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Social Media Marketing and SME Economic Sustainability: Integrating PLS-SEM and fsQCA Evidence from Thailand's Service Sector

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Abstract

Digital technology adoption alone may not fully account for the economic sustainability of service-sector SMEs. This study examines how managerial technology perceptions and digital applications relate to organizational capabilities and SME economic sustainability in Thailand. Drawing on the Technology Acceptance Model and capability-based reasoning informed by the dynamic capability perspective, the framework was developed through a three-round e-Delphi (20 experts), refined using an integrated Rough Set and Fuzzy Logic procedure, and tested with 385 SMEs. PLS-SEM assessed 13 direct and four specific indirect hypotheses; fsQCA examined sufficient configurations and configurational asymmetry. All hypotheses were supported. Social media marketing was positively associated with organizational agility, business connections and opportunities, value creation, and SME economic sustainability; its largest specific indirect relationship was through business connections and opportunities. Under the primary fsQCA specification, seven configurations were sufficient for high SMEES, with no necessary condition. Sensitivity analysis showed configuration variation, while social media marketing, organizational agility, and business connections and opportunities remained recurrent. Predictive assessment showed moderate out-of-sample performance without significant overall superiority over the linear benchmark (CVPAT $p = 0.555$). The study distinguishes the roles of managerial perceptions, digital applications, and organizational capabilities; cross-sectional findings indicate associations and configurational sufficiency rather than causality.

Keywords: social media marketing; SME economic sustainability; Technology Acceptance Model; organizational agility; organizational capabilities; service-sector SMEs; PLS-SEM; fsQCA; Thailand

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1. Introduction

Service-sector small and medium-sized enterprises (SMEs) face distinctive challenges in achieving long-term economic sustainability because they depend heavily on customer interaction, responsiveness, relationship quality, and continuous value creation. These challenges are intensified by resource constraints and rapidly changing customer expectations and competitive conditions. Although digital technologies can strengthen SME competitiveness and adaptability, smaller firms continue to face limitations related to technological resources, employee skills, and managerial capabilities [1–4]. Service-sector SMEs must therefore move beyond adopting digital tools toward developing the organizational capabilities required to use them effectively for sustained economic performance [5].

Digital adoption alone does not necessarily translate into sustainable economic outcomes. Digital technologies can support coordination, responsiveness, opportunity recognition, and value creation, but their economic relevance depends on how effectively they are integrated into organizational activities and associated with capabilities that generate continuing value [6–9]. The central research problem is therefore not simply whether SMEs adopt digital technologies, but how managerial technology perceptions are associated with digital business applications and how those applications are linked to economic sustainability both directly and through organizational capabilities.

Social media marketing (SMM) is particularly relevant to this research problem because it provides service-sector SMEs with a direct interface with customers, markets, and external stakeholders. Social-media-enabled interactions can provide market information, strengthen customer and business relationships, reveal emerging opportunities, communicate value, and support responsiveness to changing customer needs [9–13]. Accordingly, this study treats SMM not merely as a promotional tool but as a market-facing digital business application whose direct and specific indirect relationships with SME economic sustainability require examination.

The framework distinguishes four analytical levels. Perceived usefulness (PU) and perceived ease of use (PEOU) represent managerial technology-acceptance perceptions derived from the Technology Acceptance Model (TAM) [14]. In this study, these perceptions are reported by owner-managers and executives acting as organizational key informants. E-business technology (EBT) and SMM represent distinct digital business applications. Organizational agility (OA) is positioned as an adaptive dynamic capability concerned with detecting and responding to environmental change [15], whereas business connections and opportunities (BCO) represent a relational or networking capability and value creation (VC) represents the capability to transform market knowledge, relationships, and organizational resources into recognized benefits. SME economic sustainability (SMEES) represents the economic outcome of the framework.

SMEES is conceptually distinct from short-term business or financial performance. In this study, it refers to an SME's continuing capacity to maintain economically viable operations, preserve long-term competitiveness, use resources efficiently, respond to market and economic volatility, and sustain business continuity over time. It therefore concerns longer-term economic stability and resilience rather than temporary improvements in sales or profitability.

Despite growing research on SME digitalization, several gaps remain. First, technology acceptance, social media marketing, organizational capabilities, and SME performance have often been examined as separate research streams [1,8,16,17], providing limited explanation of how managerial technology perceptions are associated with organizational digital applications and the capabilities linked to economic sustainability. This fragmentation also leaves a cross-level issue in TAM-based SME research because individual managerial perceptions may be connected with firm-level applications and outcomes without clearly explaining the organizational role of the responding decision-maker. Second, the conceptual boundaries among SMM, OA, BCO, VC, and economic sustainability are not always clearly distinguished, potentially obscuring the differences between digital application, organizational capability, and long-term economic outcome.

Third, prior research has predominantly relied on net-effect approaches. Although such approaches identify direct and indirect structural relationships, they provide limited insight into how multiple technological and organizational conditions combine under configurational complexity. Fuzzy-set qualitative comparative analysis (fsQCA) complements this perspective by examining conjunctural patterns, equifinality, and configurational asymmetry [18,19]. Related SME research has linked digitalization and digital capabilities

with financial performance [20], while structural-path research has examined social media marketing in relation to SME sustainability [21]. However, limited research integrates direct, specific indirect, and configurational relationships within Thailand's service-sector SME context.

Accordingly, this study examines the direct and specific indirect relationships linking managerial technology-acceptance perceptions, digital business applications, organizational capabilities, and SME economic sustainability, while also identifying configurations sufficient for high and low SMEES among service-sector SMEs in Thailand. The measurement framework was refined through a three-round e-Delphi process followed by an integrated Rough Set and Fuzzy Logic procedure. PLS-SEM was then used to estimate the direct structural relationships and specific indirect effects, whereas fsQCA was used to identify alternative sufficient configurations. This combination distinguishes net-effect evidence from configurational evidence and provides complementary symmetric and asymmetric explanations of SME economic sustainability [18,19].

The study addresses the following research questions:

RQ1. How are perceived usefulness and perceived ease of use associated with the application of e-business technology and social media marketing among service-sector SMEs?

RQ2. How are e-business technology and social media marketing directly associated with SME economic sustainability, and what specific indirect relationships are observed through organizational agility and, for social media marketing, through business connections and opportunities and value creation?

RQ3. Which configurations of managerial technology-acceptance conditions, digital business applications, and organizational capabilities are sufficient for high and low SME economic sustainability?

This study makes three principal conceptual contributions. First, it specifies a layered theoretical architecture that distinguishes managerial technology-acceptance perceptions, digital business applications, organizational capabilities, and SME economic sustainability. Rather than treating these domains as interchangeable components of digitalization, the framework clarifies their distinct explanatory roles. TAM accounts for the managerial perceptual conditions associated with organizational digital applications, whereas capability-based reasoning helps explain how those applications are associated with adaptive, relational, and value-creating capabilities and with economic sustainability. This positioning also delineates the boundary of the dynamic capability perspective by treating OA as most directly aligned with adaptive dynamic capability logic, while BCO represents a relational or networking capability and VC represents a value-creating capability.

Second, the framework distinguishes the organizational roles of two forms of digital application. EBT represents an operationally oriented application Supporting Information exchange, coordination, and business operations, whereas SMM represents a market-facing application connecting firms with customers, markets, and external stakeholders. By examining their direct and specific indirect relationships with SMEES through distinct organizational capabilities, the study clarifies how digital applications may be associated with economic sustainability through different organizational pathways without treating technology use itself as an organizational capability.

Third, the study extends the explanation of SME economic sustainability beyond an exclusively net-effect perspective by integrating PLS-SEM and fsQCA. PLS-SEM evaluates specified direct and specific indirect structural relationships, whereas fsQCA identifies alternative sufficient configurations, equifinality, and configurational asymmetry. The recurrence of SMM, OA, and BCO across multiple fsQCA specifications provides configurational evidence that complements the structural results without implying that these conditions are individually necessary or that a single invariant configuration exists.

2. Literature Review and Hypothesis Development

The framework distinguishes four analytical levels: managerial technology-acceptance conditions (PU and PEOU) [14], digital business applications (EBT and SMM) [22,23], organizational capabilities (OA, BCO, and VC) [24,25], and SME economic sustainability as the long-term economic outcome. This structure preserves clear conceptual boundaries while specifying a theoretical sequence from managerial perceptions to digital applications, organizational capabilities, and economic sustainability.

The dynamic capability perspective is applied selectively. OA is most directly aligned with dynamic capability logic because it involves detecting environmental change and reconfiguring organizational responses [24,26]. BCO is treated as a relational or networking capability and VC as a value-creation capability [25]. SMM is a market-facing digital business application [23,27], and e-business technology represents an enabling digital resource and operational infrastructure [22,26]. Accordingly, not all digital applications or organizational capabilities are classified as dynamic capabilities.

2.1. Technology Acceptance and Digital Business Applications

Because TAM was originally developed at the individual level [14], using PU and PEOU to examine firm-level digital business applications requires explicit cross-level reasoning. In this study, PU and PEOU capture the perceptions of owners, executives, and managers who serve as organizational key informants and are directly involved in technology-related decision-making. These perceptions are not treated as firm-level capabilities; rather, they represent managerial acceptance conditions associated with organizational decisions to apply digital technologies. This interpretation is consistent with research emphasizing the role of entrepreneurs and senior decision-makers in SME digital transformation [24,28]. Accordingly, the cross-level link is grounded in the organizational decision-making roles of the respondents: managerial assessments of technological usefulness and ease of use are positioned as perceptual conditions associated with the firm-level use of EBT and SMM [22,28,29].

Prior SME research supports these relationships. PU and PEOU have been associated with e-business and e-commerce adoption [22,29], indicating that technologies are more likely to be applied when managers perceive clear benefits and manageable implementation demands. However, most evidence has focused on adoption or specific applications, particularly e-commerce. EBT and SMM represent distinct forms of digital application: EBT supports transactions, information exchange, customer communication, coordination, and digitally enabled operations [22,26], whereas SMM supports marketing communication, customer engagement, market-information acquisition, and business development [23,27].

Evidence on social media adoption further indicates that managerial perceptions operate alongside broader organizational and environmental conditions. PU and PEOU have been identified among the factors associated with social media adoption [30], while technological, organizational, managerial, knowledge, experience, and learning conditions can enable or constrain its effective use [31,32]. Thus, PU and PEOU provide important managerial foundations but are not sufficient in isolation [22,29–32]. Managers who perceive digital technologies as both beneficial and manageable should nevertheless be more likely to support operationally oriented EBT and market-facing SMM. Accordingly, the following hypotheses are proposed:

H1. *Perceived usefulness is positively associated with e-business technology.*

H2. *Perceived ease of use is positively associated with e-business technology.*

H3. *Perceived usefulness is positively associated with social media marketing.*

H4. *Perceived ease of use is positively associated with social media marketing.*

2.2. E-Business Technology, Organizational Agility, and SME Economic Sustainability

E-business technology (EBT) refers to the organizational application of digital technologies to support transactions, information exchange, customer communication, coordination, and other business operations [22,26]. It is therefore distinct from organizational capabilities: EBT provides digital operational infrastructure, whereas capabilities concern how firms mobilize resources to recognize change, coordinate action, and generate economic value.

Organizational agility (OA) is an adaptive dynamic capability that enables firms to detect environmental change, interpret relevant information, and adjust organizational activities in a timely manner [15,24,26]. Digital technologies may improve the speed and availability of information, but technology use alone does not create agility. Agility depends on how digital information is incorporated into decision-making, coordination, resource allocation, and organizational responses. This distinction is particularly relevant to service-sector SMEs, where EBT can support responsiveness by improving information exchange, digitally enabled transactions, and coordination [22,26]. More timely access to operational information can reduce the interval between recognizing a market change and implementing an organizational response.

