reliable and one-dimensional, with alpha values greater than 0.6. The study received 357 valid samples. Slovin's formula was used to determine the required minimum number of samples. Slovin's formula enables researchers to precisely sample the population and calculate the sample size required to achieve results with a respectable level of accuracy (Ellen 2022). The Slovin formula is as follows:

$$\begin{aligned} n &= N \div (1 + \mathrm{Ne}^2); \\ n &= 66.150.000 \div (1 + 66.150.000 \times 0.1^2); \\ n &= 66.150.000 \div (1 + 661.500); \\ n &= 99,99 \end{aligned} \quad (1)$$

where n = number of samples; N = total population; e = error tolerance.

There are 65 million SMEs in Indonesia (Yurivito 2024) and 1.15 million in Malaysia (Reuters 2023), comprising the study's population. Cramer and Howitt (2004) state that the threshold typically employed in social science research falls between 0.01 and 0.1. The error tolerance applied in this study is 0.1. For this inquiry, a sample size of 100 is recommended based on the calculation performed using Slovin's formula. Hair et al. (2010) recommended a minimum ratio of 5:1 between observations and measured variables when calculating sample size. Since there are 39 measured variables in this study, there are 195 observations or samples, which is five times the number of measured variables. Three hundred fifty-seven valid samples, which satisfied the minimal requirements outlined in Hair et al. (2010) and Slovin's formula, were received for this study.

This study employed a stratified random sampling approach to ensure a representative selection of SMEs from various sectors of the retail industry. Since SMEs in different industries face distinct challenges and opportunities in e-commerce adoption, stratification was based on industry type to capture these variations. The sample was drawn from SMEs operating in fashion, cosmetics, electronics, eco-friendly products, F&B, accommodation, handicrafts, education, and graphic design. Within each industry stratum, SMEs were selected using random sampling to minimize bias and ensure a diverse representation. The survey was distributed to SME owners or managers in Indonesia and Malaysia. The respondents were asked to complete a questionnaire about their perception of e-commerce technology. The structural model was evaluated using the partial least square (PLS) method, which integrates multiple regression and factor analysis to investigate the relationship between latent constructs or their correlations with measurable variables.

Result

Common method bias. Based on the Harman single-factor test conducted through factor analysis in SPSS, the results indicate that the first factor accounts for 38.57% of the total variance. This is below the commonly accepted threshold of 50%, suggesting that no single factor dominates the variance structure of the data (Podsakoff et al. 2003). Therefore, common method bias is not a significant concern in this dataset. This conclusion supports the validity of the study's measures and mitigates concerns related to the influence of common method variance.

Descriptive statistics. Descriptive statistics were computed for all latent constructs by averaging the scores of their respective indicators. The results in Table 1 show that performance expectancy (PE) had a mean score of 3.37 (SD = 0.39), effort expectancy (EE) had a mean score of 3.18 (SD = 0.47), and facilitating conditions (FC) had a mean score of 3.10 (SD = 0.51). The organizational construct demonstrated a moderate level of readiness with a mean of 3.28 (SD = 0.48), while environmental support scored slightly lower. Adoption intention reported the highest average score of 4.49 (SD = 0.58), indicating a generally favorable disposition among SMEs toward e-commerce. In

Table 1 Descriptive statistics.

Construct	Mean	Std. Dev
Performance expectancy (PE)	3.366	0.388
Effort expectancy (EE)	3.176	0.468
Social factors (SF)	0.414	0.555
Facilitating condition (FC)	3.101	0.510
Technology	3.000	0.006
Organization	3.251	0.402
Environment	4.023	0.728
Usage barrier (UB)	2.926	0.943
Value barrier (VB)	2.679	0.426
Risk barrier (RB)	2.409	0.495
Tradition barrier (TB)	2.453	0.380
Image barrier (IB)	4.019	0.677
Adoption intention	4.479	0.599

contrast, social factors (SF) had a lower mean of 0.41 (SD = 0.56), reflecting modest influence. All constructs were based on responses from 357 SMEs in Indonesia and Malaysia.

Measurement model evaluation

Parameter significance. A small *p* value indicates that the indicator can significantly measure or explain its construct (Hair et al. 2010). The results obtained a significance value of <0.001 for all indicators, indicating that every indicator can substantially measure its construct. The significance values of each indicator are shown in Table 2.

Loading factor. The value of the loading factor indicates the indicator's relationship with its latent construct. Hair et al. (2010) suggest that factor loading estimates should be higher than 0.5. The findings demonstrated that the loading factor

Table 2 Validity and reliability test results.

UTAUT		*p* value	Loading factor	AVE	CR
Performance expectancy	Increased profitability	<0.001	0.859	0.864	0.950
	Improve SME product marketing activities	<0.001	0.963		
	Improve SMEs growth	<0.001	0.963		
Effort expectancy	Easy-to-use online marketing system	<0.001	0.871	0.805	0.925
	The online marketing platform's features are user-friendly	<0.001	0.914		
	Online marketing systems are easy to learn	<0.001	0.906		
Social factors	Key people believe our SMEs should embrace online marketing	<0.001	0.937	0.910	0.968
	Important entities believe our SMEs should embrace online marketing	<0.001	0.976		
	Stakeholders support our SMEs in marketing products online	<0.001	0.949		
Facilitating condition	Our SMEs have the financial and infrastructure resources for online marketing	<0.001	0.931	0.894	0.962
	Our SMEs possess knowledge of online marketing	<0.001	0.985		
	Support from individuals or organizations in online marketing activities.	<0.001	0.919		
Innovation resistance					
Usage barrier	Online marketing is complicated	<0.001	0.849	0.689	0.869
	Online marketing is prone to fraud	<0.001	0.749		
	Online marketing is difficult	<0.001	0.886		
Value barrier	The effort to learn the online marketing system outweighs the potential income	<0.001	0.855	0.728	0.889
	The costs of online marketing exceed the potential income	<0.001	0.927		
	Online marketing offers limited benefits for SMEs	<0.001	0.771		
Risk barrier	Concerned that online marketing allows other sellers to copy our products	<0.001	0.886	0.844	0.942
	Afraid online transactions may not be secure	<0.001	0.936		
	Concerned that online transactions may lead to financial losses	<0.001	0.933		
Tradition barrier	Resolving customer issues may be challenging on online platforms	<0.001	0.680	0.703	0.875
	Order processing may be challenging with an online marketing system	<0.001	0.926		
	Payment processing may be challenging with an online marketing system	<0.001	0.888		
Image barrier	I perceive online marketing as complicated	<0.001	0.860	0.856	0.947
	I perceive online transactions as insecure	<0.001	0.970		
	I believe online transactions may lead to negative consequences	<0.001	0.941		
Technology organization environment					
Technological	The online marketing system will integrate seamlessly into our SME operations	<0.001	0.846	0.565	0.784
	Online marketing will increase revenue	<0.001	0.884		
	Online marketing requires low costs	<0.001	0.614		
Organization	Our SMEs are eager to explore new online marketing media	<0.001	0.912	0.745	0.897
	Our SME owners/managers demonstrate support for online marketing through financial and non-financial contributions	<0.001	0.745		
	Our SMEs are ready for online marketing, as reflected in the workforce's ability to manage online marketing activities	<0.001	0.921		
Environment	Our competitors have successfully sold products online	<0.001	0.891	0.875	0.892
	Our customers have begun purchasing similar products online	<0.001	0.896		
	The government supports SMEs engaged in online marketing	<0.001	0.779		
Intention					
Intention	I will pursue online marketing if given the opportunity	<0.001	0.995	0.978	0.993
	I am eager to engage in online marketing	<0.001	0.987		
	I will attempt to market the product online	<0.001	0.986		

Table 3 Construct correlation.

Constructs	PE	EE	SF	FC	Tech	Org	Env	UB	VB	RB	TB	IB	Adoption
PE	**0.929**												
EE	0.726	**0.897**											
SF	−0.474	−0.454	**0.954**										
FC	0.756	0.681	−0.495	**0.946**									
Tech	0.061	0.025	−0.08	0.075	**0.752**								
Organizt	0.733	0.84	−0.515	0.691	0.044	**0.863**							
Environm	0.066	−0.036	0.001	0.025	−0.052	0.015	**0.935**						
UB	−0.518	−0.47	0.967	−0.531	−0.09	−0.539	−0.025	**0.83**					
VB	−0.652	−0.689	0.541	−0.684	−0.095	−0.707	−0.007	0.572	**0.853**				
RB	0.567	0.667	−0.307	0.75	0.004	0.597	0.012	−0.333	−0.509	**0.919**			
TB	0.775	0.703	−0.476	0.789	−0.014	0.665	0.077	−0.508	−0.627	0.756	**0.838**		
IB	0.022	−0.019	−0.01	−0.01	0.007	−0.028	0.606	−0.027	0.008	0.006	0.029	**0.925**	
Adoption	0.799	0.782	−0.616	0.798	0.099	0.847	0.031	−0.654	−0.85	0.575	0.714	−0.033	**0.989**

value for each indicator was greater than 0.5, indicating that each indicator accurately captures its corresponding latent construct. The loading factor values of each indicator are shown in Table 2.

