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Factors influencing digital technology adoption for the sustainable growth of SMEs in Thailand

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ABSTRACT

Small and Medium Enterprises (SMEs) are essential to Thailand's economic growth, making up 99.8% of all businesses in the country. This study explores the main factors that affect the sustainable growth of digital technology adoption among Thai SMEs. A mixed-methods approach was used, combining qualitative data from the Rough Set Delphi method with 20 industry experts and quantitative data from a survey of 848 SME owners. The study focuses on eight key factors: social media usage, service quality, attitude, perceived behavioral control, subjective norms, satisfaction, intention to use, and actual usage behavior. The results show that attitude has the strongest impact on sustainable growth, followed by intention to use. Subjective norms, perceived behavioral control, and satisfaction are equally important. Experts agreed that social media plays a key role in improving customer relationships and collecting useful data. These findings offer useful guidance for policymakers and business support agencies to design effective strategies that help Thai SMEs adopt digital technologies more successfully.

1. Introduction

The digital landscape has become an essential driver of global economic development, with Small and Medium-sized Enterprises (SMEs) playing a crucial role in this transformative process. SMEs significantly contribute to employment, innovation, and overall economic growth, making digital transformation a top priority. At the same time, digital technologies are reshaping traditional business models and fundamentally changing established commercial practices (Raji et al., 2024). In Thailand, SMEs serve as a vital mechanism driving the country's socio-economic development. According to the Office of Small and Medium Enterprises Promotion's 2018 data, 3,046,793 SMEs represent 99.8% of all enterprises nationwide. These businesses were distributed across three main sectors: 1,268,202 in trading, 1,206,759 in services, and 571,828 in manufacturing (Potjanajaruwit, 2023). The COVID-19 pandemic and subsequent lockdowns severely disrupted SMEs' traditional business operations, particularly face-to-face activities (Giones et al., 2020). This crisis accelerated digital transformation in the "New Economy" era, compelling SMEs to adopt new technologies while reshaping consumer behavior towards digital platforms, especially in financial services. Consequently, SMEs must digitalize their operations to maintain customer connections, leverage data analytics, and embrace new digital platforms that enhance their business capabilities and support sustainable growth (Phimolsathien, 2022).

A review of the existing literature indicates that digital marketing is a crucial tool that helps SMEs overcome marketing and advertising challenges (Zamri et al., 2024). It enables them to compete with larger companies and achieve their objectives, opening up new opportunities and enhancing their ability to face difficulties.

Previous research suggests that SMEs use digital marketing to improve customer service, increase customer satisfaction, and increase overall business growth. However, studies focused on developing countries reveal that many SMEs remain hesitant to adopt digital technologies for their business activities compared to their larger counterparts (Díaz-Arancibia et al., 2024). Despite the high demand from today's consumers, SMEs often lack confidence and do not fully leverage the potential of digital marketing (Abraham et al., 2022; Opoku et al., 2024), especially in developing nations.

Additionally, research on the behavioral intention to adopt digital marketing among SMEs is still in its

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early stages (Frimpong et al., 2022; Hamid and Aliman, 2020), and there is a lack of sufficient studies addressing SMEs' use of digital marketing (Hakimi et al., 2023). Moreover, few studies connect digital marketing adoption to SMEs' sustainable growth, specifically in developing country contexts (Bruce et al., 2023). Therefore, there is a pressing need for further research to fill this knowledge gap.

2. Literature review and conceptual framework

2.1. Social media usage (SMU)

Social media usage has emerged as a critical strategic tool for SMEs' sustainable growth, enabling effective two-way communication between businesses and customers through various platforms (Belás et al., 2021). Research indicates that social media usage significantly impacts business performance by facilitating clear marketing strategies, enhancing customer engagement, and driving innovation through marketing intelligence (Bruce et al., 2023). Studies particularly emphasize its importance in developing countries, where social networking sites, blogs, forums, and review communities are vital platforms for business collaboration (Marolt et al., 2022). Through these digital platforms, businesses can effectively build customer relationships and expand their market reach while fostering sustainable growth (Emmanuel et al., 2022).

2.2. Service quality (SQ)

Service quality, defined as the ability to meet or exceed customer expectations (Kankam, 2023). Service quality is crucial in determining customer satisfaction throughout the transaction, from initial search to final delivery (Jasin and Firmansyah, 2023). Service quality is a vital strategic factor for companies in the service sector. It represents the characteristics of product performance that foster sustainable excellence and drive growth in market leadership (Jasin et al., 2023). Service quality is defined by the comparison between the expected level of service and the actual level of service perceived by customers (Martha et al., 2023).