Prior research supports the relationship between digital resources and agility. Digital platform capability has been positively associated with SME organizational agility [33], while e-commerce capability has been linked to organizational agility and subsequent decision-making performance [26]. Related evidence also highlights the relationship between digital capability and organizational agility in SME digital transformation [24]. Collectively, these findings suggest that digital resources are associated with agility when firms can integrate digital information into sensing, coordination, and response processes.

EBT may also be directly associated with SME economic sustainability by supporting operational efficiency, resource utilization, market access, and business continuity. Cloud-computing integration has been associated with sustainable SME performance [34], while digital technology adoption has been linked to economic value creation, SME performance, and economic sustainability [35,36]. E-business innovation has likewise been associated with SME performance [37]. However, these benefits depend on how digital technologies are applied rather than on technology ownership alone [34,37]. Accordingly, EBT is examined as a digital business application associated with both organizational agility and SME economic sustainability.

The following hypotheses are therefore proposed:

H5. *E-business technology is positively associated with organizational agility.*

H6. *E-business technology is positively associated with SME economic sustainability.*

2.3. Social Media Marketing and Organizational Capabilities

Social media marketing (SMM) is a market-facing digital business application used for marketing communication, customer engagement, market-information acquisition, and promotion [23,27]. It is conceptually distinct from the organizational capabilities examined in this study. Organizational agility (OA) reflects the ability to detect and respond to environmental change [24], business connections and opportunities (BCO) concern the development and mobilization of relationships and business opportunities [13,25], and

value creation (VC) reflects the transformation of market knowledge and resources into recognized benefits [13,25]. SMM provides information and interactions that may support these adaptive, relational, and value-creating capabilities [23,27].

2.3.1. Social Media Marketing and Organizational Agility

Social media provides timely information about customer feedback, market changes, competitors, and stakeholder responses, thereby supporting market sensing [23,38]. When such information is incorporated into decision-making and organizational responses, SMM may support OA [23,38]. Prior research links social networking technology with organizational agility [38] and strategic social media use with market-sensing and customer-linking capabilities [23]. Evidence from Thai SMEs also shows a positive relationship between social media agility and business performance, although the strength of this relationship varies with firm size and environmental dynamism [39].

However, access to real-time information does not itself constitute agility. SMM provides market-facing information and interaction, whereas OA reflects the organizational capacity to interpret and respond to that information. Accordingly:

H7. *Social media marketing is positively associated with organizational agility.*

2.3.2. Social Media Marketing and Business Connections and Opportunities

BCO represents a relational or networking capability rather than the number of online contacts a firm possesses. Social media can expand access to customers, suppliers, partners, and entrepreneurial networks [13,25], while SMM can facilitate stakeholder interaction and the identification of business opportunities [23,25].

Prior research shows that strategic social media use supports customer-linking capabilities [23], relationship development, network identity, and collaboration [25], while positive relationships between social media use, BCO, and SME sustainability have also been reported [13].

Thus, SMM provides digital interaction, whereas BCO reflects the firm's capability to develop and mobilize relationships for business purposes. Accordingly:

H8. *Social media marketing is positively associated with business connections and opportunities.*

2.3.3. Social Media Marketing and Value Creation

VC reflects the ability to transform market knowledge, customer information, relationships, and organizational resources into recognized customer and organizational benefits [13,25]. It is therefore distinct from SMM: social media provides informational and relational inputs, whereas VC concerns how firms use those inputs to create value [23,25].

SMM can provide continuous customer feedback and market information that inform service design, customer experiences, and market offerings [23,25]. Previous research has linked social media use with value-creation processes [25], market-sensing and customer-linking capabilities [23], and value creation among SMEs [13]. Accordingly:

H9. *Social media marketing is positively associated with value creation.*

2.3.4. Social Media Marketing and SME Economic Sustainability

SMM may also be directly associated with SME economic sustainability by supporting market visibility, customer communication, retention, sales opportunities, and access to market information [13,23,27]. Empirical evidence links social media adoption with SME economic sustainability [40] and social media use with SME sustainability [13], while

strategic social media use has also been associated with capabilities supporting marketing and financial performance [23].

These benefits, however, depend on the strategic use of customer interaction and market information rather than platform adoption alone [23]. SMM is therefore examined as a market-facing digital business application that is directly associated with SME economic sustainability, alongside its relationships with OA, BCO, and VC. Accordingly:

H10. *Social media marketing is positively associated with SME economic sustainability.*

2.4. Organizational Capabilities and SME Economic Sustainability

SME economic sustainability (SMEES) is conceptually distinct from short-term business or financial performance. It refers to a firm's continuing capacity to maintain economically viable operations, preserve competitiveness, use resources efficiently, sustain business continuity, and respond to market and economic volatility [13,36].

Short-term financial gains alone are insufficient to establish such sustainability. Resilience is treated here as one component of longer-term economic sustainability rather than as a synonymous construct; SMEES additionally encompasses continuing economic viability, competitiveness, resource efficiency, and business continuity over time. This distinction is particularly relevant to service-sector SMEs, whose outcomes depend strongly on customer interaction, responsiveness, relationship continuity, and service value. Evidence from Thailand also indicates continuing capability gaps in digital marketing, online customer interaction, and change management among service-sector SMEs [41].

2.4.1. Organizational Agility and SME Economic Sustainability

Organizational agility (OA) reflects the ability to recognize environmental changes, interpret information, coordinate responses, and reconfigure activities in a timely manner. Its relevance is particularly evident in service settings, where delayed responses to customer needs or market changes can weaken competitiveness.

Evidence from Thai SMEs shows a positive relationship between social media agility and business performance, although the strength of this relationship varies with firm size and environmental dynamism [39]. A systematic review likewise reports generally positive relationships between different forms of agility and organizational outcomes while emphasizing contextual variation [42]. Thus, although agility does not guarantee economic sustainability, timely and appropriate organizational responses may support continuing economic viability. Accordingly:

H11. *Organizational agility is positively associated with SME economic sustainability.*

2.4.2. Business Connections and Opportunities and SME Economic Sustainability

Business connections and opportunities (BCO) represents a relational or networking capability through which SMEs access customers, partners, suppliers, knowledge, resources, and commercial opportunities. The economic value of such connections depends not on their number but on the firm's ability to maintain and mobilize them. Network capabilities have been associated with innovation and financial performance among MSMEs [43], while BCO has also been positively related to SME sustainability [13]. Relational capability may therefore support economic viability by expanding access to resources and opportunities that strengthen competitiveness. Accordingly:

H12. *Business connections and opportunities are positively associated with SME economic sustainability.*

2.4.3. Value Creation and SME Economic Sustainability

Value creation (VC) concerns the transformation of market knowledge, relationships, and organizational resources into recognized customer and organizational benefits. It differs from BCO in that BCO facilitates access to resources and opportunities, whereas VC concerns how those resources are converted into meaningful value. Value-creation agility has been positively associated with SME business performance [44], while value creation has also been linked to SME sustainability [13]. Although the latter evidence was obtained from manufacturing SMEs in Ghana, it provides relevant support for the relationship between value creation and SME sustainability [13]. For service-sector SMEs, the ability to transform information, relationships, and resources into customer value may therefore support competitiveness and continuing economic viability. Accordingly:

H13. *Value creation is positively associated with SME economic sustainability.*

2.5. Specific Indirect Relationships Through Organizational Capabilities

The direct relationships proposed above do not fully explain how digital business applications are associated with SME economic sustainability. EBT and SMM may be related to SMEES directly and through organizational capabilities that support adaptation, relationship mobilization, and value creation. Examining specific indirect effects therefore extends the framework by assessing whether these capabilities represent statistically supported intermediate relationships between digital applications and SMEES. These indirect relationships are conceptually distinct from the configurations examined through fsQCA. PLS-SEM evaluates specific structural relationships through designated organizational capabilities, whereas fsQCA identifies combinations of conditions sufficient for an outcome [18,19]. The two approaches therefore provide complementary rather than interchangeable explanations of SME economic sustainability [18,19].

2.5.1. Specific Indirect Relationship of E-Business Technology Through Organizational Agility

EBT provides operational information, transaction support, communication, and coordination infrastructure that may support both operational continuity and organizational responsiveness. Its economic relevance may therefore depend partly on whether firms use digital information to recognize environmental change and adjust organizational activities. Prior research links digital platform and e-commerce capabilities with organizational agility [24,26,33], while agility has been positively associated with organizational and SME performance outcomes [39,42]. Evidence also suggests that complementary organizational resources can strengthen the relationship between digital capability and agility [33]. Taken together, these findings support an indirect relationship in which EBT is associated with SMEES through OA rather than implying that digital infrastructure alone generates sustainable economic outcomes. Accordingly:

H14. *E-business technology is indirectly and positively associated with SME economic sustainability through organizational agility.*

2.5.2. Specific Indirect Relationship of Social Media Marketing Through Organizational Agility

SMM provides timely customer, competitor, and market information, but access to such information does not itself constitute organizational responsiveness. Its organizational relevance depends on whether market-facing information is incorporated into decision-making and timely action. Previous studies associate social media-based activities with market

sensing, responsiveness, and organizational agility [23,38,39], while broader evidence links agility with positive organizational outcomes [42]. This literature therefore supports OA as an adaptive capability through which SMM may be indirectly associated with SMEES. Accordingly:

H15. *Social media marketing is indirectly and positively associated with SME economic sustainability through organizational agility.*

2.5.3. Specific Indirect Relationship of Social Media Marketing Through Business Connections and Opportunities

Social media can facilitate access to customers, suppliers, partners, and wider stakeholder networks, but digital interaction alone does not constitute economically valuable relational capability. Such interactions become strategically relevant when firms develop and mobilize them into sustained relationships, resources, customer access, and identifiable opportunities. Prior research links strategic social media use with customer-linking capabilities, relationship development, networking, and business opportunities [13,23,25]. Network capabilities have also been associated with innovation and financial performance among MSMEs [43], complementing prior evidence linking social media use and BCO with SME sustainability [13]. Together, these findings support BCO as a relational capability through which SMM may be indirectly associated with SMEES. Accordingly:

H16. *Social media marketing is indirectly and positively associated with SME economic sustainability through business connections and opportunities.*

2.5.4. Specific Indirect Relationship of Social Media Marketing Through Value Creation

SMM provides customer feedback, behavioral information, and market knowledge, but these inputs create economic value only when firms interpret and apply them to offerings, experiences, or organizational decisions. VC therefore captures a capability distinct from social media activity itself. Existing research links social media use with value creation, customer-linking processes, relationship development, and the organizational use of market information [13,23,25]. Value-creation capability and value-creation agility have also been associated with SME sustainability and business performance [13,44]. This evidence supports VC as a value-creating capability through which SMM may be indirectly associated with SMEES. Accordingly:

H17. *Social media marketing is indirectly and positively associated with SME economic sustainability through value creation.*

2.6. Conceptual Framework

The proposed framework comprises four interconnected levels: managerial technology-acceptance conditions (PU and PEOU), digital business applications (EBT and SMM), organizational capabilities (OA, BCO, and VC), and SME economic sustainability (SMEES) as the long-term economic outcome. The framework specifies 13 direct structural relationships linking these four levels.

Four specific indirect relationships are also proposed: EBT is associated with SMEES through OA, whereas SMM is associated with SMEES through OA, BCO, and VC. PLS-SEM is used to assess the specified direct and specific indirect relationships, while fsQCA examines alternative combinations of managerial perceptions, digital applications, and organizational capabilities sufficient for high and low SMEES. These approaches provide complementary structural and configurational perspectives, including equifinality and

configurational asymmetry [18,19]. The proposed conceptual framework and hypothesized relationships are illustrated in Figure 1.