Average variance extracted (AVE). AVE indicates the degree of convergence of all indicators against the measured latent construct. AVE values above 0.5 indicate adequate convergence (Hair et al. 2010). Table 2 showed that every construct had an AVE value of more than 0.5, indicating sufficient convergence for all constructs.

Composite reliability (CR). CR values indicate internal consistency; CR values above 0.7 reflect good reliability (Hair et al. 2010). The results in Table 2 indicate that the CR value for each construct was at least 0.8. This indicates that all indicators consistently reflect the same underlying construct.

Discriminant validity. Discriminant validity ensures that a construct in a research model is distinct from other constructs by confirming that the indicators used to measure one construct do not exhibit excessive correlation with indicators of another construct. According to the Fornell-Larcker Criterion, the square root of the average variance extracted (√AVE) should be greater than the highest correlation between that construct and any other construct to test discriminant validity. Table 3 displays the correlation between the construct, where the diagonal value shown in bold represents the square root of AVE.

Table 3 shows that the correlation between social factors (SF) and usage barriers (UB) exceeds the square root of AVE for SF, indicating a strong relationship. However, these constructs remain theoretically distinct. SF represents external social influences, while UB reflects internal perceived difficulties related to complexity, risk, or fraud. Prior research supports keeping them separate, as they influence adoption through different mechanisms (Hong and Cho 2023; Matsuo et al. 2018; Wang 2024).

While social influence can shape perceptions of difficulty, it does not define perceived barriers. Matsuo et al. (2018) found that social influence reduces resistance in non-experienced users but increases it in experienced ones, reinforcing the interaction but independence of SF and UB. Similarly, Hong and Cho (2023) found that social norms negatively impact innovation resistance in AI adoption, while Wang (2024) highlighted that social influence exposes older adults to digital learning but does not eliminate perceived barriers. High correlations between social influence and perceived barriers have been observed in prior studies, but were not considered grounds for merging constructs.

Empirically, maintaining SF and UB as separate constructs does not compromise model validity. Although the Fornell-Larcker criterion suggests a high correlation, AVE (≥0.50) confirms that both constructs capture meaningful variance, while CR (≥0.70) ensures internal consistency and reliability. Keeping them distinct allows the model to capture the nuanced interaction between social influence and internal adoption barriers, providing a more comprehensive understanding of SME behavior.

Structural model measurement. Partial least squares structural equation modeling (PLS-SEM) was employed using SmartPLS 4 to estimate the structural model. This method was selected due to the complexity of the model and the study's predictive and exploratory nature (Hair et al. 2021). As PLS-SEM does not assume multivariate normality, data normality testing was not required. The statistical significance of the path coefficients was assessed using a bootstrapping procedure with 5000 resamples. All tests were two-tailed, and p values were reported.

The model's Standardized Root Mean Square Residual (SRMR) value is 0.088. According to Hair et al. (2021), an SRMR value below 0.10 is acceptable. Since the SRMR value in this study is 0.088, it falls within the acceptable fit range, suggesting that the model adequately represents the observed data.

In hypothesis testing, the hypothesis is accepted at an error level 0.1 if the p value < 0.1. p values up to 0.10 in social sciences are often considered acceptable, particularly in studies examining complex human behaviors and decision-making (Gignac and Szodorai 2016; Murray 1998). Figure 1 shows that the three theories can predict the intention of SMEs to adopt e-commerce. In UTAUT, EE and SF were found to have an insignificant effect. In the TOE framework, technology has an insignificant influence. In IRT, the TB variable has an insignificant influence.

As shown in Table 4, two hypotheses, H7 (Environment → Intention, $p = 0.06$) and H12 (Image Barrier → Intention, $p = 0.07$), demonstrate marginal significance with p value above the conventional threshold of 0.05. Social science research often accounts for behavioral variability, allowing for a more flexible significance level when supported by theoretical justifications and practical implications. H7 (environmental factors) aligns with UTAUT, as external pressures such as competitor success, customer behavior, and government support have been shown to influence SME adoption of e-commerce (Loo et al. 2024; Setyowati et al. 2024; Urban et al. 2023). H12 (image barriers) is supported by the Innovation Resistance Theory, highlighting how perceptions of complexity and security risks can deter adoption (Lim et al. 2018; Ocampo et al. 2017). While these hypotheses exhibit small effect sizes (f^2 between 0.010 and 0.024) as shown in Table 5, their practical significance remains relevant in shaping SME decision-making. Given their alignment with prior research and potential impact on digital transformation policies, these

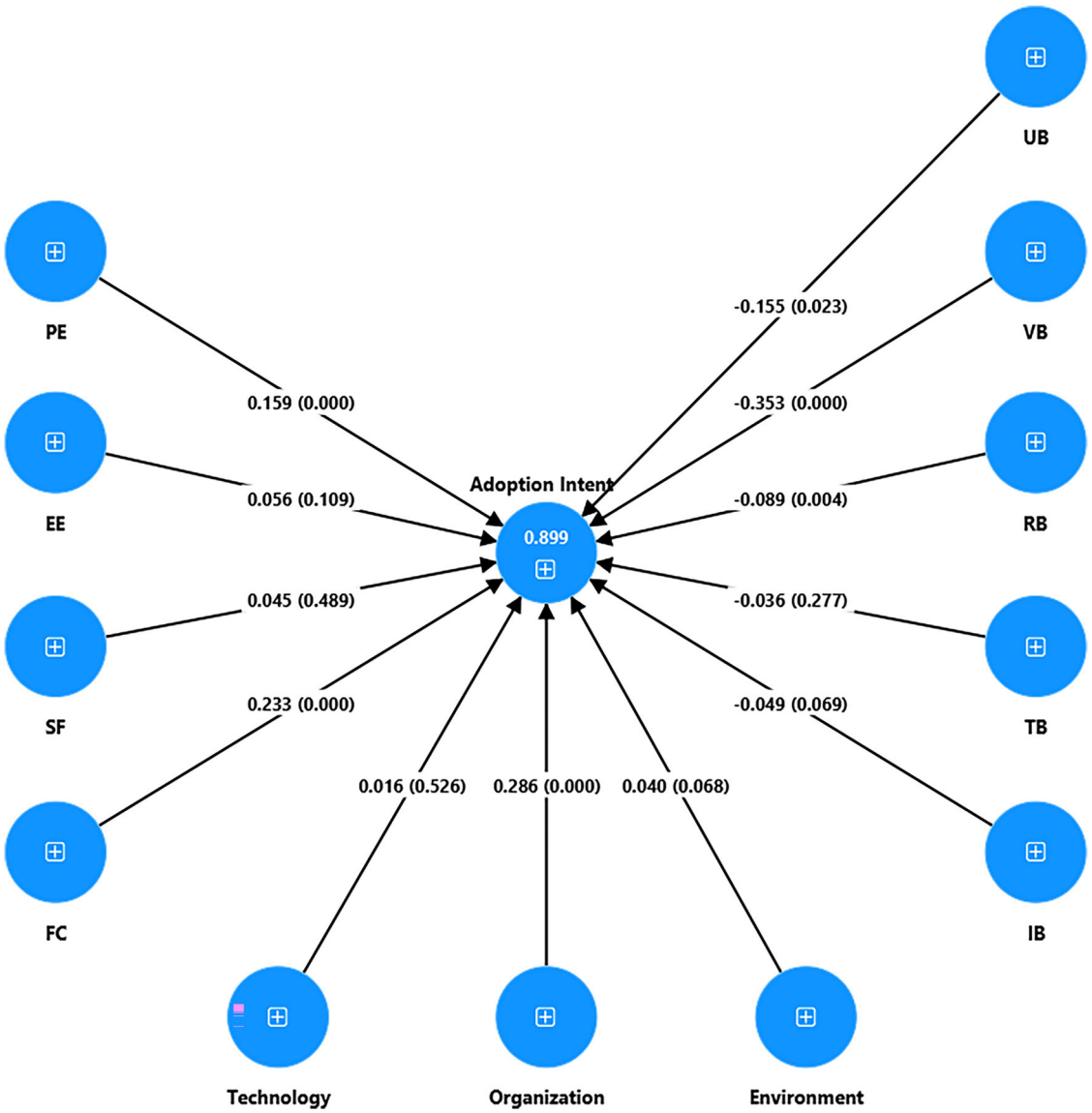

Fig. 1 Hypotheses testing.

Table 4 Hypothesis testing.

Hypothesis		Path coefficient	ρ values	Information
H1	PE → Intention	0.16	<0.01	Significant
H2	EE → Intention	0.06	0.11	Not significant
H3	SF → Intention	0.05	0.49	Not significant
H4	FC → Intention	0.23	<0.01	Significant
H5	Technology → Intention	0.02	0.53	Not significant
H6	Organization → Intention	0.29	<0.01	Significant
H7	Environment → Intention	0.04	0.06	Significant
H8	Usage barrier → Intention	−0.16	0.02	Significant
H9	Value barrier → Intention	−0.36	<0.01	Significant
H10	Risk barrier → Intention	−0.09	<0.01	Significant
H11	Tradition barrier → Intention	−0.04	0.28	Not significant
H12	Image barrier → Intention	−0.05	0.07	Significant

Significance is interpreted at $p < 0.10$ as acceptable.

findings contribute valuable insights into SME e-commerce adoption.

