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VALIDATING A HIERARCHICAL MEASUREMENT FRAMEWORK FOR BUSINESS CONTINUITY MANAGEMENT AND SUSTAINABLE PERFORMANCE IN THAI SMES: AN INTEGRATED INTERVAL TWO FUZZY LOGIC AND SECOND-ORDER CFA

Akares Suktalordcheep[1], Somchai Lekcharoen[2], Sumaman Pankham[3]

[1]College of Digital Innovation Technology, Rangsit University, Pathum Thani 12000, Thailand. Email: akares.s67@rsu.ac.th, ORCID ID: 0009-0001-4257-3435
[2]College of Digital Innovation Technology, Rangsit University, Pathum Thani 12000, Thailand. Email: somchai.l@rsu.ac.th, ORCID ID: 0009-0003-2207-6006
[3]College of Digital Innovation Technology, Rangsit University, Pathum Thani 12000, Thailand. Email: sumaman.p@rsu.ac.th, ORCID ID: 0009-0002-6821-7049

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Corresponding Author: Somchai Lekcharoen (somchai.l@rsu.ac.th)

ABSTRACT

This study develops and validates a hierarchical measurement framework for leadership, open innovation, social media usage, business continuity management (BCM), and sustainable performance in Thai small and medium-sized enterprises (SMEs). Although these constructs are widely discussed in SME resilience and sustainability research, empirical progress is often constrained by inconsistent operationalisation, limited contextual adaptation, and insufficient validation of hierarchical construct structures in emerging economy settings. To address this limitation, the study adopts a two-stage measurement validation design integrating interval two fuzzy logic and second-order confirmatory factor analysis (CFA). In the first stage, a purposive panel of 21 experts from academic, public, and SME practice backgrounds evaluated the relevance and clarity of the proposed indicators, and all retained items exceeded the predefined acceptance threshold. In the second stage, survey data from 817 Thai SME respondents were used to assess the adequacy of the hierarchical measurement structure. The results show that the proposed second-order model demonstrates excellent fit, with $\chi^2/df = 1.706$, CFI = 0.985, TLI = 0.984, RMSEA = 0.029, AGFI = 0.919, NFI = 0.965, IFI = 0.985, RMR = 0.023, and GFI = 0.928. These findings support the contextual suitability of the retained indicators and confirm the coherence of the hierarchical construct structure in the Thai SME context. The study contributes a transparent and replicable validation pipeline that strengthens construct operationalisation for continuity- and sustainability-related research. Practically, the validated instrument can support diagnostic assessment of SME readiness and capability gaps, thereby providing a stronger measurement foundation for future structural and comparative research.

KEYWORDS: Thai SMEs, Leadership, Open Innovation, Social Media Usage, Business Continuity Management, Sustainable Performance, Fuzzy Logic, Second-Order CFA.

1. INTRODUCTION

Small and medium-sized enterprises (SMEs) play a central role in Thailand's employment generation, value creation, and economic continuity, yet they remain highly vulnerable to disruption arising from supply interruptions, market volatility, digital shocks, and crisis events (Aem-on et al., 2024; Paweehirunkrai & Pankham, 2025). In this context, business continuity management (BCM) is increasingly recognised not merely as an operational contingency function, but as a strategic organisational capability that supports resilience, recovery, and longer term sustainability (Galaitsi et al., 2023). However, despite growing scholarly and practical interest in BCM, empirical progress remains constrained by measurement approaches that are often treated as narrow checklists or transferred across contexts without sufficient validation for emerging economy SMEs (Corrales-Estrada et al., 2021).

The same concern applies to the broader capability domains frequently discussed in relation to SME continuity and sustainability. Leadership, open innovation, and social media usage are often identified as important organisational and digital capabilities in turbulent environments because they shape information mobilisation, learning, external collaboration, and response readiness under uncertainty (Heenkenda et al., 2022; Gonibeed et al., 2023; Khumalo & Lingen, 2017; Malang et al., 2021). However, prior studies have often operationalised these constructs inconsistently, relied on context-specific items without rigorous screening, or treated multidimensional phenomena as simple single-layer measures (Tetteh et al., 2024). As a result, the literature still lacks sufficiently validated hierarchical instruments capable of representing these capabilities in Thai SMEs with adequate contextual relevance and measurement clarity (Paweehirunkrai & Pankham, 2025).

This issue is particularly important for BCM and sustainable performance because both constructs are conceptually multidimensional and are not well represented by simplistic or weakly validated indicators (Ali et al., 2023; Jones et al., 2023). BCM typically encompasses interrelated dimensions such as risk assessment, continuity planning, resource preparedness, communication, testing, and recovery capability, while sustainable performance commonly integrates economic, social, and environmental dimensions (Ali et al., 2023; Martins et al., 2022; Estébanez & Martín, 2025). When such constructs are studied without sufficient attention to construct hierarchy and contextual appropriateness, the validity of subsequent empirical inference is weakened, even when sample sizes are large and statistical models appear strong (Madhavan et al., 2022; Hair et al., 2019).

Accordingly, the present study is framed as a measurement validation study rather than a structural hypothesis testing study. Its purpose is to develop and validate a hierarchical measurement framework for leadership, open innovation, social media usage, BCM, and sustainable performance in Thai SMEs using a two-stage validation pipeline. In the first stage, interval two fuzzy screening is employed to evaluate indicator relevance and clarity through expert judgement before empirical estimation (Makhija & Goel, 2019). In the second stage, second-order confirmatory factor analysis is used to validate the hierarchical structure of the retained constructs and assess their measurement adequacy in a large Thai SME sample (Hair et al., 2019; Madhavan et al., 2022).

This methodological approach responds to an important gap in the literature. Although prior research has acknowledged the relevance of continuity, resilience, and sustainability related capabilities in SMEs, fewer studies have combined expert based indicator screening with hierarchical construct validation in a transparent and replicable sequence, especially in emerging economy settings (Junaidi, 2024; Madhavan et al., 2022). This is particularly relevant in Thai SMEs, where continuity practices, digital capability deployment, and sustainability orientation may vary considerably across firms, making direct adoption of unvalidated instruments problematic (Paweehirunkrai & Pankham, 2025; Steen et al., 2023).

The study makes three contributions. First, it provides a contextually validated measurement instrument for BCM and sustainable performance alongside related enabling capability domains in Thai SMEs, thereby strengthening construct operationalisation for future empirical work (Madhavan et al., 2022; Paweehirunkrai & Pankham, 2025). Second, it advances methodological practice by integrating interval two fuzzy screening with second-order CFA in a single validation pipeline designed to improve measurement credibility before any subsequent structural analysis (Makhija & Goel, 2019; Hair et al., 2019; Junaidi, 2024). Third, the validated instrument offers practical diagnostic value by enabling more consistent assessment of continuity readiness and sustainability related capability gaps in SMEs, thereby supporting more targeted managerial and policy interventions (Russo et al., 2025; Galaitsi et al., 2023).