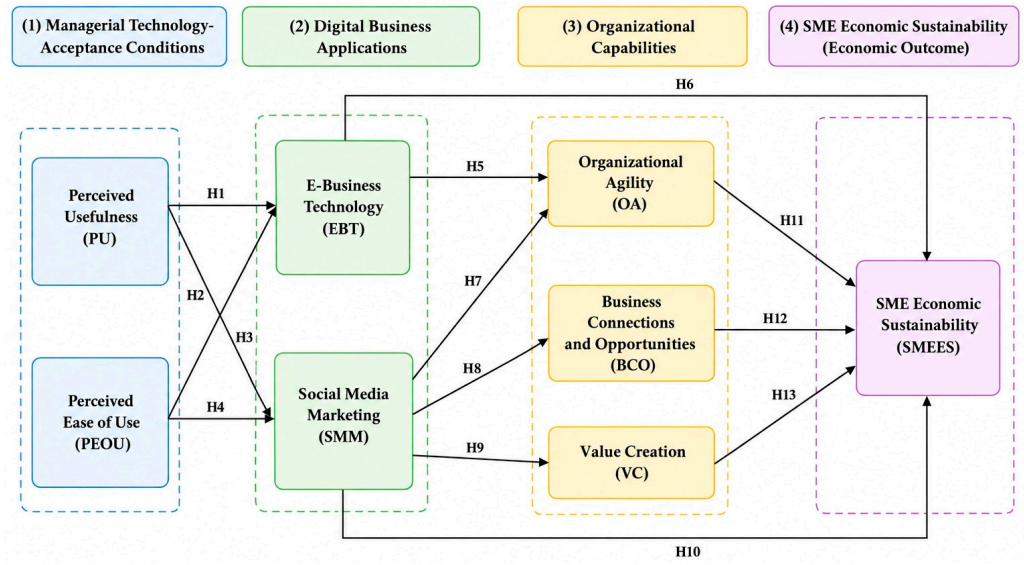


Figure 1. Proposed conceptual framework showing the 13 hypothesized direct structural relationships. Note: Arrows represent the direct-effect hypotheses (H1–H13). The four specific indirect-effect hypotheses (H14–H17) are assessed through the corresponding component structural paths but are not displayed separately in the figure for visual clarity.

3. Research Design and Analytical Framework

3.1. Overall Research Design and Analytical Sequence

This study employed a sequential, multi-stage mixed-methods design to develop and empirically evaluate a digital business capability framework for service-sector SMEs in Thailand [45]. Each method served a distinct analytical purpose. The three-round e-Delphi was used to refine the literature-derived measurement indicators through iterative expert judgment [46], while the integrated Rough Set and Fuzzy Logic procedure provided a systematic basis for indicator retention under evaluative uncertainty [47–49]. PLS-SEM was then used to assess the specified direct and specific indirect structural relationships, whereas fsQCA examined alternative sufficient configurations, equifinality, and configurational asymmetry [18,19]. This sequence enabled the measurement instrument to be refined before the structural and configurational analyses were conducted.

The model drew on the Technology Acceptance Model [14] and the dynamic capability perspective [15] and comprised eight constructs: PU, PEOU, EBT, SMM, OA, BCO, VC, and SMEES. It specified 13 direct-effect hypotheses and four specific indirect-effect hypotheses.

3.2. Expert-Based Instrument Development

The instrument-development stage combined a three-round e-Delphi procedure with integrated Rough Set and Fuzzy Logic analysis. The e-Delphi process refined the constructs and indicators through iterative expert judgment [46], while the subsequent analysis provided a systematic basis for evaluating indicator appropriateness, feasibility, and retention [47–49].

3.2.1. Expert Selection and Panel Composition

The panel comprised 20 purposively selected experts: seven service-sector SME entrepreneurs (E01–E07), seven government and private-sector specialists (E08–E14), and six university academics (E15–E20). Participants were selected for relevant practical, profes-

sional, institutional, or academic expertise, consistent with Delphi principles of informed expert judgment [46]. The three groups provided complementary perspectives on the proposed measurement framework. All 20 experts completed the third-round evaluation and were included in the subsequent Rough Set and Fuzzy Logic analysis. The composition of the e-Delphi expert panel is summarized in Table 1.

Table 1. Composition of the e-Delphi expert panel.

Expert Group	Expert Codes	Number	Principal Perspective
Service-sector SME entrepreneurs	E01–E07	7	Service-business operation or management experience of at least three years.
Government and private-sector specialists	E08–E14	7	At least three years of relevant professional experience.
University academics	E15–E20	6	Relevant research publications or academic experience of at least three years.
Total	**E01–E20**	**20**	-

3.2.2. Three-Round e-Delphi Procedure and Audit Trail

The same 20 experts completed all three e-Delphi rounds, with each round informing the subsequent stage in accordance with the iterative Delphi process [46].

Round 1 began with a literature-derived pool of 45 candidate indicators representing the eight constructs. Open-ended questions were used to obtain expert perspectives on the proposed constructs and indicators, including their relevance to the study context, clarity, potential redundancy, and areas requiring additional coverage. The expert feedback informed substantive refinement of the instrument, including wording revisions and the removal of five indicators—one EBT indicator, three BCO indicators, and one OA indicator. The revised instrument therefore comprised 40 indicators for subsequent evaluation.

In Round 2, the 40 revised indicators were subjected to structured expert evaluation. The same 20 experts independently assessed each indicator in terms of appropriateness and feasibility using a seven-point Likert-type scale. Appropriateness reflected the extent to which an indicator adequately represented its corresponding construct, whereas feasibility reflected its applicability within the operational context of service-sector SMEs.

In Round 3, the same 40 indicators were reassessed using the same appropriateness and feasibility criteria to obtain the final expert evaluations. Expert agreement remained high across the indicators, and the resulting third-round ratings constituted the dataset used in the subsequent integrated Rough Set and Fuzzy Logic analysis.

An audit trail documented the progression of the indicators across the three rounds, including expert recommendations, indicator removals, wording revisions, actions taken, recorded rationales where available, and final retention status [46]. An indicator-level audit trail of the Round 1 refinement process is provided in Supplementary Table S2. The objectives, procedures, analytical treatment, and outputs of each round are summarized in Table 2.

Table 2. Summary of the three-round e-Delphi procedure.

Round	Primary Objective	Expert-Evaluation Procedure	Analytical Treatment	Main Output
Round 1	Explore relevant content and refine the initial indicator pool.	Open-ended electronic consultation based on 45 literature-derived candidate indicators.	Expert responses were reviewed, coded, and compared with the preliminary indicators and construct definitions to identify wording issues, redundancy, conceptual overlap, and additional relevant content.	40-item revised instrument following five indicator removals and several wording refinements.
Round 2	Evaluate the appropriateness and feasibility of the revised indicators.	Seven-point ratings of appropriateness and feasibility by the same 20 experts.	Joint expert support for each of the 40 revised indicators was assessed using the appropriateness and feasibility ratings.	40 indicators advanced to Round 3 for reassessment.
Round 3	Conduct the final expert evaluation.	Reassessment of the same 40 indicators using seven-point appropriateness and feasibility ratings.	Final evaluations from 20 experts were used as the input for the integrated Rough Set and Fuzzy Logic analysis.	Final expert-evaluation dataset for Rough Set and Fuzzy Logic retention analysis.

Note: The same 20 experts participated in and completed all three e-Delphi rounds.

3.2.3. Integrated Rough Set and Fuzzy Logic Analysis

The final third-round evaluations of the 40 indicators provided by the 20 experts were analyzed using an integrated Rough Set and Fuzzy Logic procedure [47–49]. Rough Set classified each expert–indicator evaluation into supporting, boundary, or non-supporting conditions based on the joint appropriateness and feasibility ratings [47]. The resulting decisions were then transformed into triangular fuzzy numbers and aggregated to obtain crisp indicator-retention scores [48,49].

Let U_j denote the universe of expert evaluations for indicator j, and let R represent the indiscernibility relation generated by the joint appropriateness and feasibility conditions. For a positive decision class X_j, the lower approximation contained evaluations that could be classified with certainty as supporting the indicator:

$$\underline{R}(X_j) = \{x \in U_j : [x]_R \subseteq X_j\} \quad (1)$$

The upper approximation contained evaluations that possibly supported the indicator [47,49]:

$$\overline{R}(X_j) = \{x \in U_j : [x]_R \cap X_j \neq \emptyset\} \quad (2)$$

The boundary region represented evaluations that could not be assigned to the positive decision class with complete certainty [47,49]:

$$B_R(X_j) = \overline{R}(X_j) - \underline{R}(X_j) \quad (3)$$

Equations (1)–(3) provide the conceptual Rough Set definitions of the lower approximation (certain support), the upper approximation (possible support), and the boundary region (possible but not certain support). For the operational implementation in this study, these concepts were instantiated using the joint appropriateness and feasibility ratings. Evaluations with concordant high ratings (5–7 on both criteria) were treated as certain positive support, discordant high–low rating combinations were treated as boundary cases, and

concordant low ratings (1–4 on both criteria) were treated as non-supporting evaluations. Consistent with Equation (3), the upper approximation comprises the lower approximation together with the boundary region.

Based on this operational classification, supporting evaluations were coded as 1, whereas boundary and non-supporting evaluations were coded as 0. The decision rules and fuzzy-number assignments are summarized in Table 3.

Table 3. Rough Set decision conditions and triangular fuzzy-number assignments.

Decision Condition	Appropriateness Rating	Feasibility Rating	Rough Set Interpretation	Binary Decision	Triangular Fuzzy Number (L, M, U)
Supporting evaluation	5–7	5–7	Certain positive decision (lower approximation)	1	(0.50, 0.75, 1.00)
Boundary condition	5–7	1–4	Boundary region	0	(0.00, 0.25, 0.50)
Boundary condition	1–4	5–7	Boundary region	0	(0.00, 0.25, 0.50)
Non-supporting evaluation	1–4	1–4	Negative decision	0	(0.00, 0.25, 0.50)

Each binary decision was converted into a triangular fuzzy number [48,49]. A supporting decision was represented by (0.50, 0.75, 1.00), whereas decisions coded as 0, including boundary and non-supporting evaluations, were represented by (0.00, 0.25, 0.50). For each indicator j, the aggregated lower, middle, and upper fuzzy values were calculated across the 20 experts as follows:

$$L_j = \frac{1}{n}\sum_{i=1}^{n} l_{ij} \tag{4}$$

$$M_j = \frac{1}{n}\sum_{i=1}^{n} m_{ij} \tag{5}$$

$$U_j = \frac{1}{n}\sum_{i=1}^{n} u_{ij} \tag{6}$$

where $n = 20$, and l_{ij}, m_{ij}, and u_{ij} denote the lower, middle, and upper fuzzy values assigned to expert i's evaluation of indicator j. The aggregated triangular fuzzy number was subsequently defuzzified using the centroid method [50]:

$$C_j = \frac{L_j + M_j + U_j}{3} \tag{7}$$

An indicator was retained when its crisp score met or exceeded the predetermined threshold of 0.65:

$$C_j \geq 0.65 \tag{8}$$

The threshold represented a stringent level of collective expert support. Because a supporting evaluation produced a crisp value of 0.75 and an evaluation coded as 0 produced a crisp value of 0.25, the aggregated crisp score can be expressed as $C_j = 0.25 + 0.50p_j$, where p_j represents the proportion of supporting evaluations. Therefore, a score of 0.65 required supporting evaluations from at least 80% of the expert panel, equivalent to support from at least 16 of the 20 experts. The indicator-level results of this procedure are reported in the Results section.