The analysis showed an average R^2 of 0.899 ($p < 0.001$), indicating that the combined UTAUT, TOE, and IRT frameworks explain a significant portion of the variance in the dependent variable. This highlights the model's robustness and theoretical validity, underscoring the importance of integrating behavioral, organizational, and resistance perspectives in understanding the

Table 5 *f* square, *R* square, and *Q* square.

Construct	*f* square	*R* square	*Q* square
Performance expectancy (PE)	0.068		
Effort expectancy (EE)	0.007		
Social factor (SF)	0.001		
Facilitating condition (FC)	0.129		
Technology	0.003		
Organization	0.197		
Environment	0.010		
Usage barrier (UB)	0.015		
Value barrier (VB)	0.487		
Risk barrier (RB)	0.024		
Tradition barrier (TB)	0.003		
Image barrier (IB)	0.015		
Adoption intention		0.899	0.895

adoption of e-commerce among SMEs. The Q^2 value, a measure of predictive relevance, was found to be 0.895 for the endogenous constructs in this study. This value, calculated using the blindfolding procedure in partial least squares, significantly exceeds the commonly accepted threshold of 0, indicating the model has strong predictive relevance (Chin 1998). A high Q^2 value highlights the practical relevance and utility of the research model (Henseler et al. 2009). The f^2 values represent the effect size of each construct in explaining the variance of the dependent variable. According to Cohen (1988), the thresholds for interpreting f^2 values are as follows: small effect ($0.02 \le f2 < 0.15$), medium effect ($0.15 \le f2 < 0.35$), and large effect ($f2 \ge 0.35$). The result showed a range of effect sizes across the constructs. Notably, value barrier has the largest influence, while constructs such as social factors, effort expectancy, and technology contribute minimally. Constructs with small or medium effect sizes, such as organization and facilitating conditions, provide meaningful insights for targeted interventions.

Discussion

UTAUT influences SMEs' intention to adopt e-commerce technology. From four UTAUT constructs, performance expectancy, and facilitating conditions were found to significantly influence SMEs' intention to adopt e-commerce technology. The rapid shift from offline to online shopping is partly due to the COVID-19 pandemic, which forced retailers to start conducting business online. Many found fruitful results in the online environment, thus encouraging SMEs to adopt e-commerce technology to get the desired performance. Multiple studies confirm that performance expectancy is a critical factor. For instance, research on SMEs highlights that performance expectancy significantly influences the intention to adopt e-commerce, as SMEs perceive that e-commerce can enhance their operational efficiency and sales growth (Kwarteng et al. 2024; Pobee 2021; Shahzad et al. 2020; Sombultawee 2020). This holds in various settings, suggesting that the possible performance advantages of e-commerce technologies drive SMEs' adoption.

Facilitating conditions play a critical role in SMEs' adoption of e-commerce, with findings confirming a strong effect size ($f^2 = 0.129$), making it one of the most influential factors in adoption decisions. The availability of financial resources, infrastructure, technical knowledge, and external support enables SMEs to overcome barriers and effectively integrate e-commerce into their operations. Often operating with limited resources, SMEs rely on external support systems, industry guidance, and financial accessibility to adopt digital technologies (Datta 2011; Pobee 2021). When adequate support structures, such as training programs, government incentives, or assistance from e-commerce platforms, are in place, SMEs are more confident in embracing digital transformation. Additionally, having internal financial and technical capacity reduces adoption hesitancy, allowing businesses to focus on leveraging e-commerce for market expansion and revenue growth. These findings underscore the need for ongoing investment in SME support programs, financial accessibility, and digital education initiatives to further enhance adoption rates.

Unlike performance expectancy and facilitating conditions, effort expectancy and social factors do not show a significant effect. This finding provides valuable insights into the dynamics of technology adoption among SMEs, particularly in Indonesia and Malaysia. While the UTAUT model traditionally considers effort expectancy and social influence as key predictors of adoption, recent research suggests that their relevance may vary across different contexts, particularly in mandatory adoption environments or digitally mature SME sectors.

Effort expectancy, which refers to the perceived ease of use of technology, is often considered a significant determinant in early adoption phases. However, in the SME context, its influence appears to be weaker. Studies from Indonesia and Iraq indicate that perceived ease of use does not significantly impact e-commerce adoption decisions (Khsroo et al. 2024; Rafinda et al. 2024). One possible explanation is that SMEs are becoming more familiar with digital technology, reducing the relevance of effort expectancy in decision-making. Additionally, the rapid shift to online commerce, accelerated by the COVID-19 pandemic, has forced SMEs to embrace digital platforms as a necessity rather than a choice. As a result, whether e-commerce is perceived as easy to use becomes secondary to its business benefits and survival potential. Even if SMEs perceive e-commerce as challenging to operate, the need to remain competitive overrides concerns about usability.

Similarly, social factors, representing peer influence and social network effects, do not significantly impact SMEs' intention to adopt e-commerce. Prior studies from Mexico and Malaysia found that subjective norms and social influence had little to no impact on SME adoption of fintech and e-commerce technologies (Haces et al. 2024; Rafinda et al. 2024). This suggests that SMEs prioritize practical and financial considerations over peer recommendations. Unlike consumers, whose adoption decisions are often influenced by social trends, SMEs are driven by business needs, profitability, and operational efficiency. Additionally, digital infrastructure is expanding in countries like Indonesia and Malaysia, and e-commerce platforms are becoming widely accessible. Thus, participation in e-commerce is not perceived as a socially relevant decision but as a strategic business necessity.

Innovation resistance theory influences SMEs' intention to adopt e-commerce technology. H8 examined the negative relationship between usage barriers and SMEs' intention to adopt e-commerce technology, and the findings support this hypothesis. However, the effect size is small ($f^2 = 0.015$), indicating that while usage barriers hinder adoption, their influence is relatively weak compared to performance expectancy, which has a more substantial effect on adoption decisions. SMEs often face challenges in understanding and utilizing e-commerce platforms, mainly due to limited IT skills within their workforce (Azubuike et al. 2023; Nazir and Roomi 2021). While this complexity may contribute to hesitation, it does not outweigh the perceived necessity of going digital. As e-commerce adoption becomes increasingly essential for SMEs to remain competitive, performance expectancy, specifically the potential for higher sales and market expansion, holds greater weight in their decision-making. This aligns with the

broader trend that SMEs prioritize business outcomes over usability concerns, as seen in the insignificant effect of effort expectancy in the UTAUT discussion. Given the relatively weak influence of usage barriers, efforts to enhance SME adoption should focus on reinforcing the perceived benefits of e-commerce rather than solely addressing usability concerns. While improving platform accessibility remains important, SMEs appear more motivated by expected revenue growth and business sustainability, further reinforcing the dominance of performance expectancy in adoption decisions.

H9 examined the negative relationship between value barrier and SMEs' intention to adopt e-commerce, with findings confirming that value perception is the strongest determinant of adoption ($f^2 = 0.487$). This suggests that SMEs' adoption decisions are primarily driven by assessing the perceived value of e-commerce. When they see clear benefits, they are more likely to adopt; when they perceive limited value, they resist adoption. SMEs carefully weigh the expected returns against the effort and costs of adopting e-commerce. If they believe that the time required to learn online marketing systems outweighs potential revenue gains or that platform costs exceed expected profits, they are unlikely to invest in digital transformation (Karim and Gide 2018; Satar and Alarifi 2022). The strong influence of value barrier aligns with the significant role of performance expectancy in adoption decisions. SMEs are not simply deterred by usability or operational complexity; they adopt e-commerce when they perceive a strong business case, revenue potential, and strategic advantage. This underscores the need for policymakers and e-commerce platforms to enhance perceived value by demonstrating tangible benefits, ROI, and scalable growth opportunities.

H10 examined the negative relationship between risk barrier and SMEs' intention to adopt e-commerce, with findings confirming a significant but weak effect ($f^2 = 0.024$). This suggests that while SMEs acknowledge risks related to security, financial loss, and product imitation, these concerns are not the primary determinants of adoption decisions. The small effect size of risk barrier compared to performance expectancy ($f^2 = 0.068$) and facilitating conditions ($f^2 = 0.129$) indicates that SMEs place greater emphasis on having the necessary resources, infrastructure, and external support (facilitating conditions) rather than concerns about risk. While SMEs may fear transaction insecurity, product copying, or financial losses (Harsasi et al. 2023), these concerns do not outweigh their ability to secure financial resources, access infrastructure, or receive external support for digital transformation. This aligns with the finding that facilitating conditions play a more decisive role in adoption, as SMEs rely on financial and knowledge resources to engage in e-commerce confidently. The findings highlight that SMEs adopt e-commerce not because they ignore risks but because they prioritize having the necessary means to manage those risks. Trust in e-commerce platforms remains relevant (Khsroo et al. 2024), but SMEs appear more influenced by their financial and operational readiness. Therefore, reducing perceived risks alone may not be sufficient to drive adoption. Efforts should also focus on enhancing SMEs' access to financial resources, technical knowledge, and support networks to strengthen their ability to adopt and sustain e-commerce.