2. LITERATURE REVIEW AND CONCEPTUAL FOUNDATIONS

2.1. Theoretical Lens: Capability-Based Measurement in SME Resilience Research

Research on SME resilience and sustainability increasingly adopts a capability-based perspective, which holds that performance under disruption depends not only on resources, but also on the firm's ability to sense threats, mobilise information, coordinate action, and adapt over time (Galaitsi et al., 2023; Corrales-Estrada et al., 2021). From this perspective, BCM can be viewed as an organisational capability that enables firms to maintain critical functions and recover within acceptable timeframes (Matteis et al., 2023), while sustainable performance reflects the ability to balance economic continuity with social and environmental responsibility over time (Tang et al., 2023). This perspective supports treating continuity- and sustainability-related constructs as complex and potentially hierarchical rather than as isolated single indicators (Madhavan et al., 2022).

2.2. Social Media Usage As A Measurable Digital Capability

In SMEs, social media usage has developed into a digital capability that supports market sensing, customer engagement, feedback acquisition, and network mobilisation (Martín-Rojas et al., 2023). Under disruption, these functions strengthen responsiveness and continuity-related decision making (You et al., 2023), while also supporting stakeholder engagement and communication of responsible business practices (Russo et al., 2021). However, prior studies have operationalised social media usage inconsistently, creating ambiguity about what is actually being measured (Floris & Dettori, 2020). A contextually validated approach is therefore needed for Thai SMEs (Kiatsangsilp & Pankham, 2025).

2.3. Open Innovation and the Measurement of External Knowledge Mobilisation

Open innovation refers to purposive knowledge flows across organisational boundaries, including collaboration with customers, suppliers, institutions, and other external actors (Chaochotechuang et al., 2019). In SMEs, it is especially valuable because it expands access to ideas, technologies, and problem-solving capacity despite limited internal resources (Costa et al., 2023). In continuity-related contexts, such collaboration may support backup arrangements, alternative sourcing, information sharing, and coordinated responses during shocks (Sinha & Ola, 2021). It is also relevant to sustainability because it can support cleaner processes, service improvement, and responsiveness to stakeholder expectations (Annamalah et al., 2020). Nevertheless, the construct is often measured in ways that do not fully reflect its collaborative and co-creation nature in SMEs, making stronger indicator validation necessary (Puriwat & Tripopsakul, 2021; Madhavan et al., 2022).

2.4. Leadership Under Uncertainty as A Construct Requiring Contextual Validation

Leadership is widely recognised in the resilience literature as a core organisational capability because it shapes how firms interpret threats, coordinate responses, communicate priorities, and learn after disruption (Suriyankietkaew et al., 2022; Helgeson et al., 2021). In SMEs, leadership is especially consequential because decision authority is concentrated and response time is limited (Dey et al., 2023). Relevant behaviours include clarity of direction, calmness under pressure, empowerment, adaptive decision making, and learning orientation (Iyer, 2024; Walker & Ramos-Rea, 2025). Leadership is also relevant to sustainability because leaders shape organisational priorities and the balance between short-term survival and longer-term responsibility (Baird et al., 2023). Because these behaviours are not always operationalised consistently, a clearly validated measurement model is required before broader causal interpretation is attempted (Balasubramanian & Fernandes, 2022).

2.5. Business Continuity Management as A Hierarchical Construct

BCM comprises interrelated activities such as risk identification, continuity planning, backup preparation, communication, training, testing, revision, and recovery capability (Ali et al., 2023). These elements are distinguishable but operationally interconnected, supporting the treatment of BCM as a hierarchical rather than a flat construct (Galaitsi et al., 2023). A second-order representation is appropriate when lower-order dimensions collectively reflect an overall continuity capability (Madhavan et al., 2022). This is particularly relevant in emerging economy SME settings, where continuity practices may be uneven, informal, or only partially institutionalised (Steen et al., 2023). Accordingly, BCM in the present study is treated as a construct requiring both contextual screening of indicators and empirical validation of hierarchical structure (Paweehirunkrai & Pankham, 2025).

2.6. Sustainable Performance As A Multidimensional Outcome Domain

Sustainable performance is commonly conceptualised as a multidimensional construct integrating economic, social, and environmental outcomes rather than financial results alone (Jones et al., 2023). In SMEs, it may be reflected in resource efficiency, waste reduction, employee wellbeing, ethical operations, responsible customer value creation, and financial stability (Martins et al., 2022). Because these dimensions are correlated yet distinct, sustainable performance is frequently modelled as a higher-order construct (Estébanez & Martín, 2025). This reduces the risk of oversimplifying sustainability through narrow indicators (Shaukat & Alam, 2023). Robust measurement validation is therefore needed to ensure that sustainable performance is represented appropriately in the Thai SME context (Paweehirunkrai & Pankham, 2025).

2.7. Related Capability Domains Within The Broader Measurement Architecture

Corporate branding, innovation capability, and competitive advantage are also relevant to the broader capability architecture examined in this study because they represent organisational domains through which SMEs build market position, adaptability, and performance potential (Samiei et al., 2025; Handini et al., 2021). Corporate branding concerns trust, consistency, and stakeholder recognition, while innovation capability captures the ability to develop and implement new products, services, or processes (Samiei et al., 2025). Competitive advantage reflects the ability to differentiate and respond more effectively than rivals in dynamic markets (Handini et al., 2021). These constructs are included not to test a full causal chain in the present paper, but to support conceptual coherence and future empirical application of the validated instrument (Achmad & Wiratmadja, 2025; Osiyevskyy et al., 2025).

2.8. Measurement Implications And Conceptual Framework

Taken together, the literature indicates that leadership, open innovation, social media usage, BCM, and sustainable performance are conceptually important in SME resilience and sustainability research, but their empirical usefulness depends on sound operationalisation and contextual validity (Galaitsi et al., 2023; Suriyankietkaew et al., 2022). The review also indicates that BCM and sustainable performance are more appropriately treated as hierarchical constructs because they represent bundles of interrelated practices and outcomes rather than single-dimension phenomena (Ali et al., 2023; Estébanez & Martín, 2025). These observations justify the hierarchical measurement framework adopted in this study (Madhavan et al., 2022). To strengthen construct operationalisation before later structural analysis, the study integrates expert-based interval two fuzzy screening with second-order confirmatory factor analysis in the Thai SME context (Makhija & Goel, 2019; Hair et al., 2019; Paweehirunkrai & Pankham, 2025). Figure 1 summarises the hierarchical measurement architecture that guided the subsequent validation procedures in this study.

Table 1: Construct operationalisation and item sources (Source Author).

Construct	Item code	Measurement item wording
Social Media Usage (SMU)	SMU1	Our firm actively uses social media to promote products or services and strengthen market visibility.
	SMU2	We use social media to communicate with customers and respond to enquiries or complaints promptly.
	SMU3	Social media is used to monitor customer needs, competitor activities, and market trends.
	SMU4	We use social media to build relationships and engage customers through interactive content.
	SMU5	Social media supports our sales activities such as lead generation, online orders, or booking.
	SMU6	Social media improves internal coordination by enabling fast information sharing and decision support.
	CB1	Our firm communicates a clear and consistent brand identity across touchpoints.