2.3. Attitude (ATT)

Attitude focuses on utilizing popular platforms like Facebook, Twitter, and YouTube to promote brands and facilitate personalized interactions between consumers and sellers (Zhang and Landicho, 2024). Social media marketing transforms traditional promotion by making consumers active participants who engage in viral advertising and peer-to-peer communication. This enables businesses to achieve a broader reach while customers become brand ambassadors (Mehta, 2024). Attitude reflects an individual's overall evaluation of ideas or products, developing gradually through various influences (Srivastava and Rojhe, 2021). Attitude, which reflects an individual's assessment of specific behaviors, is a crucial factor in determining behavioral intentions. In the realm of SMEs and digital marketing, research indicates that the attitudes, skills, and motivation of owners play a significant role in the successful adoption and implementation of technology (Bruce et al., 2023).

2.4. Perceived behavioral control (PBC)

Perceived behavioral control is a key predictor of behavior, representing individuals' assessment of their capacity and resources to execute specific actions (Yu, 2024). In the SMEs context, it reflects owner-managers' evaluation of their ability to implement practices using both monetary and non-monetary resources (Latip and Sharkawi, 2021). Research shows that when individuals possess both confidence and necessary resources, they are more likely to act on their intentions, though its influence varies across different contexts (Galván-Mendoza et al., 2022).

2.5. Subjective norms (SN)

Subjective norms represent the perceived social pressure from reference groups that influences behavioral decisions. This includes pressure from various stakeholders, such as peers, superiors, and the media, which shapes individual behavior through normative beliefs and ethical standards (Ganat, 2024). Subjective norms represent the social pressures and normative beliefs influencing entrepreneurs' decisions regarding business development based on their social environment's perception of growth importance. Subjective norm refers to the perceived social pressure to engage in behavior based on how others would view that behavior. It influences attitudes, satisfaction, and perceived usefulness regarding technology use (Mushi, 2022). Subjective norms refer to the perceived social pressure to engage in behavior based on beliefs about how important others consider it (Alhamami, 2020).

2.6. Satisfaction (SAT)

Satisfaction is predominantly conceptualized as an affective construct, with numerous scholars defining it as an emotional response to consumption experiences. This affective nature is evidenced by the intense emotional traces left in consumers' memories that influence their evaluation of service encounters (Spreng et al., 2009). Satisfaction is a psychological state influenced by expectation confirmation and evaluations after consumption. The pleasure and arousal aspects of service experiences significantly affect satisfaction levels (Rasoolimanesh et al., 2022). Satisfaction is fundamentally a subjective evaluation of service fulfillment based on service quality dimensions

(Zygiaris et al., 2022). Satisfaction with the company's products and services enhances customers' belief in product quality (Khan et al., 2022).

2.7. Intention to use (ITU)

Intention to use indicates the user's readiness or likelihood to exhibit usage behavior (Kankam, 2023). It is a motivating factor influencing behavior and indicates the extent of an individual's effort to perform a behavior. The greater the intention and effort, the more likely the behavior will be performed (Fishman et al., 2020). Latip and Sharkawi (2021) defined intention as focusing attention, which is a decision to choose or act in a particular way with a clear direction and purpose towards the desired object, expressing attitudes or beliefs about it. This behavioral intention serves as a crucial predictor of actual behavior in technology adoption contexts. In addition, performance expectancy, or the belief that using technology will improve work performance, has been identified as a significant factor affecting intention to use. Research indicates that individuals are more likely to adopt a technology if they perceive that it will benefit their work or daily activities (Aminah et al., 2024).

2.8. Use behavior (UB)

Use behavior is behavioral intention, which is a critical predictor of actual behavior, particularly in contexts of technology adoption. Research consistently demonstrates that intention acts as a key determinant driving individuals' decisions to accept and use technological innovations, including social media engagement (Bruce et al., 2023). However, while intention to use is an important indicator of actual use behavior, the transition from intention to use to use behavior also depends on other factors, such as user experience, organizational support, or access to resources that facilitate use. These factors can either encourage or hinder the adoption of a technology in practice. In SMEs and Social Media Marketing, actual usage behavior plays a crucial role in marketing effectiveness, competitiveness, and business growth. SMEs' effective adoption of digital technologies depends on the level of entrepreneurs' digital competence, appropriate training, and strategic support from stakeholders. Furthermore, actual usage behavior is not limited to the initiation of technology adoption but also includes the continuity of use and application to produce valuable results. This means that use behavior is about experimenting with technology and integrating it into the organization's work processes. SMEs that can develop use behavior at a sustainable level are more likely to succeed in digital transformation and maintain their competitiveness in the long run (Shahreki and Lee, 2024).

This research examines the composition of Sustainability Factors in Digital Technology SMEs in Thailand. The study consists of eight key variables: 1) social media usage, 2) service quality, 3) attitude, 4) perceived behavioral control, 5) subjective norms, 6) satisfaction, 7) intention to use, and 8) use behavior, as shown in Fig. 1.