H11 hypothesized that tradition barriers exert a significant association with use intention. The study findings do not support the hypothesis. While traditional practices can shape decision-making, their impact appears to be overshadowed by more pressing factors, such as perceived business benefits, competitive pressures, and the availability of digital infrastructure (Harsasi et al. 2023). This aligns with Innovation Diffusion Theory (Rogers 2003), which suggests that resistance due to tradition decreases as a technology matures and adoption spreads. Several contextual factors may explain this insignificant relationship. First, Indonesia and Malaysia have experienced strong governmental support for digitalization, active e-commerce campaigns, and increased accessibility to affordable digital tools, which likely reduces the impact of traditional resistance. Second, the industries examined in this study, including fashion, cosmetics, and education services, are highly consumer-driven and rapidly evolving, making it essential for SMEs to adapt to technological shifts regardless of traditional norms. Third, by the time this study was conducted, e-commerce platforms had reached a high level of growth in both Indonesia and Malaysia. Tradition barriers may act as a significant obstacle when a technology is first introduced. Still, their influence tends to decline as adoption becomes widespread and digital transactions become standard business practices. These findings align with research suggesting that entrepreneurial SMEs prioritize innovation and digital transformation over traditional constraints (Himawan et al. 2024; Khsroo et al. 2024). Moreover, the increasing normalization of digital transactions in society may have weakened the role of tradition barriers. SMEs may now view digitalization as a necessary step rather than a cultural shift. While tradition barriers may not significantly impact adoption decisions in this study, future research could explore whether these barriers influence the speed of adoption rather than the decision itself. Additionally, tradition barriers may still influence rural SMEs or industries with deeply entrenched business models where cultural norms play a more prominent role in operational decision-making.

H12 examined the negative relationship between image barriers and SMEs' intention to adopt e-commerce, with findings confirming a significant but weak effect ($f^2 = 0.015$). This suggests that while some SMEs perceive e-commerce as complicated, insecure, or potentially harmful, these concerns do not dominate adoption decisions. The small effect indicates that SMEs prioritize other factors, such as expected business outcomes and resource availability over image concerns when adopting e-commerce. While some SMEs may hesitate due to fears of increased competition, uncertainty about digital transactions, or a preference for traditional business models (Kinkani et al. 2024), these concerns do not significantly deter adoption. Instead, the decision to engage in e-commerce is more influenced by practical considerations such as financial resources, infrastructure support, and the potential for revenue growth. Although image barriers exist, their influence can be mitigated by enhancing SMEs' confidence in digital platforms through financial incentives, security assurances, and industry-wide digital adoption initiatives. Rather than being a major obstacle, image barriers appear to be a secondary concern, likely to be overcome when SMEs recognize the tangible benefits of e-commerce.

TOE framework influences SMEs' intention to adopt e-commerce technology. The result showed that the technological aspect of the TOE framework does not significantly influence SMEs' intention to adopt e-commerce technology. This finding contrasts with traditional expectations that technological readiness is a key driver of digital adoption but aligns with studies suggesting that organizational and environmental factors often outweigh technological factors in SME decision-making (Tornatzky and Fleischer 1990). One possible explanation is that SMEs prioritize immediate business benefits, such as customer engagement and competitive positioning, over the technical integration of e-commerce platforms. Several contextual factors related to the specific indicators used to measure technology readiness in this study may explain the insignificant influence of technological factors. First, one measured indicator was whether the online marketing system would integrate seamlessly into SME

operations. However, many SMEs operate with flexible, informal, or hybrid business models that do not necessarily require full system integration. Retail SMEs in sectors such as fashion, cosmetics, and F&B often rely on semi-automated or manual processes sufficient for their scale of operations, making seamless technological integration a lower priority (Setiyani and Yeny Rostiani 2021). Rather than focusing on integration, these SMEs may emphasize market accessibility, branding, and customer interaction, which are captured under organizational and environmental factors. Second, the expectation that online marketing requires low costs may be met with skepticism by SMEs. While e-commerce platforms often advertise low-cost entry points, SMEs may encounter hidden costs associated with customization, platform fees, logistics, and digital marketing expenses (Satar and Alarifi 2022). These financial considerations may lead SMEs to deprioritize technology as a key adoption driver, viewing it as a tool rather than a strategic advantage. Another key factor is the growth of e-commerce platforms in Indonesia and Malaysia. Over time, the ease of adopting e-commerce platforms may have reduced the importance of technological considerations in SME decision-making. Modern platforms offer pre-integrated solutions that require minimal IT expertise, making organizational readiness (including financial and managerial support) and external environmental factors (such as competition and consumer demand) stronger predictors of adoption. Additionally, many SMEs rely on third-party services for logistics, payment integration, and digital marketing, reducing their dependence on internal technological capabilities.

On the other hand, organizational factors play a significant role in SMEs' adoption of e-commerce, with findings confirming a medium effect size ($f^2 = 0.197$), making it the second most influential factor after value barrier. This highlights that internal readiness, managerial support, and resource availability are key determinants of whether SMEs integrate e-commerce into their business operations. SMEs with a proactive approach to digital marketing, strong managerial support, and a capable workforce are better positioned for adoption. When SME owners actively support online marketing financially and non-financially, they create an environment that fosters digital adoption. This aligns with findings that organizational readiness, including financial stability and technical expertise, directly influences technology adoption (Alshamaila et al. 2013). Similarly, managerial commitment to innovation is essential for overcoming resistance to change and ensuring the successful implementation of e-commerce strategies (Ghobakhloo et al. 2011). The substantial effect size of organizational factors suggests that SMEs prioritize internal preparedness over external pressures when adopting e-commerce. Even in a rapidly digitalizing market, SMEs are more likely to adopt when they have the internal capacity to manage online marketing effectively. These findings underscore the importance of investing in digital skills development, leadership-driven digital initiatives, and financial support mechanisms to further promote e-commerce adoption among SMEs.

H7 examined the influence of environmental factors on SMEs' intention to adopt e-commerce, with findings confirming a significant but weak effect ($f^2 = 0.010$). This suggests that competitive pressure, customer behavior, and government support contribute to adoption decisions but are not primary drivers. SMEs are aware of shifting consumer preferences and increasing competition in e-commerce, but these factors alone do not significantly influence their adoption decisions. Instead, SMEs are more likely to adopt e-commerce when they have internal readiness and perceive tangible business benefits. While government support through financial incentives, training, and infrastructure development helps create a favorable environment for adoption (Triandini et al. 2023), its influence is secondary to organizational preparedness and expected performance gains. The low effect size suggests that SMEs do not passively adopt e-commerce in response to external pressures. Instead, they evaluate their internal capabilities and potential returns before making adoption decisions. This aligns with findings that competitive pressure and customer demand alone do not automatically translate to adoption unless SMEs see clear advantages in terms of sales growth and operational efficiency (Ahmad and Siraj 2023; Shahadat et al. 2023). While environmental factors shape the broader market landscape, SMEs ultimately prioritize internal readiness and perceived business value in their adoption decisions. To further encourage SME adoption, government initiatives, and market incentives should focus on external support and strengthening SMEs' internal capabilities and financial preparedness.

Industry variation. Since this study focuses on e-commerce adoption, the samples were deliberately selected from the retail industry, encompassing both goods and service retail subsectors. SMEs in the retail industry are particularly well-suited for this research, as their operations naturally align with the core functions of e-commerce. Retail SMEs can readily sell their products or services online, conduct online purchase transactions with consumers, and integrate digital platforms into their marketing and sales strategies. This contrasts with the construction, real estate, or entertainment industries, where direct online consumer transactions are more challenging or less relevant. This operational suitability makes retail SMEs an ideal setting for investigating e-commerce adoption and the factors influencing its success.

The study sample includes several retail subsectors. Based on our observation and interviews with SMEs in each subsector, each shows distinct e-commerce needs and priorities, and adoption drivers and challenges. These differences reflect variations in customer expectations, product characteristics, and operational challenges. For example, fashion retail SMEs primarily adopt e-commerce to expand their market reach and enhance consumer engagement through visually appealing digital marketing tools. Their e-commerce needs focus on platforms that support high-quality product imagery, social media integration, and user-friendly interfaces to attract customers. These businesses prioritize branding and personalized shopping experiences, often leveraging influencer marketing and digital advertising campaigns. However, key challenges include managing product returns and combating counterfeit or copied products. Despite these barriers, the availability of visually driven marketing tools and global access to customers make e-commerce a vital channel for fashion SMEs.

Like fashion, cosmetics, and skincare, SMEs emphasize visually appealing marketing and influencer-driven strategies. Their e-commerce needs include platforms that allow product tutorials, reviews, and detailed product descriptions to educate consumers about the benefits and usage of products. The primary challenges for this subsector include the inability of consumers to physically test products, concerns about product compatibility (e.g., suitability for different skin types), and managing allergic reactions or customer dissatisfaction. Overcoming these barriers requires robust return policies, digital tools such as virtual try-ons, and targeted consumer education campaigns.

