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The causal relationship model influencing innovative effectiveness of SMEs to support the enabling BCG economy in Thailand

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Abstract: There is currently no clear evidence on the study of the role of Knowledge-based dynamic capabilities (KBDC) and Open Innovation (OI) on Innovative Effectiveness (IE) in the context of Small and Medium Enterprises (SMEs) in Thailand. Therefore, the objective of this study is to investigate the relationship patterns between these variables using quantitative research methods, analyzing structural equation modeling with Jamovi version 2.6.44 software, based on a sample of 321 Thai SME personnel. The results demonstrate the positive impact of KBDC on both OI and IE. Furthermore, OI not only has a direct influence on IE but also serves as a partial mediator in the relationship between KBDC and IE. This study has practical implications that emphasize the importance of developing SMEs' knowledge management capabilities to adapt to diverse situations, leading to the development of innovations that respond to change. Additionally, it highlights the importance of seeking and utilizing external players through the OI strategy, which will encourage SMEs to combine their company's knowledge with external knowledge to position themselves for innovation development.

Keywords: *Innovative effectiveness, Knowledge-based dynamic capabilities, Open innovation, Small and medium enterprises.*

1. Introduction

Thailand can compete economically based on its rich biodiversity and cultural heritage. However, these assets must be protected against natural changes that lead to the degradation of natural resources and biodiversity, which in turn impacts economic growth. The BCG economy leverages knowledge of science, technology, and innovation through the Quadruple Helix mechanism, fostering collaboration among the public sector, private sector, academia, research institutions, and civil society. The goal is to create added value, enabling Thailand to become self-reliant by developing highly skilled human capital and nurturing innovation-driven enterprises (IDE) [1] especially in the development sector of small and medium enterprises (SMEs), which face capital, human resources, and technology limitations, posing obstacles to innovation and competitiveness [2].

Innovative Effectiveness (IE) results from an application of knowledge in developing innovations, including product, process, and marketing development. Developing IE in SMEs requires external collaboration to access knowledge and resources that compensate for their limited capabilities [3]. Open Innovation (OI) is an approach that helps SMEs collaborate with other companies, access specialized knowledge and low-cost resources, and increase opportunities for developing commercial innovations [4], which will positively impact the overall economy, as SMEs account for 99% of businesses, have a high employment rate, and constitute 35% of Thailand's total GDP [5]. In this regard, leveraging OI collaboration, SMEs must rely on the company's ability to seek and utilize the flow of knowledge

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circulating within the collaboration between companies. Therefore, Knowledge-based Dynamic Capabilities (KBDC) are crucial for companies to capture knowledge flows, thereby enhancing their capabilities in commercial innovation [6]. Especially in a constantly evolving business environment, companies must adapt to changing situations and demands. KBDC will help companies gain an advantage by adjusting their strategies to align with environmental changes, creating and transferring knowledge through OI, and increasing opportunities for innovation development both internally and externally [7]. KBDC and OI are recognized as influencing IE. However, in the context of enhancing the IE of SMEs in Thailand, further studies are still needed to provide empirical evidence for decision-making regarding the future of Thai SMEs.

To study the factors influencing IE, this research analyzes structural equation modeling to test the hypotheses. The findings contribute to the research in the following ways. First, this research highlights the significance of KBDC in driving OI and enhancing IE. Secondly, based on the pursuit of collaboration with external players, the research findings provide empirical evidence regarding the impact of OI on IE. Thirdly, OI plays a crucial role as a mediator, driving SMEs to leverage knowledge in collaboration with external partners and experts, which increases the chances of transforming SMEs' knowledge into innovation. Lastly, this research presents empirical evidence for determining the direction of SME development in conducting innovation-focused business operations.