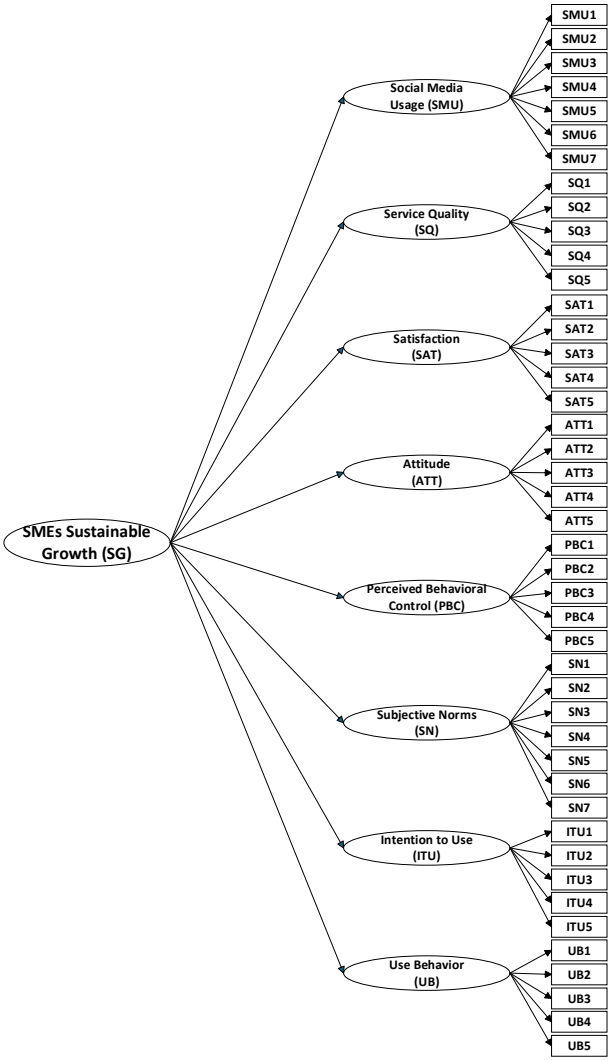

Fig. 1: Study's model

3. Research methodology

This study adopts a mixed-methods research design, incorporating qualitative and quantitative data analyses. The study protocol was reviewed and approved by the Ethics Review Board of Rangsit University, Thailand (COA No. RSUERB2024-106). The methodological framework for analyzing qualitative and quantitative research is presented as shown in Fig. 2.

3.1. Phase I: Qualitative research

3.1.1. Sample

The study employed purposive sampling to select 20 experts, divided into three groups of seven participants each: (1) government and private sector representatives involved in entrepreneurship development, (2) university professors specializing in entrepreneurship development, and (3) successful

small and medium-sized enterprise (SMEs) owners operating in the digital business sector. These 20 experts met the methodological criteria in Macmillan (1971), which stated that studies using 17 or more experts have little error, with an error rate of 0.02. Grouping these experts provided a comprehensive perspective, combining policy insights, academic knowledge, and real-world experience in Thai digital SMEs.