3.3. Quantitative Sampling and Data Collection

The survey targeted organizational key informants with ownership, managerial, or decision-making involvement in service-sector SMEs in Thailand. Purposive sampling was used to select respondents knowledgeable about firm-level digital activities and organizational practices. Data were collected through an online questionnaire from November 2025 to February 2026. The survey link was disseminated via social media and business networks to reach organizational respondents with knowledge of firm-level digital activities and organizational practices. Before accessing the substantive survey items, respondents were provided with information about the study and were required to provide electronic informed consent. Participation was voluntary, and respondents were informed of their right to withdraw, the confidentiality of their responses, and that the findings would be analyzed and reported only in aggregate form. Preliminary screening questions were administered before the main questionnaire to assess respondent eligibility.

After data screening, 385 valid responses were retained for the PLS-SEM and fsQCA analyses. SME classification followed Thailand's official SME criteria, under which annual revenue is used as the determining criterion when employment and revenue classifications differ. For trade and service enterprises, medium enterprises are defined as those with annual revenue exceeding THB 50 million but not exceeding THB 300 million [51]. All firms retained in this study reported annual revenue not exceeding THB 200 million and therefore satisfied the applicable revenue criterion for Thai service-sector SMEs.

3.4. Measurement

The questionnaire was developed from literature-derived indicators and refined through the three-round e-Delphi and integrated Rough Set and Fuzzy Logic procedures [46–49]. The final instrument comprised 40 items measuring eight reflective constructs: PU, PEOU, EBT, SMM, OA, BCO, VC, and SMEES. All items used a seven-point agreement scale from 1 ("strongly disagree") to 7 ("strongly agree"). The same response format was applied across all constructs to maintain measurement consistency and capture variation in respondents' assessments.

PU and PEOU assessed managerial perceptions of technology usefulness and ease of use [14]. EBT captured the application of digital technologies to business information exchange, communication, coordination, and operations [22,26], whereas SMM represented the use of social media as a market-facing digital business application for marketing communication, customer engagement, and market-information acquisition [52]. OA captured the organizational capability to respond and adapt to changes in the business environment [24,42]. BCO reflected the capability to develop and mobilize business relationships and opportunities through external networks [13,25], while VC captured the capability to transform market knowledge and organizational resources into customer and organizational value [13,25,44]. SMEES was operationalized as an outcome-oriented construct reflecting sustained economic performance and business continuity, including revenue and profit growth, customer and market development, adaptation to the business environment, and customer retention [13,36].

Representative items included PU ("Online platforms are useful for supporting revenue and sales"), PEOU ("Online platforms make products or services easier for customers to access"), EBT ("The business uses technology to manage internal business operations"), SMM ("The business creates content on online platforms that meets customer needs"), OA ("The business is prepared to adapt to changing situations"), BCO ("The business jointly expands business opportunities with its business network"), VC ("The business creates value through products or services that meet customer needs"), and SMEES ("The

business's sales increase continuously"). The complete 40-item measurement instrument is provided in Supplementary Table S3.

Although these constructs are theoretically related, they represent non-equivalent domains within the proposed framework. PU and PEOU represent managerial technology perceptions; EBT and SMM represent digital business applications; OA, BCO, and VC represent distinct organizational capabilities; and SMEES represents the economic sustainability outcome. In particular, SMM concerns how social media is applied in market-facing activities, whereas BCO concerns the development and mobilization of external business relationships and opportunities, and VC concerns the transformation of knowledge and resources into value. Similarly, OA represents organizational responsiveness and adaptation as a capability, whereas SMEES captures the broader economic and continuity outcomes of the business. Their empirical distinctiveness was subsequently assessed as part of the measurement-model evaluation.

3.5. Data Analysis

The data were analyzed sequentially using PLS-SEM and fsQCA. PLS-SEM assessed the specified direct and specific indirect structural relationships, whereas fsQCA identified sufficient configurations of conditions associated with SMEES [18,19]. The two approaches therefore provided complementary structural and configurational perspectives [18,19].

The PLS-SEM assessment comprised evaluations of the measurement and structural models. The reflective measurement model was assessed using standardized outer loadings, Cronbach's alpha, composite reliability (CR), average variance extracted (AVE), and the heterotrait-monotrait ratio (HTMT) of correlations. HTMT values below 0.90 were used as a conventional guideline for discriminant validity, while 95% bias-corrected and accelerated (BCa) bootstrap confidence intervals based on 10,000 subsamples were additionally examined to evaluate construct distinctiveness [53,54]. The structural model was evaluated using inner VIF, R^2, standardized path coefficients (β), t-values, *p*-values, and f^2 effect sizes [53,54]. An inner VIF threshold of 5.00 was applied, and the statistical significance of the structural relationships was assessed using bootstrapping with 5000 resamples [53,54]. Out-of-sample predictive performance was evaluated using PLSpredict [55].

For fsQCA, the resulting latent-variable scores were calibrated using the direct method [19,56], with the 10th, 50th, and 90th percentiles representing full non-membership (0.05), the crossover point (0.50), and full membership (0.95), respectively. Scores of exactly 0.500 were adjusted to 0.499 [19]. Necessity analysis used a consistency threshold of 0.90, while sufficiency analysis applied a frequency threshold of three cases, a consistency threshold of 0.80, and a PRI threshold of 0.70 [19,56]. Intermediate and parsimonious solutions were compared to identify core and peripheral conditions, and configurations were interpreted using consistency and coverage [19,56,57]. Robustness and sensitivity analyses varied the frequency and PRI thresholds, calibration anchors, and source of construct scores [19].

4. Results

The results are presented according to the analytical sequence of the study: e-Delphi and integrated Rough Set and Fuzzy Logic results, respondent characteristics, PLS-SEM assessment, and fsQCA analysis, including robustness and sensitivity tests.

4.1. e-Delphi Results

All 20 experts completed the three e-Delphi rounds. Round 1 began with 45 literature-derived candidate indicators representing the eight constructs. The open-ended expert feedback informed refinement of the initial indicator pool, including wording revisions and

the removal of five indicators. Specifically, one EBT indicator, three BCO indicators, and one OA indicator were removed following the first-round review. These revisions resulted in a 40-item revised indicator set for subsequent evaluation.

In Round 2, the same 20 experts independently evaluated the 40 revised indicators in terms of appropriateness and feasibility using a seven-point Likert-type scale. All 40 indicators advanced to Round 3 for reassessment. In Round 3, the same indicators were reassessed using the same appropriateness and feasibility criteria. Expert support remained high across the indicators, and the final third-round ratings constituted the dataset used in the subsequent integrated Rough Set and Fuzzy Logic analysis.

4.2. Integrated Rough Set and Fuzzy Logic Results

The integrated Rough Set and Fuzzy Logic analysis covered 800 expert–indicator evaluations from 20 experts and 40 indicators. Only three boundary evaluations were identified, indicating a high level of expert support across the panel.

Crisp scores ranged from 0.700 to 0.750, exceeding the predetermined retention threshold of 0.65 for all indicators. Consequently, all 40 indicators were retained for the subsequent PLS-SEM and fsQCA analyses. Indicator-level results are presented in Table 4.

Table 4. Indicator-level results of the integrated Rough Set and Fuzzy Logic analysis.

Construct	Indicator	Supporting Evaluations (N)	Boundary Evaluations (N)	Non-Supporting Evaluations (N)	L	M	U	Crisp Score	Decision
PU	PU1	20	0	0	0.500	0.750	1.000	0.750	Retained
PU	PU2	20	0	0	0.500	0.750	1.000	0.750	Retained
PU	PU3	20	0	0	0.500	0.750	1.000	0.750	Retained
PU	PU4	19	0	1	0.475	0.725	0.975	0.725	Retained
PU	PU5	19	0	1	0.475	0.725	0.975	0.725	Retained
PEOU	PEOU1	20	0	0	0.500	0.750	1.000	0.750	Retained
PEOU	PEOU2	20	0	0	0.500	0.750	1.000	0.750	Retained
PEOU	PEOU3	20	0	0	0.500	0.750	1.000	0.750	Retained
PEOU	PEOU4	20	0	0	0.500	0.750	1.000	0.750	Retained
PEOU	PEOU5	20	0	0	0.500	0.750	1.000	0.750	Retained
EBT	EBT1	20	0	0	0.500	0.750	1.000	0.750	Retained
EBT	EBT2	20	0	0	0.500	0.750	1.000	0.750	Retained
EBT	EBT3	20	0	0	0.500	0.750	1.000	0.750	Retained
EBT	EBT4	20	0	0	0.500	0.750	1.000	0.750	Retained
SMM	SMM1	20	0	0	0.500	0.750	1.000	0.750	Retained
SMM	SMM2	20	0	0	0.500	0.750	1.000	0.750	Retained
SMM	SMM3	19	0	1	0.475	0.725	0.975	0.725	Retained
SMM	SMM4	19	0	1	0.475	0.725	0.975	0.725	Retained
SMM	SMM5	20	0	0	0.500	0.750	1.000	0.750	Retained
SMM	SMM6	18	1	1	0.450	0.700	0.950	0.700	Retained
BCO	BCO1	18	0	2	0.450	0.700	0.950	0.700	Retained
BCO	BCO2	18	0	2	0.450	0.700	0.950	0.700	Retained
BCO	BCO3	18	1	1	0.450	0.700	0.950	0.700	Retained
BCO	BCO4	19	0	1	0.475	0.725	0.975	0.725	Retained
OA	OA1	20	0	0	0.500	0.750	1.000	0.750	Retained
OA	OA2	19	0	1	0.475	0.725	0.975	0.725	Retained
OA	OA3	19	0	1	0.475	0.725	0.975	0.725	Retained
OA	OA4	19	0	1	0.475	0.725	0.975	0.725	Retained
OA	OA5	19	0	1	0.475	0.725	0.975	0.725	Retained
VC	VC1	20	0	0	0.500	0.750	1.000	0.750	Retained
VC	VC2	20	0	0	0.500	0.750	1.000	0.750	Retained
VC	VC3	20	0	0	0.500	0.750	1.000	0.750	Retained
VC	VC4	20	0	0	0.500	0.750	1.000	0.750	Retained
VC	VC5	19	0	1	0.475	0.725	0.975	0.725	Retained

Table 4. *Cont.*

Construct	Indicator	Supporting Evaluations (N)	Boundary Evaluations (N)	Non-Supporting Evaluations (N)	L	M	U	Crisp Score	Decision
SMEES	SMEES1	18	1	1	0.450	0.700	0.950	0.700	Retained
SMEES	SMEES2	19	0	1	0.475	0.725	0.975	0.725	Retained
SMEES	SMEES3	19	0	1	0.475	0.725	0.975	0.725	Retained
SMEES	SMEES4	19	0	1	0.475	0.725	0.975	0.725	Retained
SMEES	SMEES5	19	0	1	0.475	0.725	0.975	0.725	Retained
SMEES	SMEES6	19	0	1	0.475	0.725	0.975	0.725	Retained

Note: L = lower fuzzy value; M = middle fuzzy value; U = upper fuzzy value. A supporting evaluation indicates that both appropriateness and feasibility ratings ranged from 5 to 7. A boundary evaluation indicates that one rating ranged from 5 to 7 while the other ranged from 1 to 4. A non-supporting evaluation indicates that both ratings ranged from 1 to 4. Indicators with a crisp score of 0.65 or higher were retained.

Overall, all 40 indicators satisfied the predetermined retention criterion and were therefore retained in the final measurement instrument. The resulting 40-item instrument was subsequently used for quantitative data collection and empirical assessment through PLS-SEM and fsQCA.

4.3. Respondent and Organizational Characteristics

Table 5 summarizes the characteristics of the 385 respondents. Most were aged 31–40 years (60.5%) and held a bachelor's degree (62.9%). Business owners and partners accounted for 81.3% of the sample, indicating substantial involvement in firm-level decision-making. The largest employment group comprised firms with 6–50 employees (48.8%), and all firms reported annual revenue not exceeding THB 200 million. As the sample comprised only service-sector SMEs, business sector was not reported separately.