Electronics retailer SMEs focus on providing detailed product information, user reviews, and comparison features to facilitate informed purchasing decisions. Their e-commerce needs revolve around reliable platforms that support advanced search filters and integration with after-sales support systems. Logistics challenges,

such as handling fragile or high-value items, providing adequate technical support, and competing in a highly price-sensitive market, are significant barriers for this subsector. Competitive pricing strategies and partnerships with logistics providers are essential to overcoming these challenges.

Eco-friendly product SMEs cater to environmentally conscious consumers, emphasizing sustainability certifications, storytelling, and eco-branding in their e-commerce strategies. Their needs include platforms that highlight product certifications (e.g., organic) and educate consumers about the environmental benefits of their products. Challenges in this subsector include high production costs, sourcing sustainable packaging materials, and increasing consumer awareness. Leveraging niche marketplaces and collaborating with environmental organizations can help overcome these barriers and build consumer trust.

F&B SMEs rely on e-commerce to enable online ordering and delivery services. Their e-commerce priorities include seamless integration with delivery platforms and user-friendly mobile applications to enhance customer convenience. However, challenges such as maintaining food quality during delivery and coping with high platform fees from delivery apps can hinder adoption. F&B SMEs need reliable cold chain systems and innovative packaging solutions to ensure product quality and customer satisfaction.

Accommodation SMEs adopt e-commerce primarily for online booking and reservation systems, enabling real-time availability updates and leveraging customer reviews to build trust. They require platforms that facilitate seamless booking experiences, integrate with travel aggregators, and provide customer feedback systems. Key challenges include maintaining personalized services, managing cancellations, and navigating platform commission fees.

Handicraft SMEs use e-commerce to preserve cultural heritage and connect with niche global markets. Their needs center on platforms that support storytelling, artisanal branding, and showcase unique, handcrafted products. Challenges for this subsector include tradition-related resistance, limited digital skills, and the inability to scale production for larger markets. Training programs in digital skills, combined with government support for promoting artisanal products, can help address these barriers.

Education SMEs offering online courses prioritize e-commerce platforms that support e-learning tools such as live streaming, recorded sessions, and learning management systems (LMS). Their needs include functionality for enrollment management and content delivery. Challenges include replicating traditional classroom experiences online, protecting intellectual property, and maintaining student engagement. Providing interactive and adaptive learning tools, as well as securing course materials, can help mitigate these challenges.

SMEs in graphic design adopt e-commerce to showcase their portfolios, attract clients, and streamline project management. Challenges include difficulties conveying the value of creative services online and competing in saturated digital marketplaces. Offering unique value propositions and leveraging SEO strategies can help graphic design SMEs stand out.

Despite their diversity, retail SMEs share commonalities in their e-commerce adoption strategies. Customer trust and engagement are universal priorities, with online reviews, secure payment systems, and responsive customer support playing critical roles. Additionally, all subsectors require reliable digital infrastructure to facilitate operations, including user-friendly platforms, social media integration, and logistics solutions. Shared barriers include financial constraints, a lack of technical expertise, and resistance to change.

Comparison with past studies. This study builds upon previous research on SME e-commerce adoption, particularly Mensah et al. (2023) and Nguyen et al. (2024), by integrating Innovation Resistance Theory (IRT) alongside TOE and UTAUT. While prior studies primarily focused on drivers of adoption, this study offers a more comprehensive perspective by examining both enablers and barriers, shedding light on why some SMEs hesitate to adopt e-commerce.

From a methodological standpoint, this study covers Indonesia and Malaysia, providing a broader regional scope compared to Mensah et al. (2023) (China) and Nguyen et al. (2024) (Vietnam—CBEC). Additionally, while Mensah et al. (2023) employed simple random sampling, this study utilizes a stratified random sampling approach based on industry sectors, ensuring that SME-specific variations are captured.

A key distinction lies in the theoretical framework used. Mensah et al. (2023) integrated TOE and UTAUT, whereas Nguyen et al. (2024) combined TOE with TPB. This study extends these models by incorporating Innovation Resistance Theory (IRT) to systematically examine five resistance factors: Usage Barrier (UB), Value Barrier (VB), Risk Barrier (RB), Tradition Barrier (TB), and Image Barrier (IB). This framework allows for a more balanced analysis of adoption motivators and inhibitors, which were not fully explored in prior studies.

Findings reveal several key differences. Unlike Mensah et al. (2023), this study finds that technological factors do not significantly drive adoption, suggesting that SMEs in Indonesia and Malaysia rely more on internal readiness and expected business outcomes than on technology infrastructure alone. Additionally, while Mensah et al. found that environmental factors had no significant impact, this study identifies a weak but present effect ($f^2 = 0.010$), indicating that competitor success, customer behavior, and government support still influence SME decisions but are not primary determinants of adoption. Compared to Nguyen et al. (2024), who found strong external pressures in cross-border e-commerce adoption, this study suggests that domestic e-commerce adoption is more internally driven, emphasizing organizational readiness and financial capacity over regulatory and market pressures.

From a practical perspective, this study highlights that reducing perceived risk and clarifying value perception are crucial for encouraging SME adoption. In contrast, Mensah et al. (2023) emphasize organizational capabilities, while Nguyen et al. (2024) stress the importance of government support. Moreover, this study finds that facilitating conditions ($f^2 = 0.129$) and organizational factors ($f^2 = 0.197$) have a greater influence on adoption decisions than external pressures, reinforcing the idea that SMEs prioritize financial resources, managerial commitment, and internal preparedness over external influences.

Conclusion

Overall, this study sheds light on the management and behavior of SMEs concerning the implementation of e-commerce technologies. The following is a summary of the study's findings. First, UTAUT dimensions influence SMEs' adoption of e-commerce technology; however, the influence is not robust, as EE and SF were found to be insignificant. Second, The TOE framework contributes to explaining SMEs' intention to adopt e-commerce technology, particularly through organizational readiness, although the technological and environmental components had limited or marginal influence. Third, IRT dimensions influence SMEs' adoption of e-commerce technology except for tradition barriers.

The theoretical implications of this study lie in its novel integration of the TOE framework, UTAUT, and IRT to analyze e-commerce adoption by SMEs. This combined approach provides a more comprehensive understanding of both the drivers

and barriers to adoption, acknowledging the multi-faceted influences on SMEs' decisions. The research enhances the analytical power for studying e-commerce adoption by bridging these theoretical models. It lays the groundwork for future studies to apply integrative frameworks in technology adoption contexts, potentially leading to more targeted and comprehensive interventions for SME digitalization efforts.

The practical implications of this study suggest several actionable steps for policymakers, platform providers, and SME leaders. Policymakers should focus on creating a supportive ecosystem that addresses structural barriers to e-commerce adoption. This includes introducing grants or low-interest loans to help SMEs invest in digital tools, build infrastructure, or train employees. Additionally, capacity-building initiatives can be implemented through widespread training programs that equip SME employees with skills in digital marketing, platform management, and cybersecurity. Simplifying regulatory frameworks and reducing bureaucratic hurdles can facilitate the adoption of e-commerce, while robust consumer protection laws can foster trust in online transactions. Policymakers should also invest in expanding internet accessibility and affordability, particularly in rural areas, to ensure SMEs' broader participation in digital platforms. To counteract the strong impact of value barriers, policymakers must reduce financial concerns, increase perceived benefits, and ensure fair market conditions. Governments may support SME digital transformation by making e-commerce adoption more financially viable and transparent. Such strategies could potentially enhance participation and contribute to long-term economic development.

E-commerce platform providers play a crucial role in making their platforms accessible and valuable for SMEs. They should design platforms with intuitive interfaces that require minimal technical expertise, thereby addressing challenges related to usage barriers. Providing SMEs with comprehensive support services, such as tutorials, FAQs, and dedicated onboarding assistance, can ease their transition to e-commerce. Enhancing data security and ensuring secure payment systems are crucial for alleviating risk-related concerns among SMEs. To address financial constraints, platform providers can offer affordable pricing models, such as tiered subscription plans or commission-based fees, tailored to SME budgets. To address the strong impact of value barriers, e-commerce platforms must lower cost concerns, demonstrate profitability, and provide tangible business benefits for SMEs. Platform providers could enhance SME confidence and support adoption by offering flexible pricing, demonstrating ROI potential, and providing strong onboarding and seller support tools.

SME leaders must take proactive steps to prepare their businesses for digital transformation. Strategic investment in building internal capabilities, such as training employees or hiring professionals to manage e-commerce operations, is key to overcoming operational challenges. A customer-centric approach, supported by digital tools such as CRM software, can enhance customer engagement and facilitate efficient issue resolution. Collaboration with other SMEs or participation in government and platform provider programs can help share best practices and provide access to new tools and strategies. For SMEs in niche markets, such as those specializing in eco-friendly products and handicrafts, focusing on storytelling and brand differentiation can maximize the impact of e-commerce on their operations. Although traditional barriers were statistically insignificant in this study, addressing them remains essential for SMEs. To resolve customer issues, SMEs can utilize CRM tools and chatbots to efficiently manage queries and provide real-time assistance. For order processing challenges, automated order management systems integrated with e-commerce platforms can streamline fulfillment and reduce errors. To overcome payment processing difficulties, SMEs can adopt secure third-party payment gateways or join established e-marketplaces, offering diverse payment options such as e-wallets and bank transfers. Training programs and partnerships with tech providers can further enhance SMEs' ability to manage these challenges effectively.