Corporate Branding (CB)	CB2	Our brand values are well defined and guide how we present the business to stakeholders.
	CB3	Our brand is distinctive and easily recognised by customers in our market.
	CB4	We invest in building trust and credibility through our corporate brand reputation.
	CB5	Our corporate brand strengthens customer loyalty and positive word of mouth.
Open Innovation (OI)	OI1	We collaborate with external partners such as suppliers, customers, or institutions to improve offerings.
	OI2	We actively seek external ideas and knowledge to support product or service development.
	OI3	Customer feedback is systematically used to refine and improve our products or services.
	OI4	We share knowledge with partners to co create solutions that benefit both sides.
	OI5	We participate in networks or communities to access resources and innovation opportunities.
	OI6	We are willing to adopt or commercialise ideas originating outside the firm when appropriate.
Leadership (LD)	LD1	Leaders in our firm provide clear direction during disruption and uncertainty.
	LD2	Leaders communicate timely information and coordinate actions when unexpected events occur.
	LD3	Leaders encourage employees to remain proactive and solution oriented in challenging conditions.
	LD4	Leaders support learning from disruptions to strengthen future preparedness.
	LD5	Leaders empower staff to make decisions quickly when continuity is threatened.
	LD6	Leaders demonstrate responsibility and calmness which strengthens confidence during crises.
Innovation Capability (IC)	IC1	Our firm is capable of developing new or improved products or services.
	IC2	We can introduce new processes or ways of working to increase efficiency or quality.
	IC3	We are able to adopt new technologies that enhance business performance.
	IC4	We can transform ideas into implementable outcomes within a reasonable timeframe.
	IC5	We regularly learn and upgrade skills to support continuous innovation.
Competitive Advantage (CA)	CA1	Our firm delivers superior value to customers compared with competitors.
	CA2	We can differentiate our products or services in ways that customers recognise.
	CA3	We compete effectively through cost efficiency or better resource utilisation.
	CA4	We respond to market changes faster than key competitors.
	CA5	Our firm maintains a strong competitive position that is difficult for rivals to imitate.

Business Continuity Management (BCM)	BCM1	Our firm identifies key risks and assesses how disruptions could affect operations.
	BCM2	We have defined continuity procedures for maintaining critical activities during disruption.
	BCM3	We have resources or backups in place such as alternative suppliers, data backups, or contingency stock.
	BCM4	Employees are informed about continuity roles and procedures in the event of disruption.
	BCM5	We test, review, or improve continuity practices based on lessons learned.
	BCM6	Our firm can restore operations within an acceptable time after an unexpected event.
Sustainable Performance (SP)	SP1	Our firm achieves stable financial outcomes while operating under uncertainty.
	SP2	We improve operational efficiency and reduce waste or unnecessary resource use.
	SP3	We consider environmental impacts in operations and seek to reduce negative effects.
	SP4	We treat employees fairly and support their wellbeing and development.
	SP5	We contribute positively to customers and community through responsible business practices.
	SP6	Overall, our firm sustains performance over time by balancing economic, social, and environmental priorities.

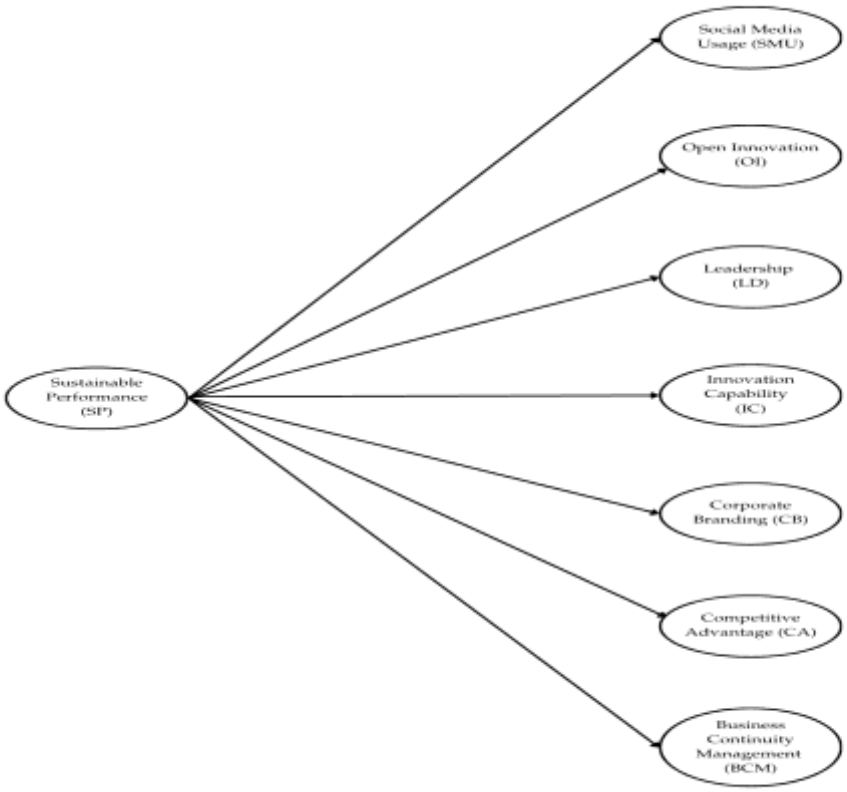

Figure 1. Conceptual framework (Source Author).
The conceptual framework guiding the measurement validation.

3. METHODS

3.1. Research Design

This study employed a quantitative measurement validation design to develop and validate a hierarchical measurement framework for leadership, open innovation, social media usage, business continuity management (BCM), and sustainable performance in Thai SMEs. The study focused on indicator suitability, construct clarity, and hierarchical measurement adequacy rather than testing causal relationships among the focal constructs.

The research design consisted of two sequential stages. First, expert-based interval two fuzzy screening was used to evaluate the relevance and clarity of draft indicators and refine the instrument before large-scale data collection. Second, survey data from Thai SMEs were analysed using confirmatory factor analysis, including first-order and second-order validation. This sequence strengthened the measurement process from content refinement to hierarchical empirical validation. The overall research workflow is presented in Figure 2, showing the two-stage process from expert-based interval two fuzzy screening to empirical measurement validation.