Table 5. Respondent and organizational characteristics.

Category	Subcategory	Frequency	Percentage (%)
Gender	Male	182	47.3
	Female	195	50.6
	Not specified	8	2.1
Age	18–30 years	55	14.3
	31–40 years	233	60.5
	41–50 years	64	16.6
	51 years or above	33	8.6
Education Level	Below bachelor's degree	11	2.9
	Bachelor's degree	242	62.9
	Master's degree	106	27.5
	Doctoral degree	26	6.8
Position in the Business	Business owner	184	47.8
	Business partner	129	33.5
	Executive (decision-making authority)	72	18.7
Annual Revenue	THB 50 million or less	157	40.8
	THB 51–100 million	146	37.9
	THB 101–200 million	82	21.3

Table 5. *Cont.*

Category	Subcategory	Frequency	Percentage (%)
Number of Employees	5 employees or fewer	92	23.9
	6–50 employees	188	48.8
	51–100 employees	91	23.6
	101–200 employees	14	3.6

Note: N = 385. All respondents represented service-sector SMEs in Thailand. Percentages may not total exactly 100% because of rounding.

4.4. PLS-SEM Results

PLS-SEM analysis was conducted using the 385 valid responses. The analysis covered the measurement model, potential common method bias, structural relationships, specific indirect effects, and out-of-sample predictive performance using PLSpredict.

4.4.1. Measurement Model

The reflective measurement models were evaluated for indicator reliability, internal consistency reliability, convergent validity, and discriminant validity. Standardized outer loadings, Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE) were examined, while discriminant validity was assessed using the heterotrait–monotrait ratio (HTMT) of correlations and 95% bias-corrected and accelerated (BCa) bootstrap confidence intervals.

As presented in Table 6, the standardized outer loadings of the 40 indicators ranged from 0.812 to 0.911, exceeding the recommended threshold of 0.70. Cronbach's alpha values ranged from 0.872 to 0.937, while composite reliability values ranged from 0.912 to 0.951. The AVE values ranged from 0.723 to 0.788, exceeding the recommended threshold of 0.50. These results indicate satisfactory indicator reliability, internal consistency reliability, and convergent validity across the eight reflective constructs.

Table 6. Measurement model assessment results.

Construct	Measurement Item	Standardized Outer Loading	Cronbach's α	CR	AVE
PU	PU1	0.911	0.932	0.949	0.788
	PU2	0.890			
	PU3	0.876			
	PU4	0.880			
	PU5	0.880			
PEOU	PEOU1	0.897	0.930	0.947	0.782
	PEOU2	0.883			
	PEOU3	0.879			
	PEOU4	0.875			
	PEOU5	0.887			
EBT	EBT1	0.846	0.872	0.912	0.723
	EBT2	0.855			
	EBT3	0.835			
	EBT4	0.864			
SMM	SMM1	0.888	0.930	0.945	0.741
	SMM2	0.870			
	SMM3	0.812			
	SMM4	0.862			
	SMM5	0.863			
	SMM6	0.868			

Table 6. *Cont.*

Construct	Measurement Item	Standardized Outer Loading	Cronbach's α	CR	AVE
OA	OA1	0.869	0.919	0.939	0.756
	OA2	0.874			
	OA3	0.849			
	OA4	0.866			
	OA5	0.890			
BCO	BCO1	0.886	0.895	0.927	0.761
	BCO2	0.847			
	BCO3	0.877			
	BCO4	0.878			
VC	VC1	0.878	0.915	0.936	0.747
	VC2	0.841			
	VC3	0.864			
	VC4	0.873			
	VC5	0.864			
SMEES	SMEES1	0.885	0.937	0.951	0.762
	SMEES2	0.874			
	SMEES3	0.864			
	SMEES4	0.882			
	SMEES5	0.873			
	SMEES6	0.860			

Note: CR = composite reliability; AVE = average variance extracted. Standardized outer loadings and reliability coefficients of 0.70 or higher and AVE values of 0.50 or higher were considered acceptable.

The HTMT estimates ranged from 0.682 to 0.950. Nineteen of the 28 construct pairs were below the conventional 0.90 guideline, whereas nine exceeded it. Among the nine elevated values were SMM–SMEES (0.949), BCO–SMEES (0.950), and VC–SMEES (0.907), indicating substantial empirical proximity among several constructs (Table S1). However, none of the corresponding 95% BCa bootstrap confidence intervals included 1.00, and all upper confidence bounds remained below 1.00. Taken together, these results provide qualified rather than unequivocal support for discriminant validity. The elevated HTMT values further suggest that relationships involving conceptually related constructs should be interpreted cautiously in conjunction with the collinearity and common-method assessments reported below.

4.4.2. Common Method Bias and Collinearity Assessment

Potential common method bias and collinearity were examined using the full-collinearity VIF approach. As reported in Table 7, the full-collinearity VIF values ranged from 3.344 to 7.752. All eight constructs exceeded the conservative threshold of 3.30, while SMM (5.952), BCO (5.405), VC (5.236), and SMEES (7.752) also exceeded 5.00. Accordingly, potential common method bias and substantial collinearity could not be completely ruled out.

Procedurally, the study incorporated electronic informed consent, voluntary participation, the right to withdraw, confidentiality of responses, aggregate reporting, and preliminary respondent screening before the substantive questionnaire, as described in Section 3.3. These procedures were intended to reduce response-related concerns; however, they do not eliminate the possibility of common method effects.

Table 7. Full-collinearity VIF results for common method bias and collinearity assessment.

Construct	R^2	Full-Collinearity VIF	Assessment
PU	0.701	3.344	Above 3.30
PEOU	0.715	3.509	Above 3.30
EBT	0.797	4.926	Above 3.30
SMM	0.832	5.952	Above 5.00
OA	0.799	4.975	Above 3.30
BCO	0.815	5.405	Above 5.00
VC	0.809	5.236	Above 5.00
SMEES	0.871	7.752	Above 5.00

Note: Full-collinearity VIF was calculated as $1/(1 - R^2)$. A value above 3.30 was treated as a conservative diagnostic flag for potential common method bias or substantial collinearity and therefore warrants cautious interpretation.

As a supplementary diagnostic, Harman's single-factor test was conducted using all 40 measurement items in an unrotated principal axis factoring solution. The first factor accounted for 60.328% of the total variance, exceeding the conventional 50% heuristic. This result further indicates that potential common method effects cannot be ruled out. Accordingly, Harman's test was interpreted as a supplementary diagnostic alongside the full-collinearity VIF results rather than as a standalone assessment of common method bias.

Given the reliance on single-informant, self-reported survey data, the elevated full-collinearity VIFs and the supplementary Harman result suggest that the observed relationships may reflect a combination of substantive associations among conceptually related constructs and shared method effects. These results were therefore treated as an interpretive caution rather than as evidence that common method bias was absent. In particular, unusually large structural coefficients involving closely related constructs were interpreted cautiously in conjunction with the discriminant-validity results reported above and the inner-model collinearity assessment reported in the following section.

4.4.3. Structural Model Assessment and Direct Effects

The structural model was assessed for predictor collinearity, explanatory power, effect sizes, and the significance of the hypothesized direct relationships. Statistical significance was evaluated using 5000 bootstrap subsamples, two-tailed testing, and 95% bias-corrected and accelerated confidence intervals.

Inner VIF values ranged from 1.000 to 4.827 and remained below the 5.00 threshold. However, the VIF values for the predictors of SMEES ranged from 4.316 to 4.827, exceeding the more conservative threshold of 3.30 and indicating elevated predictor collinearity. Structural relationships involving SMEES were therefore interpreted cautiously in conjunction with the common-method and discriminant-validity assessments reported above.

The model explained 60.5% of the variance in EBT and SMM, 72.6% in OA, 68.9% in BCO, 65.7% in VC, and 87.0% in SMEES. Adjusted R^2 values ranged from 0.603 to 0.869 and closely approximated the corresponding R^2 values. SMEES exhibited the highest explained variance ($R^2 = 0.870$; adjusted $R^2 = 0.869$). The explanatory power of the structural model is summarized in Table 8.

The effect-size results indicated substantial variation in the practical relevance of the hypothesized relationships. SMM showed very large effect sizes for BCO ($f^2 = 2.217$) and VC ($f^2 = 1.919$). Medium effect sizes were observed for PEOU → EBT ($f^2 = 0.214$), PEOU → SMM ($f^2 = 0.246$), EBT → OA ($f^2 = 0.150$), SMM → OA ($f^2 = 0.331$), and SMM → SMEES ($f^2 = 0.172$), whereas the remaining relationships showed small effect sizes ranging from 0.031 to 0.120. The very large SMM → BCO and SMM → VC effects should not be interpreted as unequivocal evidence of exceptional substantive dominance. Their magnitudes need to

be considered in light of the empirical proximity among related constructs, the elevated full-collinearity VIFs, and the supplementary common-method diagnostic reported above, all of which may contribute to the observed strength of these associations.

Table 8. Explanatory power of the structural model.

Endogenous Construct	R^2	Adjusted R^2
EBT	0.605	0.603
SMM	0.605	0.603
OA	0.726	0.725
BCO	0.689	0.688
VC	0.657	0.657
SMEES	0.870	0.869

All 13 hypothesized direct relationships were positive and statistically significant, with all 95% BCa confidence intervals excluding zero (Table 9). PEOU showed larger coefficients with EBT and SMM than PU, while the largest path coefficients were observed for SMM → BCO (β = 0.830) and SMM → VC (β = 0.811). Among the direct predictors of SMEES, SMM had the largest coefficient (β = 0.326), followed by BCO (β = 0.249). All 13 direct-effect hypotheses were therefore supported statistically. However, statistical support should be distinguished from substantive magnitude, and the particularly large SMM → BCO and SMM → VC coefficients were interpreted cautiously in light of construct proximity, elevated collinearity, and potential shared method effects identified in the preceding assessments.

Table 9. Unified hypothesis-testing results for direct and specific indirect relationships.

Hypothesis	Effect Type	Hypothesized Relationship	β	t-Value	*p*-Value	95% BCa CI	f^2	Conclusion
H1	Direct	PU → EBT	0.352	4.295	<0.001	[0.204, 0.523]	0.120	Supported
H2	Direct	PEOU → EBT	0.470	5.531	<0.001	[0.292, 0.624]	0.214	Supported
H3	Direct	PU → SMM	0.317	4.327	<0.001	[0.180, 0.475]	0.098	Supported
H4	Direct	PEOU → SMM	0.504	6.437	<0.001	[0.331, 0.638]	0.246	Supported
H5	Direct	EBT → OA	0.358	7.301	<0.001	[0.265, 0.456]	0.150	Supported
H6	Direct	EBT → SMEES	0.137	3.415	0.001	[0.060, 0.218]	0.031	Supported
H7	Direct	SMM → OA	0.532	9.817	<0.001	[0.423, 0.636]	0.331	Supported
H8	Direct	SMM → BCO	0.830	21.101	<0.001	[0.740, 0.887]	2.217	Supported
H9	Direct	SMM → VC	0.811	18.740	<0.001	[0.712, 0.873]	1.919	Supported
H10	Direct	SMM → SMEES	0.326	6.074	<0.001	[0.226, 0.436]	0.172	Supported
H11	Direct	OA → SMEES	0.146	3.028	0.002	[0.055, 0.246]	0.035	Supported
H12	Direct	BCO → SMEES	0.249	4.989	<0.001	[0.147, 0.342]	0.099	Supported
H13	Direct	VC → SMEES	0.148	3.182	0.001	[0.057, 0.238]	0.039	Supported
H14	Specific indirect	EBT → OA → SMEES	0.052	2.933	0.003	[0.021, 0.092]	—	Supported
H15	Specific indirect	SMM → OA → SMEES	0.078	2.714	0.007	[0.029, 0.143]	—	Supported
H16	Specific indirect	SMM → BCO → SMEES	0.207	4.916	<0.001	[0.124, 0.291]	—	Supported
H17	Specific indirect	SMM → VC → SMEES	0.120	3.156	0.002	[0.049, 0.196]	—	Supported

Note: β = standardized path coefficient for direct relationships (H1–H13) and standardized specific indirect effect for specific indirect relationships (H14–H17); BCa CI = bias-corrected and accelerated confidence interval. Confidence intervals were derived from 5000 bootstrap subsamples using two-tailed testing. The f^2 effect size is reported only for direct relationships (H1–H13). Effect sizes of approximately 0.02, 0.15, and 0.35 indicate small, medium, and large effects, respectively.