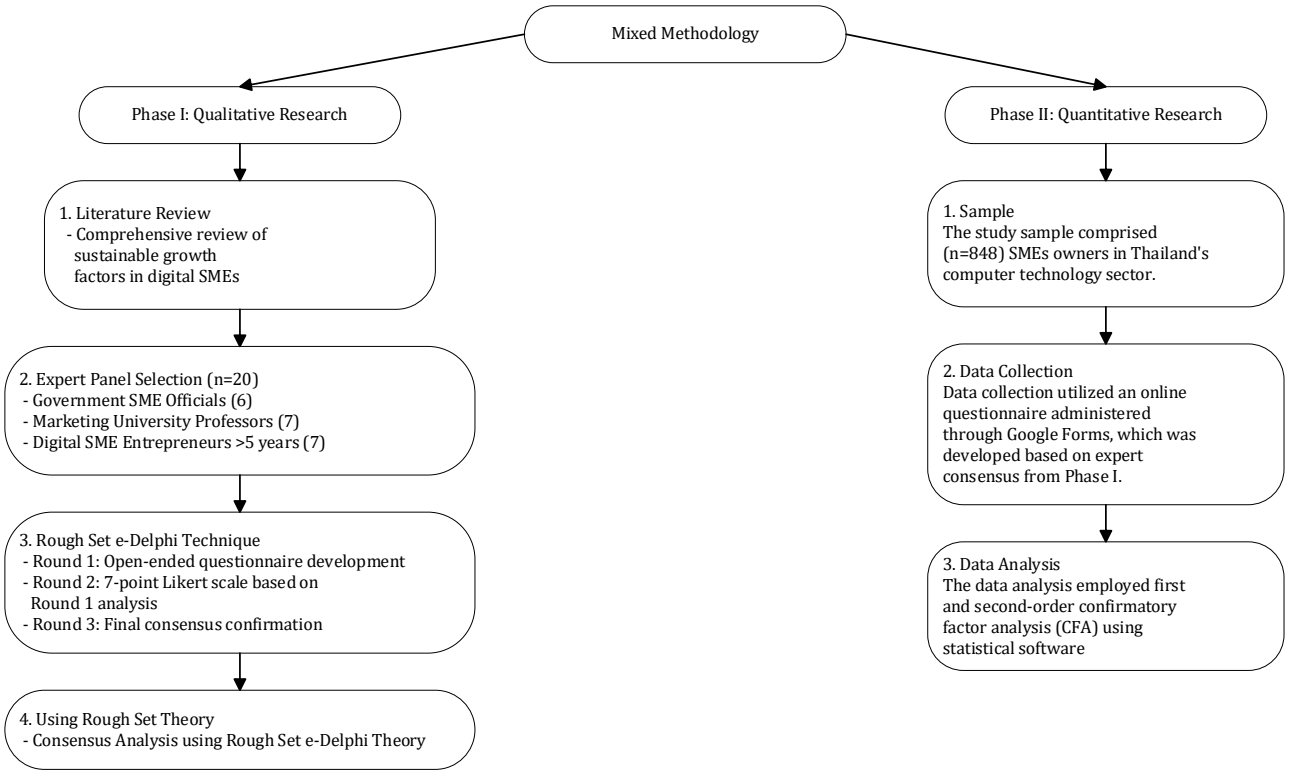

Fig. 2: Mixed-methodology research framework

3.1.2. Research instrument

The research instrument was designed based on a systematic review of the literature to ensure its validity and reliability. The questionnaire included both open-ended and closed-ended questions. The structured section measured eight key constructs: social media usage (7 items), service quality (5 items), attitude (5 items), perceived behavioral control (5 items), subjective norms (7 items), satisfaction (5 items), intention to use (5 items), and use behavior (5 items). Multiple items were used for each construct to address the limitations of single-item measurements. All closed-ended questions were rated using a 7-point Likert scale (1 = strongly disagree to 7 = strongly agree).

3.1.3. Data collection

The study employed a three-round e-Delphi approach with 20 experts from September to November 2024. The first round used open-ended questions via Google Forms to validate initial constructs. The second round featured a 7-point Likert scale assessment of 44 indicators across eight dimensions. The final round incorporated expert validation using Rough Set consensus measurement to ensure the reliability and validity of the proposed framework.

3.1.4. Data analysis

The study employed the Rough Set Delphi technique for data analysis in evaluating sustainable growth factors for digital technology adoption among Thai SMEs. Rough Set Theory, a contemporary mathematical approach to set theory and uncertainty management, effectively handles ambiguity in expert opinions through a systematic dual approximation system (Chairaksa and Pankham, 2023). The methodology utilizes two key approximation concepts. The Lower Approximation $\{x \in U: [x]R \subseteq X\}$ represents complete expert consensus, indicating unanimous agreement on critical digital transformation factors (scores 5–7). The Upper Approximation $\{x \in U: [x]R \cap X \neq \emptyset\}$ encompasses broader interpretations and varying levels of expert assessments, providing a comprehensive view of expert opinions. Typically, when experts reach a consensus by analyzing data in the third round using the average, interquartile technique, the rough set component and data from both the second and third rounds are utilized to achieve consensus. This approach results in more detailed and accurate outcomes. The decision-making framework employs a three-tier evaluation system specifically designed for the SME context. Responses are classified as full agreement (d = 1) when experts consistently rate factors between 5–7,

complete disagreement (d = 0) for ratings of 1–4, and partial disagreement (d = 2) for mixed or uncertain evaluations. The consensus validation uses the Quality Lower Approximation (QL) metric, calculated as the ratio of agreeing experts to total participants, with results presented in Table 1.

Table 1: Consensus measurement criteria for expert group using rough set theory

Consensus measurement	Criteria
QL	QL < 0.75: No consensus achieved among expert group QL ≥ 0.75: Consensus achieved among expert group

3.2. Phase II: Quantitative research

3.2.1. Sample

The study sample included 848 owners of SMEs in the computer technology sector in Thailand, selected using simple random sampling. According to Kline (2023), the sample size should be 10 to 20 times the number of observed variables. Hoelter (1983) also recommended a minimum of 200 participants to ensure a good fit for structural equation modeling with real data. The sample represented two main SME sectors: 65.6% were involved in commerce (wholesale and retail), and 34.4% operated in the services sector. This distribution offers sectoral diversity, supporting more reliable findings on digital technology adoption among different types of SMEs.

3.2.2. Research instrument

The quantitative survey instrument was developed based on the qualitative findings and comprised eight constructs with 44 total items. Social media usage (7 items), Service quality (5 items), Satisfaction (5 items), Attitude (5 items), Perceived behavioral control (5 items), Subjective norms (7 items), Intention to use (5 items), and Use behavior (5 items). All measurements utilized a 7-point Likert scale ranging from strongly disagree (1) to strongly agree (7).

3.2.3. Data collection

The quantitative data collection was conducted through online surveys targeting computer technology SME owners in Thailand from December 2024 to January 2025. A screening question verified respondent eligibility. The survey collected 848 valid responses after data cleaning and verification. The demographic data included business characteristics and owner profiles. Rigorous data quality procedures were implemented before statistical analysis.