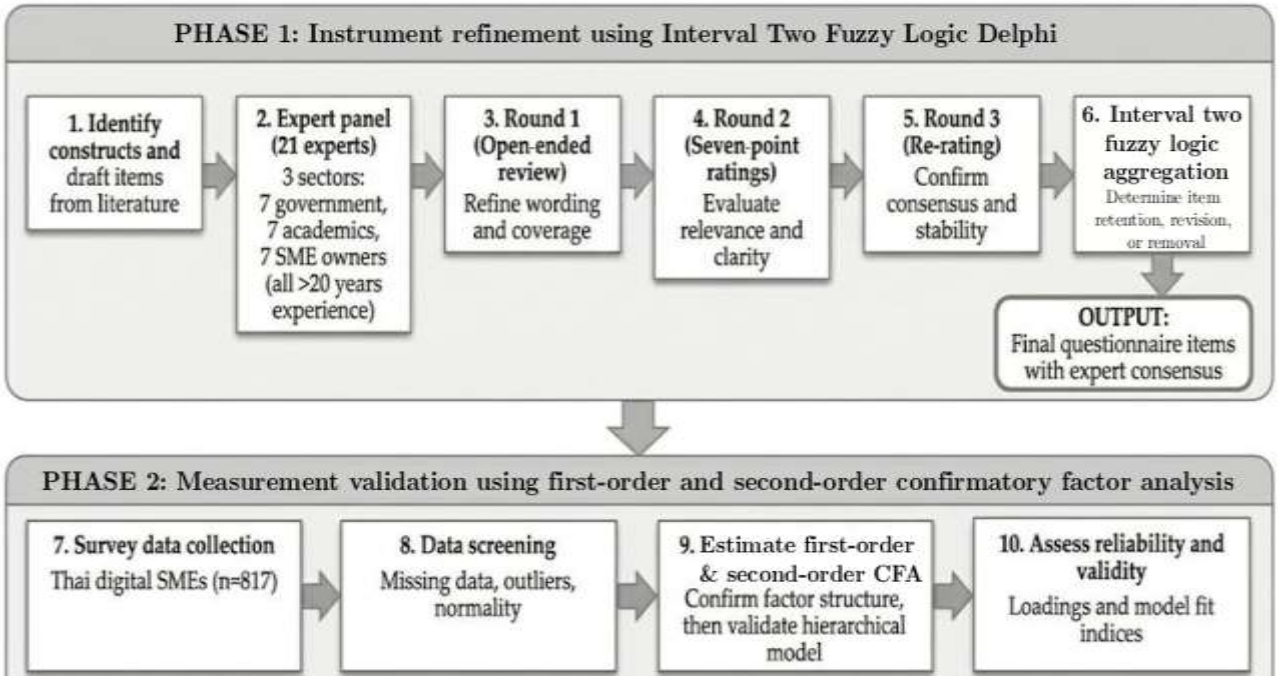

Figure 2. Research design and analysis workflow (Source Author).

As shown in Figure 2, the study proceeded sequentially from instrument refinement to first-order and second-order confirmatory factor analysis.

3.2. Instrument Development

The measurement instrument was developed from established scales in the literature on SMEs, organisational capabilities, BCM, and sustainable performance. The initial item pool covered eight latent constructs: social media usage, open innovation, leadership, corporate branding, innovation capability, competitive advantage, BCM, and sustainable performance. All constructs were specified as reflective measures and assessed using a seven-point Likert scale ranging from 1 = strongly disagree to 7 = strongly agree.

To improve contextual appropriateness, the wording of the draft items was adapted to Thai SME business practices while preserving the conceptual meaning of the source measures. Particular attention was given to item clarity, contextual fit, and conceptual consistency. Because the study aimed to validate the measurement framework rather than simply reuse existing scales, instrument refinement was treated as a central methodological stage. The full construct operationalisation and item wording are presented in Table 1.

3.3 Expert Panel and Interval Two Fuzzy Screening

The expert review focused on two criteria: item relevance and item clarity. Interval two fuzzy logic was used because it offers a structured way to analyse expert judgements under linguistic uncertainty before empirical validation. To operationalise the review, a common linguistic rating

scale was converted into triangular fuzzy values. Table 2 presents the linguistic scale and the corresponding lower, modal, and upper values.

The same rating structure was applied to both criteria to ensure consistency. The screening process involved three steps: converting expert judgements into triangular fuzzy values, aggregating these values into crisp scores, and comparing the scores with the predefined acceptance threshold to determine item retention.

Table 2. Linguistic scale and corresponding fuzzy values used in expert screening (Source Author).

Linguistic rating	Lower (L)	Modal (M)	Upper (U)
Very high	0.90	1.00	1.00
High	0.70	0.90	1.00
Moderately high	0.50	0.70	0.90
Moderate	0.30	0.50	0.70
Moderately low	0.10	0.30	0.50
Low	0.00	0.10	0.30
Very low	0.00	0.00	0.10

Note. The linguistic ratings were transformed into triangular fuzzy values to represent expert judgements under uncertainty prior to aggregation and defuzzification.

This stage was included to strengthen content validity before statistical model estimation and to reduce the likelihood that subsequent CFA results would be influenced by poorly specified or contextually ambiguous items. Detailed fuzzy screening outcomes and item retention decisions are reported in the Results section. The interval two fuzzy representation used to express expert linguistic judgements is illustrated in Figure 3.

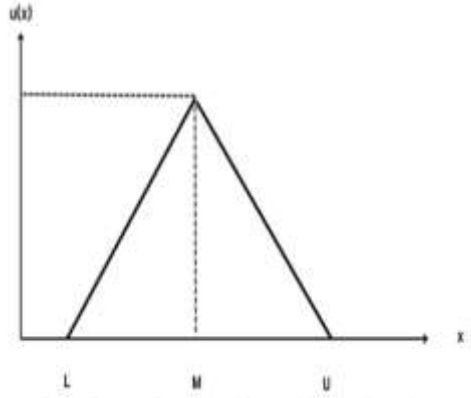

Figure 3. Triangular fuzzy representation based on interval two fuzzy logic for expert linguistic judgements (Source Author).

Figure 3 shows the triangular fuzzy representation used to capture uncertainty in expert linguistic judgements during the screening stage. In this representation, x denotes the assessment value and μ(x) denotes the degree of membership. The three values L, M, and U represent the lower bound, the most plausible value, and the upper bound of each expert judgement, respectively. Together, these three values form the fuzzy number used to represent each linguistic response under uncertainty. More specifically, L indicates the minimum plausible value assigned to a judgement, M represents the value with the highest degree of membership, and U indicates the maximum plausible value considered plausible by the expert.

Accordingly, each expert judgement can be expressed as a triangular fuzzy number:

$$F = (L, M, U)$$

where L, M, and U denote the lower, modal, and upper values of the judgement, respectively. The corresponding membership function is defined as:

$$\mu_f(x) = \begin{cases} \dfrac{x-l}{m-l} & l < x < m \\ \dfrac{u-x}{u-m} & m < x < u \\ 0 & otherwise \end{cases}$$

This function increases linearly from L to M and decreases linearly from M to U, with M representing the point of highest membership. The triangular form was adopted because it offers a transparent and practical way to convert linguistic expert responses into fuzzy values that can be aggregated systematically. To further illustrate how fuzzy values were used in the item screening stage, the selection logic underlying indicator retention is presented in Figure 4.

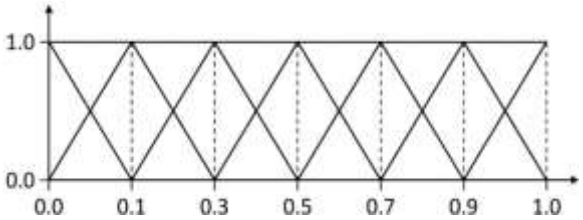

Figure 4. Selection of factors in fuzzy theory used for indicator screening (Source Author).