4.4.4. Specific Indirect Effects

Specific indirect effects were assessed using 5000 bootstrap subsamples and 95% bias-corrected and accelerated confidence intervals. All four hypothesized specific indirect effects were positive and statistically significant, with none of the confidence intervals including zero (Table 9).

The largest estimated specific indirect effect was observed for SMM → BCO → SMEES ($\beta = 0.207$, $p < 0.001$), followed by SMM → VC → SMEES ($\beta = 0.120$, $p = 0.002$), SMM → OA → SMEES ($\beta = 0.078$, $p = 0.007$), and EBT → OA → SMEES ($\beta = 0.052$, $p = 0.003$). All four 95% BCa confidence intervals excluded zero, providing statistical support for H14–H17. These results represent statistically supported specific indirect relationships within the specified structural model and should not be interpreted as evidence of causal mediation or temporal ordering. Moreover, the indirect relationships involving BCO and VC should be interpreted in conjunction with the construct-proximity, collinearity, and potential common-method concerns identified above.

4.5. Predictive Assessment Using PLSpredict

The out-of-sample predictive performance of the model was assessed using PLSpredict with 10 folds and 10 repetitions. Predictive relevance was first examined using Q^2predict, followed by a comparison of the root mean squared error (RMSE) values obtained from PLS-SEM and the linear-model benchmark. CVPAT was subsequently employed to determine whether the differences in predictive loss were statistically significant. The PLSpredict assessment results are summarized in Table 10.

Table 10. PLSpredict assessment of the structural model.

Endogenous Construct	Q^2predict Range	PLS-SEM RMSE < LM RMSE	Indicators	Assessment
SMM	0.386–0.486	6	6	PLS-SEM lower for all indicators
BCO	0.339–0.437	2	4	Mixed performance
EBT	0.357–0.459	4	4	PLS-SEM lower for all indicators
OA	0.272–0.379	5	5	PLS-SEM lower for all indicators
VC	0.416–0.463	0	5	LM lower for all indicators
SMEES	0.392–0.451	5	6	PLS-SEM lower for most indicators
Overall	0.272–0.486	22	30	Moderate predictive performance

Note: Q^2predict values above zero indicate predictive relevance. RMSE = root mean squared error; LM = linear-model benchmark. One SMEES indicator produced equal RMSE values for PLS-SEM and LM at the reported precision.

All indicator-level Q^2predict values were positive (0.272–0.486), indicating predictive relevance across the endogenous constructs. PLS-SEM produced lower RMSE values than the linear-model benchmark for 22 of 30 indicators, with one tie, supporting an overall

characterization of moderate out-of-sample predictive performance. However, predictive performance varied across constructs. In particular, PLS-SEM produced higher RMSE values than the linear-model benchmark for all five VC indicators, indicating weaker relative predictive performance for VC despite its positive Q^2predict values. Thus, predictive relevance for VC should not be interpreted as predictive superiority over the linear-model benchmark. The CVPAT results for predictive model comparison are presented in Table 11.

Table 11. CVPAT results for predictive model comparison.

Construct	PLS-SEM vs. IA: Average Loss Difference	t-Value	*p*-Value	PLS-SEM vs. LM: Average Loss Difference	t-Value	*p*-Value
SMM	−0.516	3.233	0.001	−0.015	2.799	0.005
BCO	−0.466	3.864	0.001	−0.003	0.229	0.819
EBT	−0.480	3.435	0.001	−0.014	1.936	0.054
OA	−0.402	2.837	0.005	−0.009	0.789	0.431
VC	−0.518	3.773	<0.001	0.027	1.125	0.261
SMEES	−0.475	3.267	0.001	−0.011	1.265	0.207
Overall	**−0.478**	**3.344**	**0.001**	**−0.005**	**0.591**	**0.555**

Note: IA = indicator-average benchmark; LM = linear-model benchmark. A negative average loss difference indicates lower predictive loss for PLS-SEM. Statistical significance was evaluated at the 0.05 level.

The CVPAT results showed significantly lower predictive loss for PLS-SEM than for the indicator-average benchmark across all endogenous constructs and overall ($p \leq 0.005$). In contrast, PLS-SEM did not significantly outperform the linear-model benchmark overall ($p = 0.555$), with a significant advantage observed only for SMM ($p = 0.005$). Accordingly, the findings support predictive relevance and moderate out-of-sample predictive performance, but they do not demonstrate overall predictive superiority over the linear-model benchmark. This distinction is particularly important for VC, for which all five indicators showed higher RMSE values under PLS-SEM than under the linear-model benchmark.

4.6. fsQCA Results

fsQCA was used to identify sufficient configurations associated with high and low SME economic sustainability. The analysis comprised calibration, necessity analysis, and sufficiency analysis.

4.6.1. Calibration

The latent-variable scores obtained for the seven antecedent conditions and the outcome were transformed into fuzzy-set membership scores ranging from 0 to 1 using the direct calibration method. Because externally established substantive thresholds were unavailable for these sample-relative latent-variable scores, the 10th, 50th, and 90th percentiles of each construct were used as the anchors for full non-membership, the crossover point, and full membership, respectively. These anchors corresponded to fuzzy-set membership scores of 0.05, 0.50, and 0.95. This percentile-based specification was treated as the primary calibration and represents relative set membership within the present sample rather than universal substantive thresholds. Its sensitivity to alternative calibration anchors was subsequently examined in the robustness analysis. To avoid cases remaining at the point of maximum ambiguity, membership scores exactly equal to 0.500 were recoded to 0.499. The calibration anchors used for the 385 cases are presented in Table 12. These values represent sample-relative thresholds and should not be interpreted as universal substantive cutoffs.

Table 12. Calibration anchors for the fsQCA.

Construct	Full Non-Membership (P10)	Crossover Point (P50)	Full Membership (P90)
PU	−0.992	0.251	0.801
PEOU	−0.652	0.349	0.557
EBT	−0.589	0.247	0.803
SMM	−0.460	0.261	0.621
OA	−1.033	0.245	0.676
BCO	−0.774	0.266	0.794
VC	−0.465	0.189	0.618
SMEES	−0.604	0.301	0.661

Note: P10, P50, and P90 represent the 10th, 50th, and 90th percentiles used as the anchors for full non-membership, the crossover point, and full membership, respectively. These anchors are sample-relative rather than absolute substantive thresholds. Exact fuzzy-set membership scores of 0.500 were recoded to 0.499 to avoid maximum ambiguity.

4.6.2. Necessary-Condition Analysis

Necessary-condition analysis was conducted using a consistency threshold of 0.90. No condition, in either its presence or absence, reached this threshold for high or low SMEES (Table 13). Thus, no single condition was individually necessary for either outcome, and the subsequent analysis focused on sufficient configurations. Accordingly, the recurrence of SMM, OA, or BCO across subsequent sufficient configurations should not be interpreted as evidence that any of these conditions is individually necessary for high SMEES.

Table 13. Necessary-condition analysis for high and low SMEES.

Condition	High SMEES Consistency	High SMEES Coverage	Low SMEES Consistency	Low SMEES Coverage
PU	0.694	0.646	0.662	0.599
~PU	0.569	0.633	0.610	0.659
PEOU	0.660	0.662	0.588	0.574
~PEOU	0.574	0.589	0.654	0.652
EBT	0.676	0.700	0.562	0.566
~EBT	0.581	0.577	0.703	0.679
SMM	0.734	0.732	0.550	0.533
~SMM	0.531	0.548	0.723	0.726
OA	0.799	0.731	0.559	0.497
~OA	0.449	0.511	0.698	0.772
BCO	0.755	0.758	0.536	0.523
~BCO	0.524	0.537	0.752	0.749
VC	0.720	0.667	0.592	0.533
~VC	0.496	0.556	0.631	0.686

Note: A condition was considered necessary when its consistency was equal to or greater than 0.90. The symbol ~ denotes the absence or negation of a condition. High and low SMEES refer to membership in the outcome set and its negation, respectively.

4.6.3. Sufficiency Analysis for High SMEES

The sufficiency analysis applied a frequency threshold of three cases, a consistency threshold of 0.80, and a PRI threshold of 0.70. Following outcome assignment, the retained truth-table rows yielded an effective consistency cutoff of 0.911.

Under the primary specification, the intermediate solution identified seven sufficient configurations for high SMEES (Table 14), with overall solution coverage of 0.676 and solution consistency of 0.842. These configurations represent multiple alternative combinations

associated with high SMEES under the selected calibration and analytical thresholds and should not be interpreted as invariant configurations. Within this primary solution, BCO appeared in six of the seven configurations, while SMM and OA each appeared in five, indicating their comparatively frequent recurrence across the identified configurations. The stability of these recurring conditions and of the exact configuration structure was further examined through the robustness and sensitivity analyses reported below.

Table 14. Sufficient configurations for high SMEES.

Condition	C1	C2	C3	C4	C5	C6	C7
PU	⊗	⊗	—	—	—	—	⊗
PEOU	—	•	—	—	•	—	—
EBT	—	—	•	•	—	—	•
SMM	—	•	•	•	—	•	•
OA	•	—	•	•	•	•	—
BCO	•	•	•	—	•	•	•
VC	—	—	—	•	•	•	•
Raw coverage	0.438	0.330	0.437	0.422	0.436	0.445	0.280
Unique coverage	0.057	0.015	0.018	0.038	0.026	0.011	<0.001
Consistency	0.890	0.931	0.896	0.883	0.899	0.882	0.945

Overall solution metric	**Value**
Solution coverage	0.676
Solution consistency	0.842

Note: • indicates the presence of a core condition; ⊗ indicates the absence of a core condition; • indicates the presence of a peripheral condition; and — indicates a "do not care" condition. Core and peripheral conditions were identified by comparing the intermediate and parsimonious solutions. Values are rounded to three decimal places.

4.6.4. Sufficiency Analysis for Low SMEES

The sufficiency analysis for low SMEES applied the same thresholds as the high-SMEES analysis, yielding an effective consistency cutoff of 0.921. Under the primary specification, the intermediate solution identified two sufficient configurations (Table 15), with overall solution coverage of 0.363 and solution consistency of 0.940. Fewer configurations were identified for low SMEES than for high SMEES. As with the high-SMEES solution, the exact configuration structure should be interpreted as conditional on the selected calibration and analytical thresholds.

Configuration L1 was characterized by the core absence of PEOU, EBT, SMM, OA, and BCO, whereas L2 combined the core presence of PU with the core absence of EBT, SMM, BCO, and VC and the peripheral absence of OA (Table 15). The presence of PU in L2 should not be interpreted as causing low SMEES; rather, it formed part of a conjunctural, sample-relative configuration.

Across both configurations, EBT, SMM, and BCO were consistently absent as core conditions. However, none was individually necessary for low SMEES, as established by the preceding necessity analysis. Moreover, the low-SMEES configurations were not simple inverses of those for high SMEES, illustrating configurational asymmetry between the two outcomes.

Table 15. Sufficient configurations for low SMEES.