2. Literature Review and Hypotheses Development

KBDC is developed from the resource-based view and knowledge-based view theories, focusing on utilizing knowledge resources as a key factor in creating competitive advantages for companies in changing environments [8] which is important for driving the company's innovation, especially for companies that use the OI strategy, where the flow of knowledge occurs through collaboration between organizations. KBDC will serve as a crucial foundation that enables the company to discover and utilize knowledge [9]. Companies with personnel who can create new knowledge and integrate internal and external knowledge have a higher chance of fostering innovation [10]. Since KBDC is crucial in driving the company's operations to adapt to changing environments, it can improve its operations and deliver innovations to the market [11].

Incremental innovation involves continuously improving existing company assets, which is necessary to respond to changing market conditions. Radical innovation involves creating something new from diverse knowledge that can drive long-term growth for the company. Both types of innovation depend on the company's knowledge [12]. The characteristics of KBDC: Knowledge acquisition is a crucial foundation for the company to gain insights, enabling it to adapt promptly to external changes. Knowledge creation is essential for the company to review and revise existing knowledge, generating new knowledge that responds to changes. Knowledge combination enables the company to leverage both internal and external knowledge to generate new ideas. Knowledge sharing helps disseminate knowledge across departments, fostering collaboration and reducing redundancy in company operations [13]. Additionally, KBDC is a foundational capability that enables companies to apply modern tools and technologies, such as Generative AI, more effectively in innovation development [14]. Based on the literature review, the following hypothesis is proposed.

H_1: KBDC has a positive influence on IE

In an environment of collaboration between companies with embedded knowledge Ahuja, et al. [15] OI provides companies with opportunities to access knowledge and foster innovation development. Companies must be able to adapt and apply internal and external knowledge to improve and develop innovations [16]. Although small companies face limitations in obtaining external collaboration, KBDC will help promote the ability to identify knowledge sources and access new knowledge and information, enabling the company to adapt promptly to changes [17, 18]. Moreover, having a good relationship with customers in OI helps companies gain a competitive advantage, as they need to receive and apply knowledge from customers to create and customize existing products with functionalities that meet

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customers' specific needs [19]. Therefore, KBDC helps companies effectively utilize OI, leading to the following hypothesis.

H_2: KBDC has a positive influence on OI

OI encourages companies to systematically seek and utilize external knowledge to increase opportunities for innovation development. Incorporating new external knowledge internally enables companies to introduce new ideas and resources, thereby improving work processes and positively impacting the development of incremental and radical innovation [20]. Exporting the company's knowledge externally through research and development, or technology transfer, encourages the company to utilize its knowledge and resources to create new products [21]. Building collaborations with diverse networks, including customers, universities, suppliers, and competitors, helps the company understand market demands and acceptance, access modern technologies, and adapt to market changes [22]. According to Yang, et al. [23] building partnerships with compatible partners in terms of operational systems, work culture, knowledge, and experience in technology will facilitate resource sharing and knowledge transfer, thereby promoting innovation development. OI is not only about creating opportunities to access external knowledge and resources to compensate for the company's lack, but also increases the chances of delivering commercial innovations. Therefore, the following hypothesis is proposed.

H_3: OI has a positive influence on IE

OI creates a collaborative environment, facilitating knowledge exchange among companies. Companies with high-level KBDC will have an advantage in an open environment. The eagerness to acquire knowledge and opportunities from outside will give the company an advantage in responding to changes. Collaboration with external parties will encourage the company to develop knowledge and create new business models. Additionally, sharing knowledge through OI will create opportunities for the company to establish new markets [24]. The company can utilize KBDC to learn and apply knowledge from networks in OI, facilitating rapid innovation development [25]. Furthermore, building external collaborations, such as with industry or universities, helps companies strengthen their KBDC to stay updated on advancements in the innovation ecosystem, access modern resources, and adapt their operational infrastructure to digital modernization [26] thereby increasing IE. Therefore, the following hypothesis is proposed.

H_4: OI mediates between KBDC and IE.