For each indicator, the fuzzy values obtained from expert responses were aggregated across rounds, and the resulting triangular fuzzy numbers were then converted into crisp scores. A cutoff of 0.75 was adopted to ensure that only indicators demonstrating sufficiently strong expert agreement were retained for subsequent empirical validation. Indicators meeting or exceeding this threshold were accepted,

whereas indicators below the cutoff would have been excluded from the next stage of analysis. The lower, modal, and upper values reported later in Table 4 correspond directly to the triangular fuzzy representation presented in Figure 3 and the screening logic summarised in Figure 4.

3.4. Survey Sample and Data Collection

After expert screening, the retained questionnaire was administered to SME respondents in Thailand through a combination of online and field distribution channels. Participation was voluntary and anonymous. Target respondents were individuals with direct knowledge of business operations, such as owners or partners, to ensure informed responses regarding firm-level practices and capabilities.

A total of 817 usable responses were retained after data screening. This sample size was considered adequate for confirmatory factor analysis and hierarchical measurement validation. To preserve the distinction between procedure and findings, detailed respondent and firm characteristics are reported in the Results section.

3.5 Data Screening

Prior to confirmatory factor analysis, the dataset was screened for completeness, outliers, and distributional adequacy to ensure suitability for covariance-based measurement analysis. These checks were conducted to support the reliability of the subsequent first-order and second-order confirmatory factor analyses.

3.6. First-Order Confirmatory Factor Analysis and Measurement Quality Assessment

Following data screening, first-order confirmatory factor analysis was conducted to evaluate the adequacy of the retained indicators at the construct level before assessing the hierarchical measurement structure. This step was necessary to confirm that the observed items loaded appropriately on their intended latent constructs and that the lower order measurement model demonstrated satisfactory psychometric properties prior to second-order validation.

Measurement quality was assessed using standardised factor loadings, coefficients of determination (R^2), construct reliability (CR), Cronbach's alpha, and average variance extracted (AVE). Standardised factor loadings were examined to assess the strength of the relationships between observed items and their corresponding latent constructs, while R^2 values were used to evaluate item reliability. Internal consistency was assessed through CR and Cronbach's alpha, and convergent validity was evaluated using AVE. Detailed first-order CFA results are reported in the Results section.

3.7. Second-Order Confirmatory Factor Analysis

After establishing acceptable first-order measurement quality, second-order confirmatory factor analysis was conducted to validate the hierarchical structure of the focal constructs. A second-order specification was appropriate because the study conceptualised the broader measurement architecture as hierarchical, with lower-order dimensions representing more general higher-order capability domains.

Model fit was evaluated using multiple indices, including chi-square divided by degrees of freedom, comparative fit index, Tucker–Lewis index, goodness-of-fit index, adjusted goodness-of-fit index, normed fit index, incremental fit index, root mean square error of approximation, and root mean square residual. In addition to global fit indices, standardised loading estimates were examined to assess the coherence of the hierarchical measurement structure. The purpose of this stage was to validate the second-order construct configuration rather than to test hypothesised structural relationships. Detailed model fit results and loading estimates are reported in the Results section.

3.8. Ethical Considerations

The study was conducted in accordance with recognised ethical principles for research involving human participants. Ethical approval was granted by the Rangsit University Ethics Review Board under COA. NO. RSUERB2025-175. Participants were informed about the purpose of the study, the voluntary nature of participation, confidentiality protections, and their right to withdraw at any time without consequence. Informed consent was obtained before questionnaire completion, and all collected data were managed anonymously and securely, with access restricted to the research team.

4. RESULTS

4.1 Respondent Profile

A total of 817 usable responses from Thai SMEs were retained for analysis after data screening. This sample provided a strong empirical basis for measurement validation and hierarchical confirmatory factor analysis. The respondents represented a range of demographic and firm

characteristics, including gender, age, marital status, education level, position in the business, type of operation, annual sales revenue, and number of employees. These characteristics indicate that the validation exercise was conducted across a heterogeneous SME sample in the Thai context. The detailed respondent and firm profile is presented in Table 3.

Table 3: Respondent profile and firm characteristics (Source Author).

Demographic Factor	Classification	Respondent Count (n)
Gender	Male	399
	Female	350
	Alternative gender	68
Age	18 to 28 years	64
	29 to 45 years	529
	46 to 60 years	218
	61 years and above	6
Marital status	Single	230
	Married	560
	Widowed or Divorced	27
Education level	Below bachelor's degree	58
	Bachelor's degree	541
	Master's degree	195
	Doctoral degree	23
Position in the business	Business owner	567
	Partner	250
Type of operation	Manufacturing (production of goods)	363
	Services	336
	Trading (wholesale trade)	118
Annual sales revenue	Less than 50 million baht	756
	51 to 100 million baht	56
	100 to 200 million baht	4
	More than 200 million baht	1
Number of employees in the business	No more than 5 employees	72
	6 to 50 employees	676
	51 to 100 employees	65
	More than 100 employees	4
Total		**817**

4.2. *Interval two fuzzy screening* outcomes

The first stage of the validation process examined the suitability of the draft indicators using expert-based interval two fuzzy screening. As shown in Table 4, all retained indicators achieved crisp values above the predefined acceptance threshold. The results showed that all indicators exceeded the predefined crisp acceptance threshold, indicating satisfactory expert agreement on both item relevance and item clarity. These findings support the retention of the full indicator set for subsequent empirical validation. The detailed crisp values and item retention decisions are reported in Table 4.

This result is important because it demonstrates that the instrument was screened for contextual appropriateness before statistical model estimation. In other words, the retained indicators entered the empirical validation stage only after passing an expert based refinement process, thereby strengthening the content adequacy of the measurement framework.

Table 4: Item-level screening outcomes and retention decisions (Source Author).

Item	Round 1			Round 2			Average			Threshold	Result
	F1			F2			F3 = (F1+F2)/2			0.75	
	L	M	U	L	M	U	L	M	U	Crisp	
SMU1	0.80	0.93	0.97	0.82	0.94	0.98	0.81	0.94	0.98	0.91	Accept
SMU2	0.78	0.91	0.97	0.82	0.95	0.99	0.80	0.93	0.98	0.90	Accept
SMU3	0.80	0.92	0.97	0.80	0.93	0.98	0.80	0.93	0.97	0.90	Accept
SMU4	0.73	0.89	0.95	0.72	0.88	0.95	0.73	0.88	0.95	0.85	Accept
SMU5	0.70	0.85	0.93	0.70	0.84	0.92	0.70	0.85	0.93	0.83	Accept
SMU6	0.69	0.85	0.94	0.70	0.86	0.95	0.70	0.85	0.94	0.83	Accept
CB1	0.67	0.81	0.90	0.69	0.83	0.91	0.68	0.82	0.90	0.80	Accept
CB2	0.62	0.77	0.86	0.70	0.84	0.91	0.66	0.80	0.89	0.78	Accept
CB3	0.62	0.79	0.90	0.66	0.82	0.92	0.64	0.80	0.91	0.79	Accept