3.2.4. Data analysis

The data was analyzed using first and second-order confirmatory factor analysis through a statistical software (Abd Halim and Ismail, 2023). The parameters were estimated using maximum likelihood (ML) estimation. To evaluate the construct validity of the key factors influencing sustainable growth in digital technology adoption among Thai SMEs, multiple fit indices were utilized, including the Chi-square statistic ($\chi 2$), relative chi-square (CMIN/df ≤ 3), goodness of fit index (GFI ≥ 0.9), adjusted goodness of fit index (AGFI ≥ 0.9), comparative fit index (CFI ≥ 0.9), incremental fit index (IFI ≥ 0.9), Tucker-Lewis index (TLI ≥ 0.9), root mean square error of approximation (RMSEA ≤ 0.08), and root mean square residual (RMR ≤ 0.08). These comprehensive model fit criteria helped assess the alignment between the empirical data and the theoretical model.

4. Results

The consensus analysis using the Rough Set Theory showed unanimous agreement among all 20 experts regarding the sustainability factors for digital SMEs. The QL values were consistently above the threshold of 0.75 across all three expert groups: Seven government and private sector representatives, seven university professors specializing in entrepreneurship development, and seven successful digital SME entrepreneurs. This high level of consensus (QL ≥ 0.75) validates the identified factors as essential components for measuring sustainable growth in Thailand's digital technology SMEs. Key consensus elements as shown in Table 2. The strong agreement among various expert groups enhances the content validity of the factors selected for the following quantitative analysis.

First–order confirmatory factor analysis: The results of the first-order confirmatory factor analysis (CFA) showed that all constructs had high factor loadings and good internal consistency, as presented in Fig. 3. Convergent validity was assessed by checking whether the items had significantly high loadings on their respective factors, suggesting they measure the same underlying concept. According to Hair (2011), standard loading values should be at least 0.5, with values above 0.7 considered ideal. As shown in Table 3, each construct met acceptable standards for internal consistency and convergent validity.

Second–order confirmatory factor analysis: A second-order confirmatory factor analysis was conducted to assess the structure of sustainable growth in digital technology adoption among Thai SMEs. The model revealed different factor loadings, with ATT (Attitude) having the highest at 0.88, followed by ITU (Intention to Use) at 0.86. SN, PBC, and SAT (Satisfaction) each had loadings of 0.85. These standardized coefficients indicate strong links between the underlying variables and their observed indicators, supporting the hierarchical model of digital technology adoption. Fig. 4 illustrates the validated structure through the strong factor loadings.

Table 2: Expert consensus assessment through rough set e-Delphi: Analysis from 20 key industry specialists

	Key consensus elements	QL	Result
	Social media usage		
SMU1	You consistently use social media to attract new customers.	0.90	Consensus
SMU2	You use social media to enhance your company's image.	0.95	Consensus
SMU3	You effectively promote products through social media.	0.90	Consensus
SMU4	You respond quickly to customer inquiries via social media.	0.90	Consensus
SMU5	You use social media to improve customer experience.	1.00	Consensus
SMU6	You collect customer data through social media.	1.00	Consensus
SMU7	You build ongoing customer relationships via social media.	0.95	Consensus
	Service quality		
SQ1	You provide accurate product information via social media.	0.95	Consensus
SQ2	You deliver complete product details through social media.	0.95	Consensus
SQ3	You respond promptly to customer needs via social media.	1.00	Consensus
SQ4	You use social media admins who sell products to care about providing service and answering questions.	1.00	Consensus
SQ5	You use social media to provide good after-sales services, such as product warranties.	1.00	Consensus
	Satisfaction		
SAT1	You are satisfied with social media that facilitates selling products.	1.00	Consensus
SAT2	You are satisfied with social media that helps in providing product information quickly.	0.95	Consensus
SAT3	You appreciate social media for its ability to compare a wide range of products.	1.00	Consensus
SAT4	You are happy with social media that has a secure payment system.	1.00	Consensus
SAT5	You are satisfied with social media that provides more channels for customers to contact you.	1.00	Consensus
	Attitude		
ATT1	You have a good attitude towards social media marketing.	0.95	Consensus
ATT2	You always feel happy when you promote on social media.	0.95	Consensus
ATT3	You always feel rewarded when you advertise on social media.	0.95	Consensus
ATT4	You think using social media marketing is a good idea.	0.95	Consensus
ATT5	You always enjoy organizing promotional activities through social media.	0.90	Consensus
	Perceived behavioral control		
PBC1	You believe that your business will be successful using social media to sell your products.	0.95	Consensus
PBC2	You believe that running a business using social media is easy.	0.90	Consensus
PBC3	You have the knowledge and ability to use social media to sell products.	0.90	Consensus
PBC4	You can plan your social media marketing very well.	0.90	Consensus
PBC5	You are always learning new things about social media marketing.	0.90	Consensus
	Subjective norms		
SN1	You think your family has any influence on your social media business.	0.80	Consensus
SN2	You think your partners are contributing to your business using social media.	1.00	Consensus
SN3	You think the people around you have an impact on your business using social media.	0.95	Consensus
SN4	You think your successful business people are contributing to your business using social media marketing.	0.95	Consensus
SN5	You think your business competitors are contributing to your business using social media marketing.	0.95	Consensus
SN6	You think your customers are the reason your business uses social media.	1.00	Consensus
SN7	You think the advancement of computer technology has influenced your business to use social media.	1.00	Consensus
	Intention to use		
ITU1	You intend to use social media to run your business in the future.	0.95	Consensus
IUT2	You always intend to use social media to improve the quality of your service.	0.95	Consensus
ITU3	You always intend to use social media to reach your customers.	0.90	Consensus
ITU4	You intend to use social media to continuously expand your customer base.	0.90	Consensus
ITU5	You always intend to use social media to interact with your customers.	0.95	Consensus
	Use behavior		
UB1	You regularly use social media to promote your products.	0.95	Consensus
UB2	You are constantly using social media to promote your business.	0.95	Consensus
UB3	You use social media to increase the variety of channels you have to communicate with your customers.	1.00	Consensus
UB4	You are using social media to enhance your customer experience.	0.95	Consensus
UB5	You are using social media to collect more customer data.	1.00	Consensus