While this study focuses on Indonesia and Malaysia, the findings may offer preliminary insights for other emerging markets that share similar infrastructural and organizational conditions. However, further cross-country validation is recommended. Emerging markets often face comparable challenges, such as limited digital infrastructure, varying technological readiness levels, and cultural resistance to innovation. These shared characteristics provide a foundation for generalizing the insights gained from this study to other contexts with similar developmental and economic profiles.

Emerging markets often present multiple opportunities and constraints during their digital transformation journeys. For instance, many SMEs in such regions struggle with inadequate infrastructure, limited access to digital skills, and the high cost of adopting technology. Similarly, cultural factors such as resistance to change and reliance on traditional business practices often hinder the adoption of e-commerce. The findings of this study highlight the role of organizational readiness in facilitating conditions and barriers, such as tradition and risk, which resonate with the universal challenges that SMEs face in other emerging economies, including India, Vietnam, and African nations. Therefore, the study provides valuable insights that can guide policymakers and practitioners in similar contexts.

While this study offers valuable insights into the drivers and barriers of e-commerce adoption among SMEs in emerging markets, several limitations should be acknowledged. First, the research was geographically confined to Indonesia and Malaysia. Although both countries represent dynamic and growing digital economies in Southeast Asia, the findings may not be fully generalizable to other emerging markets with different regulatory environments, cultural characteristics, or levels of digital infrastructure. Second, the study employed a cross-sectional survey design, which limits the ability to observe changes in adoption behavior over time or establish causal relationships between the identified variables. Future research employing longitudinal or experimental designs could better capture the temporal dynamics of e-commerce adoption and resistance. Third, the study sample was restricted to SMEs operating within the retail sector, including both goods and service providers. This sector was chosen for its high relevance to e-commerce, but the results may not be transferable to SMEs in other industries, such as manufacturing, agriculture, or healthcare, which may face different adoption challenges and opportunities.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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References

Abdulkarem A, Hou W (2022) The influence of the environment on cross-border E-commerce adoption levels among SMEs in China: the mediating role of organizational context. Sage Open 12. https://doi.org/10.1177/21582440221103855

Adeniran AO, Akinsehinwa FO, Olorunfemi SO (2022) Factors influencing the acceptance and patronage of E-commerce logistics operations in Nigeria. Bull Natl Res Cent 46:128. https://doi.org/10.1186/s42269-022-00816-x

Ahmad M, Siraj S (2023) Determinants impacting the assimilation stages of E-commerce in SMEs: a modified TOE framework. Int J Electron Commer Stud 14:101. https://doi.org/10.7903/ijecs.2220

Almashawreh R, Talukder M, Charath SK, Khan MI (2024) AI adoption in Jordanian SMEs: the influence of technological and organizational orientations. Glob Bus Rev. https://doi.org/10.1177/09721509241250273

Alshamaila Y, Papagiannidis S, Li F (2013) Cloud computing adoption by SMEs in the north east of England. J Enterp Inf Manag 26:250–275. https://doi.org/10.1108/17410391311325225

Alshourah S, Altawalbeh M, Jodeh I, Hasan M (2023) Factors Affecting the Adoption of Social Media Among Jordanian SMEs Based on UTAUT Mode. In: Hamdan A, Shoaib HM, Alareeni B, Hamdan R (eds) The Implementation of Smart Technologies for Business Success and Sustainability. Studies in Systems, Decision and Control, vol 216. Springer, Cham. https://doi.org/10.1007/978-3-031-10212-7_13

Amornkitvikai Y, Tham SY, Harvie C, Buachoom WW (2022) Barriers and factors affecting the e-commerce sustainability of Thai micro-, small- and medium-sized enterprises (MSMEs). Sustainability 14:8476. https://doi.org/10.3390/su14148476

Aremu AY, Arfan S (2023) Factors influencing the usage of e-business to improve SME performance. Int J E-bus Res 19:1–16. https://doi.org/10.4018/IJEBR.324065

Awa HO, Ojiabo OU, Emecheta BC (2015) Integrating TAM, TPB and TOE frameworks and expanding their characteristic constructs for e-commerce adoption by SMEs. J Sci Technol Policy Manag 6:76–94. https://doi.org/10.1108/JSTPM-04-2014-0012

Awa HO, Ojiabo OU, Orokor LE (2017) Integrated technology-organization-environment (T-O-E) taxonomies for technology adoption. J Enterp Inf Manag 30:893–921. https://doi.org/10.1108/JEIM-03-2016-0079

Ayaz A, Yanartaş M (2020) An analysis on the unified theory of acceptance and use of technology theory (UTAUT): acceptance of electronic document management system (EDMS). Comput Hum Behav Reports 2. https://doi.org/10.1016/j.chbr.2020.100032

Azahar S (2021) Post-pandemic growth: address barriers to business digital transformation. Malaysian Rep. https://themalaysianreserve.com/2021/10/21/post-pandemic-growth-address-barriers-to-business-digital-transformation/#google_vignette

Azubuike O, Herrieth C, Rahim ARA (2023) A systematic review and proposition of an e-commerce framework for African SMES: integrating TAM and TPB into TOE framework. Int J Bus Manag Stud 04:15–37. https://doi.org/10.56734/ijbms.v4n7a3

Badghish S, Soomro YA (2024) Artificial intelligence adoption by SMEs to achieve sustainable business performance: application of technology–organization–environment framework. Sustainability 16. https://doi.org/10.3390/su16051864

Boston Consulting Group & Blibli (2022) Unlocking inclusive growth through digitalization of Indonesian MSMEs. https://web-assets.bcg.com/f7/12/69a982464a39922b1951f28fa4f0/whitepaper-unlocking-inclusive-growth-throughdigitalization-of-indonesian-msmes.pdf

Cazabat G, Paraschiv DM, Calin AC, Popovici OC (2019) A contemporaneous statistical note on e-commerce adoption in Romania-based SMEs. 21:177. www.amfiteatrueconomic.ro; https://doi.org/10.24818/EA/2019/50/177

Chauhan S, Jaiswal M (2016) Determinants of acceptance of ERP software training in business schools: empirical investigation using UTAUT model. Int J Manag Educ 14:248–262. https://doi.org/10.1016/j.ijme.2016.05.005

Check J, Schutt RK (2012) Research methods in education. SAGE Publications, Inc., London

Chin WW (1998) The partial least squares approach for structural equation modeling. In Marcoulides GA (ed), Modern methods for business research (pp. 295–336). Lawrence Erlbaum Associates Publishers, US

Chong S (2008) Success in electronic commerce implementation. J Enterp Inf Manag 21:468–492. https://doi.org/10.1108/17410390810904247

Chrysochou P (2017) Consumer Behavior Research Methods. In Emilien G, Weitkunat R, Lüdicke F (eds), Consumer Perception of Product Risks and Benefits (pp. 409-428). Springer. https://doi.org/10.1007/978-3-319-50530-5_22

Cohen J (1988) Statistical power analysis for the behavioral sciences, 2nd edn. Lawrence Erlbaum Associates, US

Cramer D, Howitt D (2004) The SAGE dictionary of statistics. SAGE Publications, Ltd, London

Creswell JW (2003) Research design: qualitative, quantitative, and mixed method approaches. Sage Publications, Thousand Oaks

Daoud Y, Kammoun A (2024) Analyzing and forecasting e-commerce adoption drivers among SMEs: a machine learning approach. Hum Behav Emerg Technol 2024. https://doi.org/10.1155/2024/7747136

Datta P (2011) A preliminary study of ecommerce adoption in developing countries. Inf Syst J 21:3–32. https://doi.org/10.1111/j.1365-2575.2009.00344.x

Ding M-C, Wu K-W, Liu S-W (2008) Determinants of B2C EC success on market performance of different sizes of firms in Taiwan's E-brokerage sector. J Small Bus Strateg 19:17–36

Dutta S, Shivani S (2023) Acceptance and use of e-commerce technology among female entrepreneurs of micro and small businesses in India: analysis of determinants. Int J Bus Innov Res 31:356–377. https://doi.org/10.1504/IJBIR.2023.132898

Dwivedi YK, Balakrishnan J, Das R, Dutot V (2023) Resistance to innovation: a dynamic capability model based enquiry into retailers' resistance to blockchain adaptation. J Bus Res 157:113632. https://doi.org/10.1016/j.jbusres.2022.113632

Eid R, Trueman M (2004) Factors affecting the success of business-to-business international Internet marketing (B-to-B IIM): an empirical study of UK companies. Ind Manag Data Syst 104:16–30. https://doi.org/10.1108/02635570410514061

Ellen S (2022) Slovin's formula sampling techniques. https://www.sciencing.com/slovins-formula-sampling-techniques-5475547/

Gao J, Siddik AB, Khawar Abbas S et al. (2023) Impact of E-commerce and digital marketing adoption on the financial and sustainability performance of MSMEs during the COVID-19 pandemic: an empirical study. Sustainability 15:1594. https://doi.org/10.3390/su15021594