CB4	0.62	0.77	0.86	0.65	0.80	0.91	0.64	0.79	0.89	0.77	Accept
CB5	0.69	0.85	0.95	0.70	0.86	0.96	0.70	0.86	0.95	0.84	Accept
OI1	0.64	0.82	0.93	0.67	0.84	0.94	0.65	0.83	0.94	0.81	Accept
OI2	0.60	0.78	0.90	0.66	0.83	0.94	0.63	0.80	0.92	0.78	Accept
OI3	0.66	0.83	0.94	0.69	0.85	0.94	0.68	0.84	0.94	0.82	Accept
OI4	0.72	0.87	0.96	0.69	0.85	0.93	0.71	0.86	0.95	0.84	Accept
OI5	0.70	0.85	0.95	0.68	0.84	0.94	0.69	0.84	0.95	0.83	Accept
OI6	0.66	0.82	0.93	0.68	0.84	0.94	0.67	0.83	0.94	0.81	Accept
LD1	0.77	0.91	0.97	0.77	0.91	0.97	0.77	0.91	0.97	0.89	Accept
LD2	0.75	0.90	0.96	0.74	0.90	0.96	0.75	0.90	0.96	0.87	Accept
LD3	0.77	0.92	0.98	0.76	0.91	0.98	0.77	0.92	0.98	0.89	Accept
LD4	0.79	0.91	0.96	0.79	0.92	0.97	0.79	0.92	0.96	0.89	Accept
LD5	0.81	0.94	0.99	0.80	0.94	0.99	0.81	0.94	0.99	0.91	Accept
LD6	0.83	0.95	0.99	0.81	0.95	0.99	0.82	0.95	0.99	0.92	Accept
CA1	0.72	0.87	0.95	0.73	0.88	0.95	0.73	0.87	0.95	0.85	Accept
CA2	0.62	0.78	0.89	0.66	0.82	0.92	0.64	0.80	0.90	0.78	Accept
CA3	0.68	0.82	0.90	0.68	0.83	0.91	0.68	0.83	0.91	0.80	Accept
CA4	0.74	0.88	0.95	0.73	0.87	0.94	0.73	0.87	0.94	0.85	Accept
CA5	0.65	0.84	0.94	0.71	0.87	0.96	0.68	0.85	0.95	0.83	Accept
IC1	0.63	0.77	0.87	0.66	0.79	0.88	0.65	0.78	0.88	0.77	Accept
IC2	0.67	0.82	0.90	0.70	0.84	0.92	0.68	0.83	0.91	0.81	Accept
IC3	0.67	0.82	0.90	0.72	0.86	0.93	0.69	0.84	0.92	0.82	Accept
IC4	0.62	0.77	0.87	0.67	0.80	0.89	0.64	0.79	0.88	0.77	Accept
IC5	0.70	0.85	0.93	0.71	0.85	0.93	0.70	0.85	0.93	0.83	Accept
BCM1	0.71	0.86	0.95	0.74	0.88	0.96	0.73	0.87	0.96	0.85	Accept
BCM2	0.71	0.85	0.95	0.72	0.87	0.95	0.71	0.86	0.95	0.84	Accept
BCM3	0.73	0.88	0.95	0.74	0.89	0.96	0.74	0.88	0.96	0.86	Accept
BCM4	0.70	0.85	0.95	0.74	0.89	0.97	0.72	0.87	0.96	0.85	Accept
BCM5	0.75	0.90	0.96	0.75	0.90	0.97	0.75	0.90	0.97	0.87	Accept
BCM6	0.73	0.87	0.95	0.75	0.90	0.97	0.74	0.89	0.96	0.86	Accept
SP1	0.72	0.87	0.96	0.73	0.89	0.97	0.73	0.88	0.97	0.86	Accept
SP2	0.74	0.89	0.97	0.73	0.89	0.97	0.73	0.89	0.97	0.86	Accept
SP3	0.67	0.85	0.95	0.68	0.86	0.95	0.68	0.85	0.95	0.83	Accept
SP4	0.74	0.89	0.96	0.73	0.89	0.96	0.74	0.89	0.96	0.86	Accept
SP5	0.72	0.87	0.95	0.73	0.87	0.95	0.72	0.87	0.95	0.85	Accept
SP6	0.71	0.85	0.93	0.73	0.87	0.94	0.72	0.86	0.93	0.84	Accept

Table 5. First-order CFA model fit indices (Source Author).

Goodness-of-Fit Summary-order CFA Model.			
Fit Index	Acceptable Threshold	First-Order CFA Value	Fit Decision
Chi square divided by df	<3.00	1.414	Pass
CFI	>0.9	0.990	Pass
TLI	>0.9	0.989	Pass
RMSEA	<0.08	0.023	Pass
AGFI	>0.9	0.926	Pass
NFI	>0.95	0.967	Pass
IFI	>0.9	0.990	Pass
RMR	<0.05	0.019	Pass
GFI	>0.9	0.934	Pass

Note: The first-order CFA results indicate that the measurement model demonstrated a satisfactory fit to the data, as all reported fit indices met the recommended acceptance thresholds.

Table 6: Second-order CFA model fit indices (Source Author).

Goodness-of-Fit Summary-order CFA Model.			
Fit Index	Acceptable Threshold	Second-Order CFA Value	Fit Decision
Chi square divided by df	<3.00	1.706	Pass
CFI	>0.9	0.985	Pass
TLI	>0.9	0.984	Pass
RMSEA	<0.08	0.029	Pass
AGFI	>0.9	0.919	Pass
NFI	>0.95	0.965	Pass
IFI	>0.9	0.985	Pass
RMR	<0.05	0.023	Pass
GFI	>0.9	0.928	Pass

Note: The second-order CFA results indicate that the hierarchical measurement model demonstrated a satisfactory fit to the data, as all reported fit indices met the recommended acceptance thresholds.

4.3. First-Order Confirmatory Factor Analysis

First-order confirmatory factor analysis was conducted to assess the adequacy of the retained indicators at the construct level. The results showed that all observed items loaded satisfactorily on their respective latent constructs. Standardised factor loadings ranged from 0.706 to 0.917, exceeding the recommended threshold of 0.50. These results indicate that the retained indicators demonstrated strong relationships with their intended constructs. The detailed first-order CFA estimates are presented in Table 5.

The coefficients of determination (R^2) were also acceptable across the retained indicators, supporting item reliability at the measurement level. Collectively, these findings suggest that the lower-order construct structure was measured adequately in the Thai SME sample and provided a sound basis for subsequent hierarchical validation.

4.4. Reliability And Convergent Validity

Measurement quality was further assessed using construct reliability (CR), Cronbach's alpha, and average variance extracted (AVE). The results showed that CR values ranged from 0.917 to 0.958, indicating strong internal consistency across the study constructs. Cronbach's alpha values ranged from 0.916 to 0.952, further supporting the reliability of the measurement model. In addition, AVE values ranged from 0.669 to 0.790, demonstrating satisfactory convergent validity for all constructs.