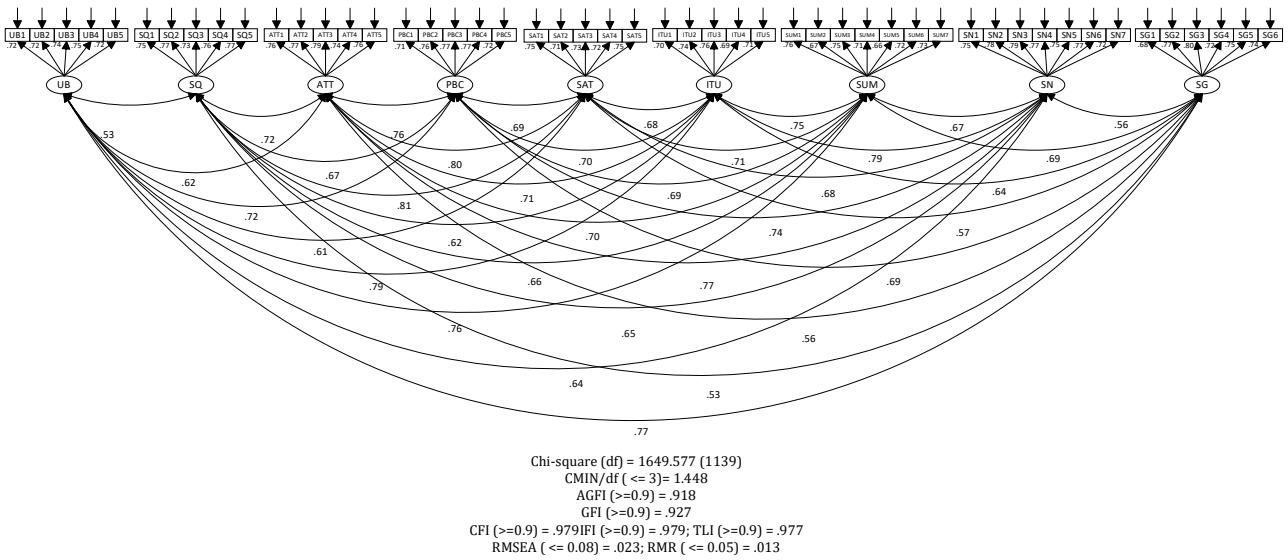

Fig. 3: First–order CFA of sustainability factors in digital technology SMEs in Thailand

Table 3: Assessment of internal consistency and convergent validity

Construct	Item	Factor loading (p < .001)	Cronbach's Alpha (≥ 0.7)	CR (≥ 0.7)	AVE (≥ 0.5)
Social media usage	SMU1	0.761	0.879	0.880	0.511
	SMU2	0.666			
	SMU3	0.752			
	SMU4	0.712			
	SMU5	0.659			
	SMU6	0.718			
	SMU7	0.731			
Service quality	SQ1	0.751	0.870	0.870	0.573
	SQ2	0.772			
	SQ3	0.731			
	SQ4	0.758			
	SQ5	0.771			
Attitude	ATT1	0.758	0.879	0.879	0.592
	ATT2	0.772			
	ATT3	0.790			
	ATT4	0.741			
	ATT5	0.785			
Perceived behavioral control	PBC1	0.708	0.862	0.863	0.557
	PBC2	0.762			
	PBC3	0.769			
	PBC4	0.774			
	PBC5	0.718			
Subjective norms	SN1	0.752	0.906	0.906	0.580
	SN2	0.781			
	SN3	0.787			
	SN4	0.775			
	SN5	0.745			
	SN6	0.766			
	SN7	0.723			
Satisfaction	SAT1	0.750	0.853	0.853	0.538
	SAT2	0.710			
	SAT3	0.734			
	SAT4	0.721			
	SAT5	0.750			
Intention to use	ITU1	0.696	0.843	0.843	0.519
	ITU2	0.740			
	ITU3	0.760			
	ITU4	0.695			
	ITU5	0.708			
Use behavior	UB1	0.722	0.852	0.852	0.535
	UB2	0.723			
	UB3	0.739			
	UB4	0.755			
	UB5	0.719			

The goodness-of-fit indices support the model's adequacy for both first– and second–order CFA models, as shown in Table 4.