Condition	L1	L2
PU	—	•
PEOU	⊗	—
EBT	⊗	⊗
SMM	⊗	⊗
OA	⊗	∅
BCO	⊗	⊗
VC	—	⊗
Raw coverage	0.329	0.191
Unique coverage	0.173	0.034
Consistency	0.949	0.931

Overall solution metric	Value
Solution coverage	0.363
Solution consistency	0.940

Note: • indicates the presence of a core condition; ⊗ indicates the absence of a core condition; ∅ indicates the absence of a peripheral condition; and — indicates a "do not care" condition. Core and peripheral conditions were identified by comparing the intermediate and parsimonious solutions. Values are rounded to three decimal places.

4.6.5. Configurational Asymmetry and Complementarity with PLS-SEM

The high- and low-SMEES configurations were consistent with configurational asymmetry. High SMEES was associated with multiple alternative configurations, whereas the low-SMEES configurations were not simple inversions of those for high SMEES. SMM, OA, and BCO appeared recurrently across the high-SMEES configurations, while their joint absence characterized the low-SMEES configurations.

The fsQCA findings complemented the PLS-SEM results by revealing conjunctural patterns and equifinality beyond the average structural relationships. PLS-SEM identified positive relationships among the specified constructs, whereas fsQCA showed that no individual condition was necessary and that high SMEES could arise through alternative combinations. The absence or irrelevance of a condition within a configuration should therefore not be interpreted as a negative net relationship, but as indicating that high membership in that condition was not required within that particular configuration.

Together, the results show that SME economic sustainability can be understood through both structural relationships among individual constructs and the alternative configurations in which these conditions combine.

4.6.6. Robustness and Sensitivity Analysis

Robustness and sensitivity analyses varied the truth-table frequency threshold, PRI threshold, calibration anchors, and source of construct scores. As summarized in Table 16, stricter frequency thresholds reduced the number of sufficient configurations and solution coverage while maintaining broadly comparable consistency. Lowering the PRI threshold increased both the number of configurations and coverage.

Greater sensitivity was observed for alternative calibration anchors and construct-score sources. The P5/P50/P95 specifications produced substantially higher coverage but lower overall solution consistency, whereas the raw-composite P10/P50/P90 specification yielded results broadly comparable to the primary model. The fixed 2/4/6 calibration produced exceptionally high consistency and coverage, reflecting the concentration of raw composite scores toward the upper end of the response scale; it was therefore retained only as a sensitivity specification.

Table 16. Robustness and sensitivity analysis.

Specification	No. of Configurations	Solution Consistency	Solution Coverage	Main Recurring Pattern
Primary specification	7	0.842	0.676	BCO appeared in six configurations; SMM and OA each appeared in five.
Frequency cutoff = 5	3	0.849	0.623	OA appeared in all three configurations; BCO appeared in two.
Frequency cutoff = 10	2	0.865	0.558	SMM and OA appeared in both configurations; one configuration was SMM × OA × BCO.
PRI cutoff = 0.65	10	0.828	0.721	BCO appeared in seven configurations; EBT, SMM, and OA each appeared in six.
PLS scores; P5/P50/P95 anchors	4	0.757	0.930	OA and BCO emerged as separate terms; EBT appeared in two configurations.
Raw composites; P10/P50/P90 anchors	8	0.839	0.663	SMM, OA, BCO, and VC each appeared in six configurations.
Raw composites; P5/P50/P95 anchors	5	0.758	0.933	OA and BCO emerged as separate terms; EBT, SMM, and the absence of PU each appeared in two configurations.
Raw scale; fixed 2/4/6 anchors	1	0.998	0.951	EBT × SMM × OA × BCO × VC.

Note: The primary specification used PLS latent-variable scores calibrated at the 10th, 50th, and 90th percentiles, with a frequency threshold of three cases, a raw-consistency threshold of 0.80, and a PRI-consistency threshold of 0.70. Unless otherwise indicated, the alternative specifications retained these truth-table thresholds and directional expectations. The fixed 2/4/6 calibration generated an effective frequency cutoff of five cases because the least frequent positive truth-table row contained five cases. Values are rounded to three decimal places.

Overall, the number and composition of sufficient configurations varied across specifications, indicating that the exact configuration structure was specification- and sample-dependent rather than invariant. Nevertheless, SMM, OA, and BCO showed comparatively recurrent presence across multiple specifications, whereas PU, PEOU, EBT, and VC were more specification-sensitive. These recurring patterns should be interpreted as evidence of relative configurational stability rather than individual necessity or universal applicability.

5. Discussion

This study examined how managerial technology perceptions, digital business applications, and organizational capabilities are associated with SME economic sustainability among service-sector SMEs in Thailand. The PLS-SEM results supported all proposed direct and specific indirect relationships, while the fsQCA results showed that high and low SMEES were associated with alternative configurations rather than a single universal configuration. These findings provide complementary structural and configurational explanations of SME economic sustainability [18,19].

The significant indirect relationships through OA, BCO, and VC indicate that the organizational relevance of digital applications extends beyond their direct associations with SMEES. However, because the data are cross-sectional, these relationships should be interpreted as structural associations rather than evidence of temporal ordering or causal mediation. The fsQCA findings further demonstrate equifinality and configurational asymmetry, emphasizing that the relevance of individual conditions depends on the combinations in which they occur [19,56,57]. The robustness and sensitivity analyses further showed that the exact configuration structure was specification- and sample-dependent rather than invariant, while SMM, OA, and BCO showed comparatively recurrent presence across multiple specifications.

5.1. Managerial Perceptions and Digital Business Applications

PEOU showed stronger associations with both EBT and SMM than did PU, with medium effect sizes for PEOU and small effect sizes for PU, although all four relationships were positive and statistically significant. This pattern is consistent with TAM [14], and prior SME research linking PU and PEOU with e-business, e-commerce, and social media adoption [22,29,30]. Previous studies also show that technological knowledge, organizational conditions, experience, and learning influence the adoption and effective use of digital technologies [31,32].

The comparatively stronger relationships associated with PEOU suggest that perceived manageability may be particularly relevant in resource-constrained SMEs. Recognizing the potential value of a technology may be insufficient when its implementation is perceived as difficult, costly, or disruptive [31,32]. This interpretation is particularly relevant to service-sector SMEs, where digital technologies are closely integrated with customer communication, transactions, and service delivery. Evidence from Thai service-sector MSMEs similarly identifies capability needs in digital marketing, customer interaction, and organizational adaptation [41]. These findings position PU and PEOU as managerial perceptual conditions associated with organizational digital application rather than direct explanations of economic sustainability. TAM therefore explains an important perceptual layer of SME digitalization [14], while the broader capability perspective helps explain how digital applications are associated with organizational and economic outcomes [15]. Importantly, the positive structural associations of PU should not be interpreted as implying a stable configurational role. In the fsQCA sensitivity analyses, PU was comparatively specification-sensitive, illustrating that positive net structural relevance and configurational recurrence represent distinct analytical properties.

5.2. Digital Applications and Organizational Capabilities

The results distinguish EBT and SMM as digital applications associated with different organizational functions. Both were positively associated with OA, but SMM showed a stronger relationship with agility and particularly strong relationships with BCO and VC. Digital applications should therefore not be treated as interchangeable manifestations of digitalization. However, the particularly strong SMM–BCO and SMM–VC relationships

should be interpreted cautiously because construct proximity, elevated collinearity, and potential common method effects may have contributed to their magnitude.

EBT represents a more operationally oriented application supporting transactions, information exchange, communication, and coordination. Its association with OA is consistent with prior research linking digital platform, e-commerce, and digital capabilities with organizational agility [24,26,33]. These findings support interpreting EBT as an applied digital resource linked to the informational and coordination foundations of agility rather than as an adaptive capability itself.

SMM, by contrast, provides a market-facing interface through which firms access customer feedback, market information, competitor activity, and stakeholder responses. Previous research similarly links social media with market sensing, customer linking, and organizational responsiveness [23,38,39]. However, access to information should not be equated with agility: SMM provides market-facing information and interaction, whereas OA represents the capability to interpret and respond to such information.

The strong relationships of SMM with BCO and VC further indicate that its organizational relevance extends beyond promotion. Social media can facilitate relationships, networking, opportunity recognition, and value-creation processes [13,23,25]. BCO and VC nevertheless remain conceptually distinct from SMM because they represent the organizational capabilities through which relational and informational resources are developed and utilized. Together, these findings support SMM as a market-facing digital application associated with adaptive, relational, and value-creating capabilities. These conceptual distinctions do not eliminate their empirical proximity; accordingly, the qualified discriminant-validity evidence and elevated collinearity should be considered when interpreting the strength of the SMM–BCO and SMM–VC relationships.

5.3. Digital Applications, Organizational Capabilities, and SME Economic Sustainability

All modeled antecedents were positively associated with SMEES, with SMM showing the strongest direct relationship and BCO the second strongest. This pattern is particularly relevant to service-sector SMEs because customer interaction, market information, relationships, and opportunity development are central to service-based economic activity. It is also consistent with prior research linking social media use and customer-linking or relational capabilities with SME performance and sustainability [13,23,40,58]. EBT, OA, and VC also showed significant direct relationships with SMEES. Their smaller coefficients should be interpreted as unique relationships within the specified structural model rather than evidence of limited strategic relevance. Prior research similarly connects digital technology application with sustainable performance [34–37], organizational agility with organizational outcomes [42], and value-creation capability with SME performance [44]. Nevertheless, the comparatively strong relationships involving SMM and BCO should be interpreted cautiously in light of construct proximity, elevated collinearity, and potential common method effects.

All four hypothesized specific indirect effects were statistically supported, with the largest specific indirect relationship observed for SMM through BCO, followed by VC and OA, while EBT showed a smaller specific indirect relationship through OA. The prominence of BCO highlights the relational dimension of SMM: market-facing interaction may be economically relevant when associated with the development and mobilization of customer, partner, and business relationships [13,23,25,58]. The indirect relationships through VC and OA further indicate that SMM is associated with SMEES through value-creating and adaptive capabilities [13,23,25,42,44], while EBT exhibits a more operationally focused indirect relationship through OA [24,26,33]. Because the study is cross-sectional, these specific indirect relationships should be interpreted as statistically supported structural associations

rather than evidence of temporal ordering or causal mediation. The comparatively large indirect relationships involving BCO and VC should also be interpreted cautiously because the underlying SMM–BCO and SMM–VC relationships are accompanied by construct proximity, elevated collinearity, and potential common method effects.

5.4. Net Structural Relationships and Configurational Explanations

PLS-SEM and fsQCA address different but complementary analytical questions. PLS-SEM estimates specified direct and specific indirect relationships, whereas fsQCA identifies combinations of conditions sufficient for an outcome and captures conjunctural patterns, equifinality, and configurational asymmetry [18,19,56,57].

This distinction is evident in the findings. PLS-SEM identified positive relationships across all hypothesized paths, whereas fsQCA identified multiple sufficient configurations for high SMEES and no individually necessary condition. Within the primary high-SMEES solution, SMM, OA, and BCO appeared recurrently across multiple configurations, although none was required in every configuration. Across the sensitivity specifications, these three conditions also showed comparatively recurrent presence, while the exact configuration structure varied across specifications. Thus, a positive structural relationship can coexist with configurational irrelevance in particular configurations.

PU illustrates this distinction. Although PU was positively associated with EBT and SMM in PLS-SEM, its relative absence appeared in several high-SMEES configurations, while its presence occurred in one configuration within the primary low-SMEES solution. Similarly, VC was present in some high-SMEES configurations but irrelevant in others. These findings do not contradict the structural results; they indicate that configurational relevance depends on the broader conjunction of conditions [19,56,57]. The sensitivity analyses further indicated that PU and VC were comparatively specification-sensitive, reinforcing that configurational relevance should not be inferred directly from the direction or magnitude of structural relationships. Moreover, because calibration used sample-relative percentile anchors, absence represents relative non-membership rather than absolute absence.