Ghobakhloo M, Arias-Aranda D, Benitez-Amado J (2011) Adoption of e-commerce applications in SMEs. Ind Manag Data Syst 111:1238–1269. https://doi.org/10.1108/02635571111170785

Gignac GE, Szodorai ET (2016) Effect size guidelines for individual differences researchers. Pers Individ Dif 102:74–78. https://doi.org/10.1016/j.paid.2016.06.069

Gomes C, Busanello E, Padilha B et al. (2024) Exploring key factors for implementing manufacturing execution systems (MES) within the framework of industry 4.0 for small and medium-sized enterprises (SMEs) in the Manufacturing sector. Production 34. https://doi.org/10.1590/0103-6513.20230085

Grandón EE, Ramírez-Correa P (2018) Managers/owners' innovativeness and electronic commerce acceptance in Chilean SMEs: a multi-group analysis based on a structural equation model. J Theor Appl Electron Commer Res 13:1–16. https://doi.org/10.4067/S0718-18762018000300102

Haces G, Medina J-M, Roque R-V et al. (2024) Factors of adoption of electronic commerce in SMEs in Mexico. TEM J 1413–1422. https://doi.org/10.18421/TEM132-55

Hair J, Hult GT, Ringle CM, Sarstedt M (2021) A primer on partial least squares structural equation modeling (PLS-SEM), 3rd edn. Sage Publications

Hair JF, Babin BJ, Black W, Anderson RE (2010) Multivariate data analysis: a global perspective, 7th edn. Pearson, New York

Harsasi M, Mulyana A, Mutmainah I et al. (2023) Small and medium enterprises (SMES) perceptions of drivers and barriers to e-commerce adoption. Proc Int Semin Bus Econ Soc Sci Technol 3:341–350. https://doi.org/10.33830/isbest.v3i1.1756

Haryanti T, Subriadi AP (2020) Factors and theories for E-commerce adoption: a literature review. Int J Electron Commer Stud 11:87–105. https://doi.org/10.7903/IJECS.1910

Hasani T, Rezania D, Levallet N et al. (2023) Privacy enhancing technology adoption and its impact on SMEs' performance. Int J Eng Bus Manag 15:1–26. https://doi.org/10.1177/18479790231172874

Henseler J, Ringle CM, Sinkovics RR (2009) The use of partial least squares path modeling in international marketing. pp 277–319

Herzallah F, Mukhtar M (2016) The impact of percieved usefulness, ease of use and trust on managers' acceptance of e-commerce services in small and medium-sized enterprises (SMEs) in Palestine. Int J Adv Sci Eng Inf Technol 6:922. https://doi.org/10.18517/ijaseit.6.6.1377

Himawan EN, Djuwaini A, Putra AD (2024) Adoption of e-commerce in small and medium-sized enterprises in Bogor District. Int J Sci Technol Manag 5:211–219. https://doi.org/10.46729/ijstm.v5i1.1050

Hoang TDL, Nguyen HK, Nguyen HT (2021) Towards an economic recovery after the COVID-19 pandemic: empirical study on electronic commerce adoption of small and medium enterprises in Vietnam. Manag Mark Chall Knowl Soc 16:47–68. https://doi.org/10.2478/mmcks-2021-0004

Hong D, Cho C-H (2023) Factors affecting innovation resistance of smartphone AI voice assistants. Int J Hum Comput Interact 39:2557–2572. https://doi.org/10.1080/10447318.2022.2080899

Indiani NLP, Amerta IMS, Sentosa I (2024) Exploring the moderation effect of consumers' demography in the online purchase behavior. Cogent Bus Manag 11. https://doi.org/10.1080/23311975.2024.2393742

International Monetary Fund (2024) Indonesia. IMF Staff Ctry Reports 2024:1. https://doi.org/10.5089/9798400284663.002

Jennex ME, Amoroso D, Adelakun O (2004) E-commerce infrastructure success factors for small companies in developing economies. Electron Commer Res 4:263–286. https://doi.org/10.1023/B:ELEC.0000027983.36409.d4

Jin Q, Raza SH, Mahmood N et al. (2022) Exploring influence of communication campaigns in promoting regenerative farming through diminishing farmers' resistance to innovation: an innovation resistance theory perspective from Global South. Front Psychol 13:1–15. https://doi.org/10.3389/fpsyg.2022.924896

Karim S, Gide E (2018) Barriers to adopting E-commerce with small to midsized enterprises-SMEs in developed countries: an exploratory study in Australia. Glob J Inf Technol Emerg Technol 8:24–36. https://doi.org/10.18844/gjit.v8i1.3438

Khsroo ITN, Burhanuddin M, Ali MA, Shihab Ahmed M (2024) The influence of technological factors on adoption E-commerce in SME: the role of trust. J Glob Inf Technol Manag 27:148–167. https://doi.org/10.1080/1097198X.2024.2327945

Kinkani BH-L, Tumana ML, Gerendawele NH (2024) A study on the influencing factors of e-commerce adoption among small medium enterprises in Democratic Republic of the Congo. Int J Small Bus Entrep Res 12:125–148. https://doi.org/10.37745/ijsber.2013/vol12n2125148

Kwarteng MA, Ntsiful A, Diego LFP, Novák P (2024) Extending UTAUT with competitive pressure for SMEs digitalization adoption in two European nations: a multi-group analysis. Aslib J Inf Manag 76:842–868. https://doi.org/10.1108/AJIM-11-2022-0482

Lee S (2013) An integrated adoption model for e-books in a mobile environment: evidence from South Korea. Telemat Inform 30:165–176. https://doi.org/10.1016/j.tele.2012.01.006

Lestari ED, Abd Hamid N, Shamsuddin R et al. (2024) Investigating the factors of SMEs' business resilience in the post-pandemic crisis of COVID-19 with technology adoption as a quasi-moderator: a multigroup analysis of Indonesian and Malaysian SMEs. Cogent Bus Manag 11. https://doi.org/10.1080/23311975.2023.2301135

Lim SC, Lim SP, Trakulmaykee N (2018) An empirical study on factors affecting e-commerce adoption among SMEs in west Malaysia. Manag Sci Lett 381–392. https://doi.org/10.5267/j.msl.2018.4.008

Loo MK, Ramachandran S, Raja Yusof RN (2024) Systematic review of factors and barriers influencing e-commerce adoption among SMEs over the last decade: a TOE framework perspective. J Knowl Econ. https://doi.org/10.1007/s13132-024-02257-5

Mapeshoane TJ, Pather S (2016) The adoption of E-commerce in the Lesotho tourism industry. Electron J Inf Syst Dev Ctries 75:1–24. https://doi.org/10.1002/j.1681-4835.2016.tb00550.x

Matsuo M, Minami C, Matsuyama T (2018) Social influence on innovation resistance in internet banking services. J Retail Consum Serv 45:42–51. https://doi.org/10.1016/j.jretconser.2018.08.005

Mensah IK, Wang R, Gui L, Wang J (2023) Exploring the elements influencing the behavioral adoption of e-commerce by chinese small and medium enterprises (SMEs). Inf Dev 39:679–698. https://doi.org/10.1177/02666669211048486

Migliore G, Wagner R, Cechella FS, Liébana-Cabanillas F (2022) Antecedents to the adoption of mobile payment in China and Italy: an integration of UTAUT2 and innovation resistance theory. Inf Syst Front 24:2099–2122. https://doi.org/10.1007/s10796-021-10237-2

Misra R, Mahajan R, Singh N et al. (2022) Factors impacting behavioural intentions to adopt the electronic marketplace: findings from small businesses in India. Electron Mark 32:1639–1660. https://doi.org/10.1007/s12525-022-00578-4

Moghawemi S, Mohd Salleh NA, Zhao W, Mattila M (2012) The entrepreneur's perception on information technology innovation adoption: an empirical analysis of the role of precipitating events on usage behavior. Innov Manag Policy Pr 14:231–246. https://doi.org/10.5172/impp.2012.14.2.231

Moorthy K, Suet Ling C, Weng Fatt Y et al. (2017) Barriers of mobile commerce adoption intention: perceptions of generation X in Malaysia. J Theor Appl Electron Commer Res 12:37–53. https://doi.org/10.4067/S0718-18762017000200004

Murray DM (1998) Design and analysis of group-randomized trials. Oxford University Press

Muslim, Sandhyaduhita PI (2016) Supporting and inhibiting factors of e-commerce adoption: exploring the sellers' side in Indonesia. In: 2016 International conference on advanced computer science and information systems (ICACSIS). IEEE, pp 207–214

Musyaffi AM, Gurendrawati E, Afriadi B et al. (2022) Resistance of traditional SMEs in using digital payments: development of innovation resistance theory. Hum Behav Emerg Technol 2022. https://doi.org/10.1155/2022/7538042

Najib M, Ermawati WJ, Fahma F et al. (2021) Fintech in the small food business and its relation with open innovation. J Open Innov Technol Mark Complex 7. https://doi.org/10.3390/joitmc7010088

Nazir MA, Roomi MA (2021) Barriers to adopting electronic commerce for small and medium-sized enterprises in emerging economies. EMAJ Emerg Mark J 10:43–55. https://doi.org/10.5195/emaj.2020.203