5. Discussion

5.1. Theoretical implications

This study's findings provide important theoretical contributions to understanding digital technology adoption among Thai SMEs. The second-order confirmatory factor analysis revealed ATT as the most influential factor (0.88), followed by intention to use ITU at 0.86. At the same time, SN, PBC, and SAT showed equal importance (0.85). These findings align with and extend the TPB framework in several important ways.

The strong influence of attitude as the main predictor supports the core principle of the TPB proposed by Ajzen (1991), which highlights attitudes toward a behavior as key factors influencing behavioral intentions. In the context of Thai SMEs, owners' attitudes toward digital technologies and social media marketing show that personal evaluations play an important role in adoption decisions. This result not only supports the TPB framework but also extends its relevance to Thailand's digital transformation, where attitudes seem to have a particularly strong impact.

The high loading of intention to use (0.86) provides robust empirical support for TPB's position that behavioral intention is the immediate antecedent to actual behavior. This strong intention-behavior pathway in our model confirms that Thai SME owners' intentions to adopt digital technologies translate effectively into actual implementation. The strength of this relationship may reflect the accelerated digital transformation necessitated by the COVID-19 pandemic, which created urgency for converting intentions into actions among Thai SMEs.

Interestingly, our results show equal importance (0.85) for subjective norms, perceived behavioral control, and satisfaction. This finding provides a nuanced extension to traditional TPB, which often demonstrates varying weights for subjective norms and perceived behavioral control. The equal significance suggests a uniquely balanced influence pattern in the Thai SME context, where subjective norms and perceived behavioral control carry similar weight in technology adoption decisions. This balanced relationship may reflect Thailand's cultural position at the intersection of collectivist social values and growing entrepreneurial self-efficacy. Integrating satisfaction (0.85) alongside core TPB

constructs represents an important theoretical extension. While satisfaction is not a primary TPB component, its equal significance with subjective norms and perceived behavioral control suggests that experiential factors play an equally important role in sustaining digital technology adoption among Thai SMEs. This finding extends TPB by highlighting how post-adoption satisfaction feeds into the behavioral model, potentially reinforcing attitudes and intentions for continued use.

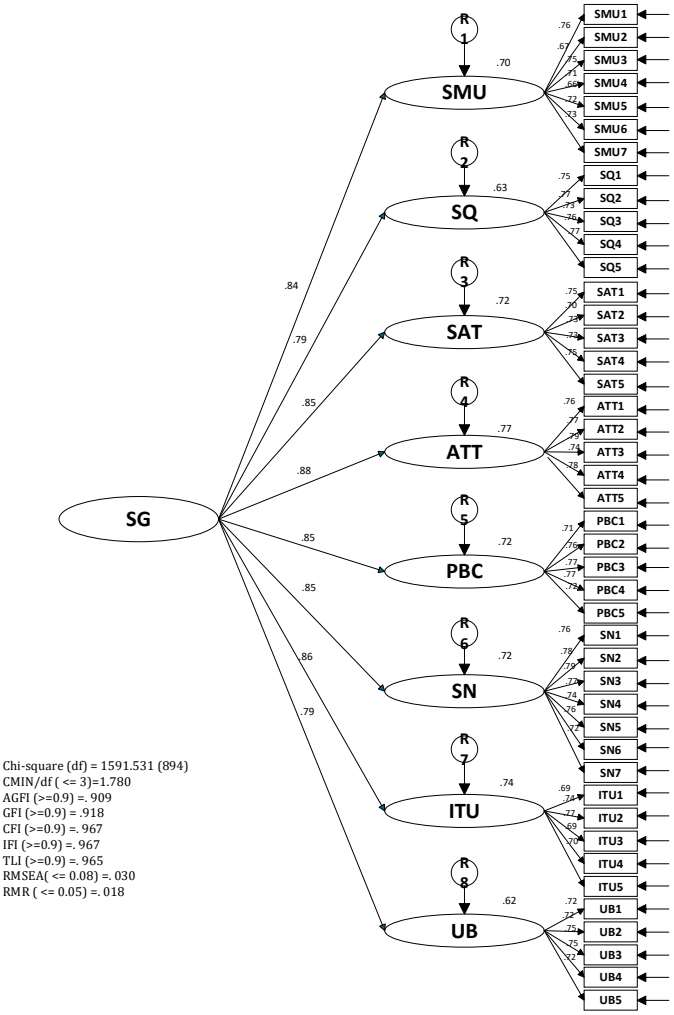

Fig. 4: A second–order CFA of sustainability factors in digital technology SMEs in Thailand