Theoretically, this divergence suggests that managerial technology perceptions may function as upstream enabling conditions rather than universally required ingredients of economic sustainability. PU can support the organizational application of digital technologies on average, yet high SMEES may still emerge through alternative combinations of digital applications and organizational capabilities when PU is relatively less prominent. This distinction reinforces the layered logic of the framework: technology-acceptance perceptions help explain digital application, whereas sustained economic outcomes depend more broadly on how digital applications and organizational capabilities are combined. The comparatively recurrent presence of SMM, OA, and BCO across the configurational analyses further suggests that conditions closer to organizational application and capability deployment may play a more consistent role in high-SMEES configurations than upstream perceptual conditions such as PU.

High and low SMEES were also configurationally asymmetric. The low-SMEES configurations were not simple inversions of those associated with high SMEES, and the joint relative absence of EBT, SMM, and BCO characterized both low-outcome configurations in the primary solution. Overall, integrating PLS-SEM and fsQCA indicates that positive structural relationships can coexist with equifinality, condition-specific irrelevance, and configurational asymmetry [18,19].

5.5. The Thai Service-Sector SME Context

The findings should be interpreted within the context of Thai service-sector SMEs, where customer interaction, relationship continuity, responsiveness, and service adjustment

are particularly important. In such firms, the relevance of digitalization may depend not only on access to technology but also on how digital applications are incorporated into customer-facing and organizational activities. Evidence from Thai service-sector MSMEs similarly identifies continuing needs in digital marketing, online customer interaction, and change management [41].

The comparatively recurrent configurational presence of SMM, BCO, and OA is consistent with this contextual interpretation. Social media can support customer communication, market sensing, relationship development, and opportunity recognition [13,23,25], while organizational responsiveness is relevant to firms' ability to respond to changing customer and market information. Evidence from Thai SMEs also links social media agility with business performance [39].

These interpretations should not imply that the observed relationships are unique to Thailand or uniform across all Thai SMEs. National context, owner involvement, organizational informality, and related contextual characteristics were not directly tested. They should therefore be regarded as plausible contextual considerations rather than empirically established mechanisms.

5.6. Boundary Conditions and Scope of Interpretation

Several organizational and environmental conditions may qualify the findings. The analyses were conducted at the overall sample level and did not test whether structural relationships or configurations differ systematically according to firm size, resource availability, service characteristics, digital maturity, or environmental dynamism. These factors should therefore be regarded as potential sources of heterogeneity rather than established moderators.

Firm size and resources may influence how digital technologies and organizational capabilities are developed and used. Smaller firms may depend more heavily on owner-managers and informal decision structures, whereas larger SMEs may distribute digital, marketing, and strategic functions across specialized roles. Prior Thai SME research also indicates that the relationship between social media agility and business performance varies with firm size [39]. Heterogeneity across service activities may further affect the relevance of SMM, EBT, BCO, VC, and OA because service firms differ in customer-contact intensity, transaction frequency, and relationship dependence.

Digital maturity and environmental dynamism provide additional boundaries. Firms may differ in technological experience, system integration, employee skills, and data-use routines even when reporting similar levels of digital application [41]. Likewise, rapidly changing customer preferences and competitive conditions may increase the relevance of sensing and organizational responsiveness [33,39]. Neither digital maturity nor environmental dynamism was directly modeled in this study.

These considerations also qualify the configurational findings. The fsQCA solutions indicate equifinality within the observed sample, while the robustness and sensitivity analyses showed that the exact configuration structure varied across analytical specifications. The configurational findings should therefore be interpreted as specification- and sample-dependent and should not be expected to reproduce identically in different populations or under alternative calibration schemes [18,19,56,57]. Future research should therefore examine these contingencies through multigroup analysis, moderation analysis, subgroup-specific fsQCA, and independent-sample replication.

5.7. Theoretical Implications

The study contributes to SME digitalization research by specifying a layered theoretical architecture that distinguishes four analytical levels: managerial perceptions, digital

business applications, organizational capabilities, and SME economic sustainability. The theoretical contribution lies not in combining these elements per se, but in clarifying their distinct explanatory roles and the relationships linking technology acceptance, organizational application, capability development, and economic outcomes.

First, the framework extends the organizational application of TAM by positioning PU and PEOU as managerial perceptual conditions associated with EBT and SMM [14]. TAM therefore explains an enabling perceptual layer of digitalization without being treated as a complete explanation of economic sustainability. This delineates the explanatory boundary of TAM: it helps account for perceptual conditions associated with digital application, whereas capability-based explanations are required to interpret the organizational and economic relationships associated with those applications.

Second, the framework distinguishes digital applications from organizational capabilities. EBT represents an operationally oriented digital application, while SMM represents a market-facing application [22,23]. OA is most directly aligned with adaptive dynamic capability logic [15,24,42], whereas BCO represents a relational or networking capability [13,25,43], and VC represents a value-creating capability [13,25,44]. This distinction avoids treating technology use itself, or every organizational capability, as a dynamic capability.

Third, the significant specific indirect relationships provide evidence consistent with the proposed capability-conversion logic. Digital applications are associated with SMEES both directly and through statistically supported specific indirect relationships involving distinct organizational capabilities, although these cross-sectional relationships do not establish temporal or causal sequencing.

Finally, integrating PLS-SEM and fsQCA extends the framework beyond an exclusively net-effect explanation [18,19]. The results accommodate both structural relationships and alternative sufficient configurations, thereby incorporating equifinality and configurational asymmetry into the explanation of SME economic sustainability [19,56,57]. The robustness and sensitivity analyses further indicate that the exact configuration structure is specification- and sample-dependent, while SMM, OA, and BCO show comparatively recurrent configurational presence across multiple specifications.

5.8. Practical and Policy Implications

For service-sector SMEs, digitalization should be managed as a capability-development process rather than solely as technology acquisition. The comparatively strong relationships associated with PEOU suggest that managerial attention should be given to the manageability of digital technologies, their compatibility with existing routines, and the skills required for their effective use [22,29–32]. This priority is consistent with identified capability needs among Thai service-sector SMEs [41].

SMM should likewise be treated as a source of market intelligence rather than merely a promotional channel. Customer comments, enquiries, reviews, and recurring service requests can support market sensing and customer linking [23,25]. Firms can establish routines for interpreting this information, identifying opportunities or problems, assigning responsibility, and making timely service or communication adjustments.

Relational capability represents another managerial priority. The relevance of BCO suggests that digital relationships should be evaluated according to the opportunities, resources, referrals, collaboration, market access, and knowledge they generate rather than audience size alone [13,23,25,43,58]. At the same time, the configurational findings do not support a single universal capability profile. Because the exact configuration structure varied across analytical specifications, the identified configurations should not be treated as fixed managerial prescriptions. Managers may instead use the recurring rel-

evance of digital application, relational capability, and organizational responsiveness to identify complementary capability gaps rather than follow a uniform sequence of digital investments [19,56,57].

For policymakers and SME-support organizations, digital-support programs can extend beyond platform use and basic technical skills toward market sensing, customer-information use, relationship management, opportunity recognition, and rapid-response routines [41]. Network-building initiatives may also support SMEs' access to external relationships, knowledge, resources, and business opportunities [43,59]. These recommendations are derived from observed associations and configurations and should not be interpreted as causally tested interventions.

5.9. Limitations and Future Research

First, purposive sampling and the focus on Thai service-sector SMEs limit statistical generalizability. Future studies should replicate the framework using broader, probability-based, cross-sectoral, and cross-national samples.

Second, the cross-sectional design limits temporal and causal interpretation. The significant direct and specific indirect relationships do not establish temporal ordering or causal mediation. Longitudinal or temporally separated designs would provide stronger evidence regarding capability-development processes.

Third, the measures relied primarily on single-informant self-reports, and the measurement assessment provided qualified rather than unequivocal support for discriminant validity. Although no 95% BCa HTMT confidence interval included 1.00, nine of the 28 HTMT ratios exceeded the 0.90 guideline, particularly among conceptually proximate constructs. Common-method concerns also remain because the first factor in Harman's single-factor test accounted for 60.328% of the total variance, while the full-collinearity VIF values ranged from 3.344 to 7.752; SMM, BCO, VC, and SMEES exceeded 5.00. These diagnostics do not by themselves establish common method bias; however, when considered alongside the single-informant design and elevated HTMT values, they indicate that potential shared method effects and empirical overlap among constructs could not be completely ruled out. Future studies should employ multiple informants and, where feasible, combine perceptual measures with temporally separated or objective indicators of organizational and economic outcomes.

Fourth, the predictive assessment indicated predictive relevance and moderate out-of-sample predictive performance, but it did not demonstrate overall predictive superiority over the linear-model benchmark. All Q^2predict values were positive, and PLS-SEM produced lower RMSE values than the linear model for 22 of the 30 indicators, with one tie. However, CVPAT showed no significant overall predictive advantage over the linear-model benchmark ($p = 0.555$), and the PLS-SEM RMSE values for all five VC indicators were higher than their corresponding linear-model values. These findings therefore warrant a cautious interpretation of predictive performance, and future research should examine predictive generalizability using independent samples.

Fifth, the fsQCA results were sensitive to calibration choices and analytical specifications [19,56,57]. The number and composition of sufficient configurations varied across specifications; therefore, the exact minimized configurations should not be interpreted as universal formulas. The comparatively recurrent presence of SMM, OA, and BCO across multiple specifications is more appropriately interpreted as a recurring configurational pattern than as evidence of individual necessity or an invariant solution. Independent-sample replication, alternative theoretically justified calibrations, and qualitative or process-oriented case studies could strengthen configurational interpretation.

Finally, the study did not directly test heterogeneity associated with firm size, resources, service characteristics, digital maturity, or environmental dynamism. Future research should examine these potential boundary conditions through multigroup, moderation, subgroup-specific configurational, and replication analyses.

6. Conclusions

This study examined how managerial technology perceptions, digital business applications, and organizational capabilities are associated with SME economic sustainability among service-sector SMEs in Thailand using complementary PLS-SEM and fsQCA analyses. Social media marketing was positively associated with organizational agility, business connections and opportunities, value creation, and SME economic sustainability. The specific indirect results further indicated statistically supported relationships between digital applications and SME economic sustainability through organizational capabilities. From a configurational perspective, no individual condition met the threshold for necessity. Under the primary fsQCA specification, seven sufficient configurations were identified for high SMEES; however, sensitivity analyses showed that the exact configuration structure varied across alternative specifications. Social media marketing, organizational agility, and business connections and opportunities were comparatively recurrent across these analyses.

The findings contribute by distinguishing the explanatory roles of managerial technology perceptions, digital business applications, and organizational capabilities in relation to SME economic sustainability. The integration of PLS-SEM and fsQCA provides complementary structural and configurational perspectives: the former estimates the specified structural associations among constructs, whereas the latter identifies multiple sufficient configurations associated with high SME economic sustainability. Predictive assessment indicated moderate out-of-sample predictive performance, but CVPAT did not show significant overall superiority over the linear-model benchmark ($p = 0.555$).

These conclusions should be interpreted in light of several limitations. The cross-sectional design does not establish causality or temporal ordering. Construct proximity, qualified rather than unequivocal support for discriminant validity, elevated collinearity, and potential common method effects warrant caution when interpreting the larger structural coefficients. Finally, the outcome examined is economic sustainability among Thai service-sector SMEs and should not be generalized directly to social or environmental sustainability or to other sectors and national contexts.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/su182110789/s1: Table S1: Heterotrait–monotrait ratios and 95% BCa bootstrap confidence intervals; Table S2: Indicator-level audit trail of the Round 1 e-Delphi refinement; Table S3: Full 40-Item Measurement Instrument.

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