Nguyen CQ, Nguyen AM-T, Tran P (2024) Assessing the critical determinants of cross-border E-commerce adoption intention in Vietnamese small and medium-sized enterprises: PLS-SEM algorithm approach. J Open Innov Technol Mark Complex 10:100257. https://doi.org/10.1016/j.joitmc.2024.100257

Ocampo L, Alarde RMB, Kilongkilong DA, Esmero A (2017) Adoption of online marketing for service SMEs with multi-criteria decision-making approach. pp 226–243

Pobee F (2021) Modeling the factors that influence Ghanaian entrepreneurs to adopt e-commerce. Int J Innov Technol Manag 18. https://doi.org/10.1142/S0219877021500292

Podsakoff PM, MacKenzie SB, Lee JY, Podsakoff NP (2003) Common method biases in behavioral research: a critical review of the literature and recommended remedies. J Appl Psychol 88:879–903. https://doi.org/10.1037/0021-9010.88.5.879

Praswati AN, Sukresna IM, Muna N, Muna N (2024) The adoption of business-to-consumer commerce for small and medium enterprises growth. Uncertain Supply Chain Manag 12:2051–2062. https://doi.org/10.5267/j.uscm.2024.2.001

Pu L, Radics RI, Umar M, Quan Z (2024) Investigating how Chinese e-commerce SMEs would adopt AI live-streaming via a dual analysis: trendy and transformative. J Organ End Use Comput 36:1–22. https://doi.org/10.4018/JOEUC.349934

Rafinda A, Rauf BR, Hewiyanti E (2024) Analysis of factors affecting intention to use Fintech & e-commerce for SMEs. J Ris Akunt Dan Bisnis Airlangga 9:62–73. https://doi.org/10.20473/jraba.v9i1.57051

Ram S, Sheth JN (1989) Consumer resistance to innovations: the marketing problem and its solutions. J Consum Mark 6:5–14. https://doi.org/10.1108/EUM0000000002542

Ray A, Bala PK, Dwivedi YK (2022) Exploring barriers affecting e-health service continuance intention in India: from the innovation resistance theory stance. Asia Pac J Inf Syst 32:890–915. https://doi.org/10.14329/APJIS.2022.32.4.890

Reuters (2023) Access all areas – European SMEs and Malaysia. https://www.reuters.com/plus/access-all-areaseuropean-smes-and-malaysia

Rogers EM (2003) Diffusion of innovations, 5th edn. Free Press, New York

Salah OH, Ayyash MM (2024) E-commerce adoption by SMEs and its effect on marketing performance: an extended of TOE framework with ai integration, innovation culture, and customer tech-savviness. J Open Innov Technol Mark Complex 10:100183. https://doi.org/10.1016/j.joitmc.2023.100183

Santoso DR, Handayani PW, Azzahro F (2022) The resistance to adopting online marketplace: the influence of perceived risk and behavioral control of small and medium enterprises in Indonesia. Commun Inf Technol J 16:53–68. https://doi.org/10.21512/commit.v16i1.7858

Sarfo CA, Song H (2021) E-commerce adoption within SME's in Ghana, a tool for growth. Int J Electron Bus 16:32. https://doi.org/10.1504/IJEB.2021.112764

Sastika W, Kusumahadi K, Hanifa FH, Marcelino D (2023) E-commerce website quality: usability, information, service interaction & visual quality on customer satisfaction. In: 2023 11th international conference on cyber and IT service management (CITSM). IEEE, pp 1–7

Satar MS, Alarifi G (2022) Factors of e-business adoption in small and medium enterprises: evidence from Saudi Arabia. Hum Behav Emerg Technol 2022:1–13. https://doi.org/10.1155/2022/2445624

Setiyani L, Yeny Rostiani (2021) Analysis of e-commerce adoption by SMEs using the technology - organization - environment (TOE) model: a case study in Karawang, Indonesia. Int J Sci Technol Manag 2:1113–1132. https://doi.org/10.46729/ijstm.v2i4.246

Setyowati N, Masyhuri M, Mulyo JH, Irham I (2024) Motivational factors and the impact of e-commerce adoption on business performance: evidence from traditional drink SMEs in Indonesia. Int J Data Netw Sci 8:1689–1700. https://doi.org/10.5267/j.ijdns.2024.2.018

Shahadat MMH, Nekmahmud M, Ebrahimi P, Fekete-Farkas M (2023) Digital technology adoption in SMEs: what technological, environmental and organizational factors influence in emerging countries? Glob Bus Rev. https://doi.org/10.1177/09721509221137199

Shahzad A, Azuan MS, Kotzab H et al. (2023) Adoption of fourth industrial revolution 4.0 among Malaysian small and medium enterprises (SMEs). Humanit Soc Sci Commun 10:693. https://doi.org/10.1057/s41599-023-02076-0

Shahzad A, Keong CH, Altaf M, Anwar F (2020) Malaysian SMEs performance and the use of E-commerce: a multi-group analysis of click-and-mortar and pure-play E-retailers. Pak J Commer Soc Sci 14:1–33

Sombultawee K (2020) Antecedents and consequences of e-commerce adoption for SMEs. Kasetsart J Soc Sci. https://doi.org/10.34044/j.kjss.2020.41.2.05

Soong KK, Ahmed EM, Tan KS (2020) Factors influencing Malaysian small and medium enterprises adoption of electronic government procurement. J Public Procure 20:38–61. https://doi.org/10.1108/JOPP-09-2019-0066

Subramaniam R, Palakeel P, Arunmozhi M et al. (2024) Factors driving business intelligence adoption: an extended technology-organization-environment framework. Indones J Electr Eng Comput Sci 34:1893–1903. https://doi.org/10.11591/ijeecs.v34.i3.pp1893-1903

Ta VA, Lin CY (2023) Exploring the determinants of digital transformation adoption for SMEs in an emerging economy. Sustainability 15:1–13. https://doi.org/10.3390/su15097093

Thaha AR, Maulina E, Muftiadi RA, Alexandri MB (2022) TOE factors and value chain effects of e-business adoption on SMEs. Uncertain Supply Chain Manag 10:1029–1036. https://doi.org/10.5267/j.uscm.2022.2.009

Tornatzky LG, Fleischer M (1990) The processes of technological innovation. Lexington Books

Triandini E, Wijaya IGNS, Suniantara IKP (2023) Analysis of technology adoption by SMEs using technology organization environment model. J Syst Manag Sci 13:225–240. https://doi.org/10.33168/JSMS.2023.0216
Urban B, van der Putten WF (2023) The importance of e-commerce adoption to boost small enterprise growth in the South African tourism industry. Int J Entrep Small Bus 50:1–22. https://doi.org/10.1504/IJESB.2023.133479
Venkatesh V, Morris MG, Davis GB, Davis FD(2003) User acceptance of information technology: toward a unified view MIS Q 27:425. https://doi.org/10.2307/30036540
Wang YL (2024) Technophilia or technophobia: the unified model of the paradox of Taiwanese older adults' digital learning. Universal Access in the Information Society. https://doi.org/10.1007/s10209-024-01184-1
Yap B (2023) How private and SME businesses can thrive under the Malaysia MADANI roadmap. https://www.ey.com/en_my/insights/tax/how-private-and-sme-businesses-can-thrive-under-the-malaysia-madani-roadmaps
Yoon C (2024) Factors affecting the adoption of digital marketing in non-profit organizations: an empirical study. Adm Sci 14. https://doi.org/10.3390/admsci14010010
Yurivito B (2024) Tujuh Tahun Mendukung Usaha Mikro Bertumbuh: Evaluasi dan Tantangan. Kompas
Zabri MS (2024) Factors affecting digitalization acceptance among micro, small and medium enterprises in Malaysia. PaperASIA 40:151–156. https://doi.org/10.59953/paperasia.v40i4b.208
Zian LQ, Zulkarnain NZ, Kumar YJ (2024) Challenges in big data adoption for Malaysian organizations: a review. Indones J Electr Eng Comput Sci 33:507–517. https://doi.org/10.11591/ijeecs.v33.i1.pp507-517

Author contributions

NLPI was responsible for the study conception, design, drafting of the paper, analysis and interpretation of the data, KSJS was responsible for the study conception and paper proofreading, NIW was responsible for the survey administration in Indonesia and GSA was responsible for the survey administration in Malaysia. These authors contributed equally to this work.

Competing interests

The authors declare no competing interests.

Ethical approval

This study was approved by the Directorate of Research and Community Service of Warmadewa University (Approval Number: 328/UNWAR/DPPM/PD-13/2024), granted in April 2024. All procedures involving human participants were performed in accordance with the ethical standards of the institutional research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. The scope of the approval covered the research design, instrument development, questionnaire distribution, and data collection stages involving human subjects.

Informed consent

Written informed consent was obtained from all participants via the questionnaire prior to their involvement in the study. The research team provided clear and comprehensive information regarding the objectives of the study, procedures involved, the voluntary nature of participation, the right to withdraw at any time without consequence, and the assurance of anonymity and confidentiality. Participants were informed that their data would be used solely for academic research purposes and that no personally identifying information would be collected or disclosed.

Additional information

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