More specifically, the social media usage construct showed CR = 0.930 and AVE = 0.690, corporate branding showed CR = 0.917 and AVE = 0.687, open innovation showed CR = 0.924 and AVE = 0.669, leadership showed CR = 0.927 and AVE = 0.681, competitive advantage showed CR = 0.923 and AVE = 0.705, innovation capability showed CR = 0.934 and AVE = 0.740, BCM showed CR = 0.958 and AVE = 0.790, and sustainable performance showed CR = 0.934 and AVE = 0.703. Cronbach's alpha values for these constructs ranged from 0.916 to 0.952, confirming consistently high reliability across the full instrument.

Taken together, the first-order CFA findings, reliability statistics, and convergent validity results indicate that the retained indicators and lower-order constructs demonstrate satisfactory psychometric quality in the Thai SME context. Importantly, these results should be interpreted as evidence of measurement adequacy rather than as support for causal relationships among the constructs.

4.5. First-Order Measurement Model Fit

The first-order measurement model was also evaluated using multiple goodness of fit indices. These values indicate that the first-order measurement model adequately represented the observed data. The detailed model fit statistics are presented in Table 5.

This result further supports the adequacy of the retained first-order measurement structure and confirms that the observed indicators were appropriately specified before the hierarchical model was assessed. In the context of the present study, this stage should be interpreted as part of the measurement validation process rather than as a step toward testing hypothesised structural relationships.

4.6. Second-Order Confirmatory Factor Analysis

After establishing satisfactory first-order

measurement quality, second-order confirmatory factor analysis was conducted to validate the hierarchical structure of the broader measurement framework. These results indicate that the proposed hierarchical construct structure was coherently represented in the Thai SME sample. The second-order loading estimates and measurement quality results are reported in Table 7.

The second-order loading estimates further supported the coherence of the hierarchical configuration, indicating that the lower-order dimensions were appropriately associated with their broader higher order constructs. Accordingly, the results provide evidence that the proposed measurement architecture demonstrates satisfactory hierarchical validity in the Thai SME context. The final second-order CFA model with standardised loadings, as shown in Figure 5, visually confirms the coherence of the hierarchical structure summarised in Table 7.

4.7. Summary Of Measurement Validation Results

Taken together, the results provide consistent evidence of satisfactory measurement quality for the proposed instrument. The interval two fuzzy screening confirmed indicator suitability at the expert review stage, while the first-order CFA results supported indicator performance, construct reliability, and convergent validity. The first-order model fit statistics showed that the retained lower-order structure was adequately represented in the data, and the second-order CFA results further confirmed the coherence of the hierarchical measurement framework. Collectively, these findings support the use of the validated instrument for future research on continuity and sustainability related capabilities in Thai SMEs.

Table 7: Second-order factor loadings and model fit statistics (Source Author).

Path	Std. Estimate	SE	CR	P-Value
SP → SMU	0.978	-	-	-
SP → OI	0.923	0.041	24.096	***
SP → LD	0.966	0.038	27.190	***
SP → IC	0.976	0.040	29.147	***
SP → CB	0.964	0.041	25.913	***
SP → CA	0.975	0.040	26.658	***
SP → BCM	0.925	0.046	27.298	***

Note: *** indicates p < 0.001.

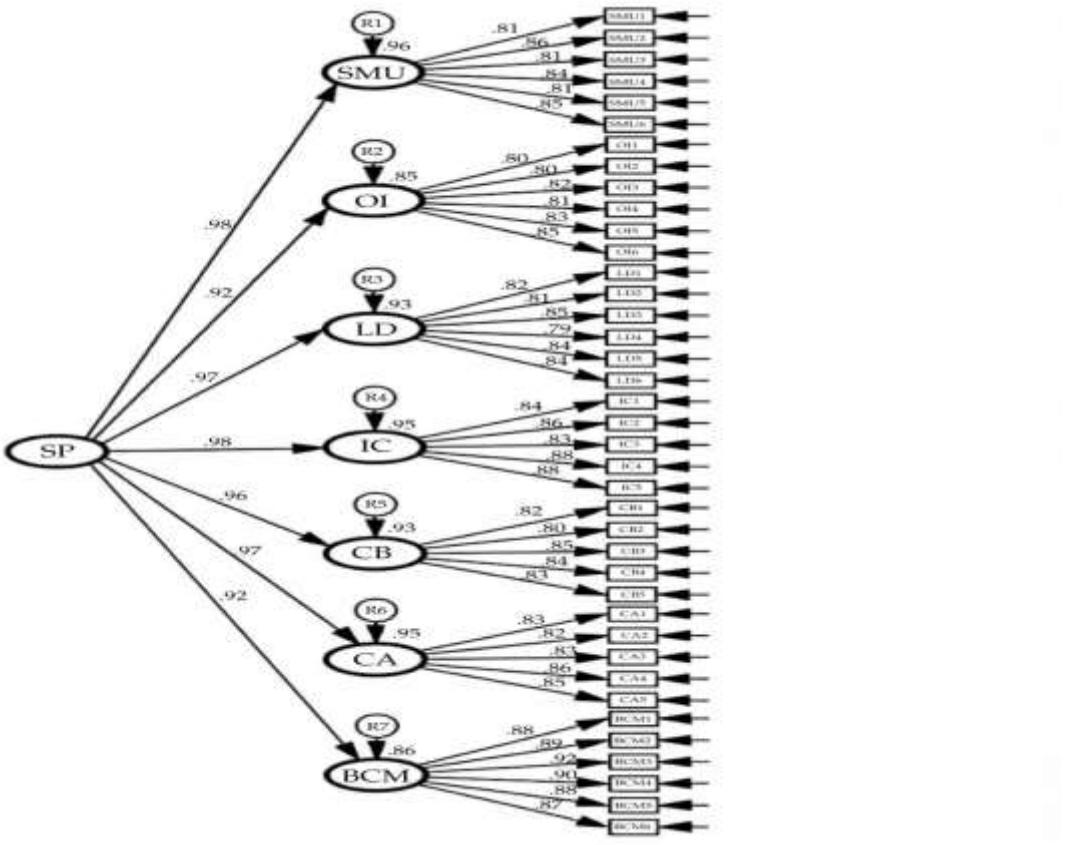

Figure 5. The validated second-order CFA model with standardised loadings (Source Author).

4.8. Discussion

4.8.1. Discussion of Measurement Validation Findings

The purpose of this study was to develop and validate a hierarchical measurement framework for leadership, open innovation, social media usage, business continuity management (BCM), and sustainable performance in Thai SMEs. The findings provide evidence that the proposed instrument demonstrates satisfactory measurement adequacy in this context. At the content validation stage, the interval two fuzzy screening results indicated that all retained indicators were judged by experts to be sufficiently relevant and clear for application in Thai SMEs. This interpretation is supported by the item-level screening results reported in Table 4, where all retained indicators exceeded the predefined acceptance threshold. At the empirical validation stage, the confirmatory factor analysis results further supported the coherence of the proposed hierarchical measurement structure. Taken together, these findings indicate that the instrument is suitable for representing the focal constructs in a contextually grounded and methodologically defensible manner.