Table 4: Goodness of fit indices of the first–order CFA and second–order CFA

	CFA first-order	Approval	CFA second-order	Approval	Reference
Chi-square	1649.577	Yes	1591.531	Yes	
χ^2/df (≤ 3)	1.448	Yes	1.780	Yes	Kline (2023)
AGFI (≥ 0.9)	0.918	Yes	0.909	Yes	Tanaka and Huba (1985) and Schumacker and Lomax (2004)
GFI (≥ 0.9)	0.927	Yes	0.918	Yes	Jöreskog and Sörbom (1984)
CFI (≥ 0.9)	0.979	Yes	0.967	Yes	Hu and Bentler (1999)
IFI (≥ 0.9)	0.979	Yes	0.967	Yes	Bollen (1989)
TLI (≥ 0.9)	0.977	Yes	0.965	Yes	Schumacker and Lomax (2004)
RMSEA (≤ 0.08)	0.023	Yes	0.030	Yes	Schreiber et al. (2006)
RMR (≤ 0.05)	0.013	Yes	0.018	Yes	Schumacker and Lomax (2004)
Hoelter (> 200)	644	Yes	530	Yes	Hoelter (1983)

These findings collectively advance TPB's application to digital technology adoption by demonstrating the theory's effectiveness in explaining adoption behaviors among Thai SMEs while revealing contextual refinements specific to Thailand's unique business culture and digital transformation landscape.

5.2. Contradictions with prior literature

Our findings reveal notable contradictions with existing literature. While Belás et al. (2021) emphasized social media usage as the primary driver of business performance, our results indicate that psychological factors, precisely attitude, exert a more significant influence than technological usage. This challenges techno-centric perspectives in digital transformation literature and suggests that attitudinal factors may precede technological considerations within the Thai SME context.

The equal importance of subjective norms, perceived behavioral control, and satisfaction (all at 0.85) contradicts typical TPB applications, which often show varying strengths for these constructs.

Research in Western contexts frequently demonstrates perceived behavioral control as more influential than subjective norms (Galván-Mendoza et al., 2022), while our findings suggest a more balanced relationship in Thailand's business environment.

These contradictions highlight the importance of cultural contextualization when applying established theories to Thailand's unique business environment and offer guidance for designing more effective interventions that address the underlying factors influencing digital technology adoption among Thai SMEs.

6. Conclusion

This research provides crucial insights into the sustainability factors driving digital technology adoption among Thai SMEs. Through a mixed-methods approach combining qualitative expert consensus via the Rough Set Delphi technique and quantitative validation with 848 SME owners, the study establishes a comprehensive framework of eight interconnected factors: Social media usage, service quality, attitude, perceived behavioral control, subjective norms, satisfaction, intention to use, and use behavior.

The findings demonstrate strong construct validity and reliability across all measured dimensions, with Cronbach's alpha values consistently above 0.7 and AVE scores exceeding 0.5. The confirmatory factor analyses, both first- and second-order, show excellent model fit (RMSEA = 0.023–0.030, CFI > 0.96), validating the theoretical framework's structural integrity. Particularly noteworthy is the strong consensus among industry experts (QL ≥ 0.75) regarding the critical role of social media usage in enhancing customer relationships, with agreement levels reaching 1.00 for customer experience improvement and data collection capabilities.

The results highlight that successful digital transformation in Thai SMEs requires a holistic approach integrating technological and behavioral factors. Service quality emerges as a fundamental driver, with standardized loadings ranging from 0.731 to 0.772, emphasizing the importance of reliable digital service delivery. Additionally, the high factor loadings for subjective norms (0.723-0.787) underscore the significant influence of social and professional networks in driving digital adoption.

These findings have important implications for policymakers, business support organizations, and SME owners. They suggest that sustainable digital growth requires technological infrastructure and careful attention to user attitudes, behavioral controls, and satisfaction metrics. Future research could explore how these factors evolve across different industry sectors and investigate their relative importance during various stages of digital maturity. This understanding will be crucial for developing targeted interventions to support Thai SMEs in their digital transformation journey and enhance their competitive position in the global digital economy.

List of abbreviations

SMEs	Small and medium enterprises
ATT	Attitude
PBC	Perceived behavioral control
SN	Subjective norms
SAT	Satisfaction
ITU	Intention to use
UB	Use behavior
SMU	Social media usage
SQ	Service quality
CFA	Confirmatory factor analysis
QL	Quality lower approximation
GFI	Goodness of fit index
AGFI	Adjusted goodness of fit index
CFI	Comparative fit index
IFI	Incremental fit index
TLI	Tucker-Lewis index
RMSEA	Root mean square error of approximation
RMR	Root mean square residual
CR	Composite reliability
AVE	Average variance extracted
TPB	Theory of planned behavior
ML	Maximum likelihood

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Compliance with ethical standards

Ethical considerations

This study adhered to Rangsit University's ethical standards for human research, reviewed and approved by the Ethics Review Board of Rangsit University in Thailand with COA No. RSUERB2024-106. Participants agreed to take part in the survey after being informed about the study. Privacy and confidentiality of their information were rigorously protected, and no personal details were gathered.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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