These results should be interpreted as evidence of measurement quality rather than as confirmation of causal relationships among constructs. This distinction is important because the current study was designed to validate construct operationalisation and hierarchical structure, not to test whether one capability directly influences another or whether the proposed domains produce performance outcomes in a structural sense. The contribution of the findings therefore lies in demonstrating that the retained indicators and higher order construct architecture can be measured consistently and meaningfully in Thai SMEs. This provides a stronger empirical foundation for future studies that may later examine structural relationships using the validated instrument.

The findings are especially important for BCM and sustainable performance because these constructs are conceptually multidimensional and can be weakened by oversimplified measurement. In the present study, the hierarchical representation was supported by the second-order CFA results, which showed excellent overall fit and coherent standardised loadings across the retained dimensions. The adequacy of the first-order and second-order measurement models is reflected in Tables 5 and 6, while the hierarchical configuration of the validated framework is illustrated in Figure 5 and summarised in Table 7. This suggests that the instrument captures not only individual observed indicators, but also the broader structure through which lower-order dimensions collectively represent more complex capability domains. In this respect, the study helps address recurring concerns in the SME literature regarding inconsistent operationalisation, limited context sensitivity, and insufficient attention to construct hierarchy.

A further implication of the findings is that the validated framework offers a more reliable basis for subsequent comparative and theory driven research. Because measurement inconsistency can undermine interpretation even when sample sizes are large and model fit appears strong, the present validation process contributes by reducing ambiguity at the construct level before future explanatory analysis is attempted. In other words, the study does not claim that the broader capability architecture has been causally established. Rather, it demonstrates that the architecture can now be measured with greater clarity and empirical discipline in the Thai SME context.

4.8.2. Methodological Contribution

A key contribution of the study lies in its two-stage validation pipeline integrating interval two fuzzy screening with second-order confirmatory factor analysis. The expert based fuzzy stage provides a structured mechanism for evaluating indicator relevance and clarity before model estimation, thereby reducing the risk that subsequent CFA results are driven by poorly specified or contextually ambiguous items. In the present study, this process was operationalised through the linguistic scale reported in Table 2, the triangular fuzzy representation shown in Figure 3, and the indicator screening logic illustrated in Figure 4. This is particularly valuable in emerging economy SME settings, where linguistic nuance, sectoral diversity, and variation in managerial practice may affect the transferability of imported measurement instruments.

The second-order CFA stage then provides a rigorous assessment of hierarchical measurement structure after expert screening has already strengthened content adequacy. Used together, the two methods improve transparency in instrument development and offer a more replicable path for validating multidimensional constructs than reliance on survey estimation alone. The methodological contribution of the study therefore does not lie in proposing a new causal theory, but in demonstrating a disciplined validation sequence that can be adapted in future continuity and sustainability research

where construct hierarchy and contextual appropriateness are both important.

This contribution is strengthened by the strong fit of the second-order model, which indicates that the proposed measurement architecture is empirically coherent in the Thai SME sample. Even so, the principal methodological value of the study is not the fit indices alone, but the combination of expert screening and hierarchical confirmation in a single validation design. This integrated process strengthens construct operationalisation and supports more confident use of the instrument in subsequent studies that move beyond measurement validation into structural testing or cross context comparison.

4.8.3. Practical Implications For SME Owners And Support Agencies

The practical value of the study should be interpreted primarily in diagnostic rather than predictive terms. The validated instrument can be used by SME owners, consultants, and support agencies as a structured assessment tool to evaluate organisational readiness across continuity and sustainability related capability domains. Rather than claiming that the instrument directly improves performance, the more defensible implication is that it enables more systematic identification of capability strengths and weaknesses at the firm level. This narrower interpretation is more appropriate to the scope of the present study and aligns with the function of a validated measurement tool.

At the firm level, SME owners may use the instrument to identify areas where continuity readiness appears underdeveloped, such as continuity planning discipline, backup preparedness, communication readiness, or organisational learning after disruption. This can support more targeted internal review and capability development rather than broad or generic continuity advice. In this sense, the instrument can function as an evidence based self-assessment tool that helps businesses recognise where structured improvement may be needed.

At the programme level, SME support agencies or relevant public bodies may use the instrument to classify firms according to relative readiness or capability maturity. This creates a practical basis for segmenting SMEs into different support categories, such as firms requiring basic continuity preparation, firms needing targeted resilience training, or firms that may be ready for more advanced digital or sustainability oriented initiatives. Framed in this way, the instrument is most useful as a readiness assessment and benchmarking tool, not as a basis for making broader causal claims about policy outcomes. This narrower practical interpretation responds directly to the advisor's concern that the implications section should be more specific and should emphasise evaluation of business readiness and grouping of firms by preparedness level.

5. CONCLUSIONS

5.1. Conclusion and Contributions

This study developed and validated a hierarchical measurement framework for leadership, open innovation, social media usage, business continuity management, and sustainable performance in Thai SMEs. By integrating expert- based interval two fuzzy screening with second-order confirmatory factor analysis, the study provides evidence that the proposed instrument is contextually appropriate and empirically coherent for use in the Thai SME setting. The principal value of the study lies in strengthening construct operationalisation rather than in testing causal pathways among the focal variables.

The study contributes in three main ways. First, it provides a validated instrument for examining BCM and sustainable performance as multidimensional constructs within a broader capability based measurement architecture. Second, it demonstrates a transparent validation process that combines expert judgement with hierarchical statistical confirmation, thereby improving methodological discipline in this domain. Third, it offers a practical assessment tool that may support more consistent evaluation of continuity and sustainability related readiness in SMEs. Collectively, these contributions establish a stronger measurement foundation for future research and practice in SME resilience and sustainability, particularly in contexts where direct transfer of existing instruments may be problematic.

5.2. Limitations

Several limitations should be acknowledged. First, the study was limited to measurement validation and did not test the structural relationships among the focal constructs. Accordingly, the findings should not be interpreted as confirming theoretical cause and effect pathways among leadership, open innovation, social media usage, BCM, and sustainable performance. This limitation is central to the scope of the article and should be stated explicitly.

Second, the study adopted a cross sectional design, which limits assessment of the temporal stability of the validated structure. Although the

model performed well in the present sample, future work is needed to determine whether the same measurement properties remain stable over time or under different disruption conditions. Third, the data relied on self-reported responses from SMEs, which may still carry some risk of response related bias despite careful instrument design and data screening procedures. Fourth, although the sample size was strong, SMEs across sectors and regions may differ in continuity routines, digital maturity, and sustainability priorities, which may affect generalisability beyond the sampled context.

5.3. Future Research Directions

Future research should extend this work by moving from measurement validation to structural model testing. Because the present study has established a more defensible measurement foundation, subsequent studies can examine whether and how the validated constructs are causally related within a full explanatory framework. This is the most important next step and directly follows from the current study's scope.

Future studies may also test the instrument across different SME sectors, regions, and national contexts to assess measurement invariance and cross context transferability. Such work would help determine whether the validated hierarchical structure is stable beyond Thai SMEs or whether further adaptation is needed in other emerging economy environments. In addition, longitudinal designs could be used to examine whether continuity and sustainability related capabilities evolve over time and whether the measurement structure remains stable across repeated observations. These directions would strengthen both the generalisability and the cumulative value of the present validation framework.

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