3. Methodology

3.1. Conceptual Framework in Research

The conceptual framework of this research includes three latent variables. The independent variable is knowledge-based dynamic capabilities, which consists of four observable variables: knowledge acquisition, knowledge creation, knowledge combination, and knowledge sharing. The mediator variable is open innovation, which consists of three observable variables: inbound open innovation, outbound open innovation, and coupled open innovation. The dependent variable is innovative effectiveness, which consists of 6 observable variables: incremental product innovation, radical product innovation, incremental process innovation, radical process innovation, incremental marketing innovation, and radical marketing innovation, as shown in Figure 1.

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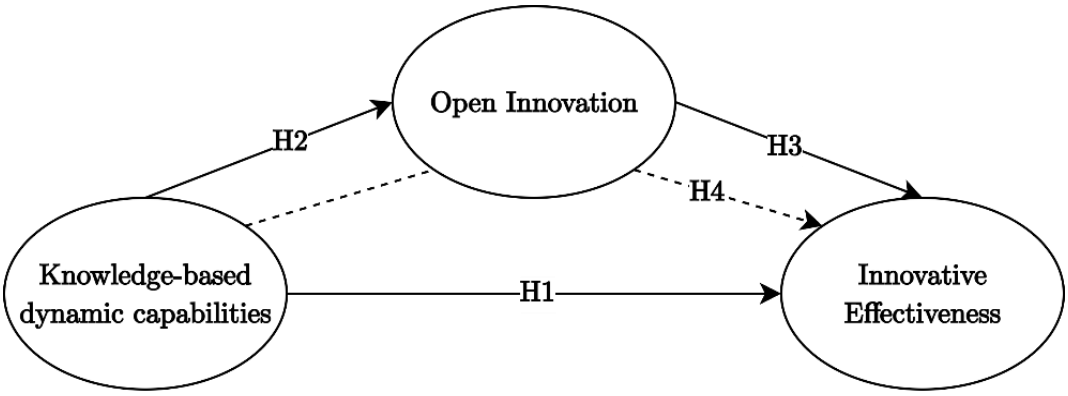

Figure 1.
Conceptual Framework in Research.

3.2. Population and Sampling

The sample group used in this study consists of personnel from SMEs in Thailand, which are divided into four business sectors: the trade sector with 1,335,629 companies, the service sector with 1,278,957 companies, the manufacturing sector with 518,989 companies, and the agricultural business sector with 53,803 companies, totaling 3,187,378 companies.

The sample size should be 5 to 20 times the number of observable variables [27]. This research comprises 13 observable variables, enabling a sample size of 260 participants. The sampling method used is simple random sampling, categorized by business sector, with proportions determined by the probability proportional to size. The resulting proportions are as follows: 109 samples from the trade sector, 104 samples from the service sector, 42 samples from the manufacturing sector, and 5 samples from the agricultural business sector.

The researchers collected questionnaires online by sending them to 453 SMEs, resulting in 321 usable responses. The sample data is as follows: 168 males, 153 females; ages 20-30: 30 people, 31-40: 138 people, 41-50: 127 people, over 50: 26 people; positions: business owners: 19 people, C-level executives: 31 people, managing directors: 23 people, managers: 65 people, employees: 183 people; business sectors: trade SMEs: 125 people, service SMEs: 128 people, manufacturing SMEs: 63 people, agricultural business SMEs: 5 people.

3.3. Measurement Instrument

The measurement instrument is a questionnaire based on a 5-point Likert scale (5 = strongly agree, 4 = Agree, 3 = Neutral, 2 = Disagree, 1 = strongly disagree) consisting of 59 questions. Knowledge-based dynamic capabilities (KBDC) consists of 20 questions, including five questions on knowledge acquisition (KAC), five questions on knowledge creation (KCR), five questions on knowledge combination (KCO), and five questions on knowledge sharing (KS), as referenced in Zheng, et al. [8] and Nazari, et al. [13]. Open innovation (OI) comprises 13 questions, consisting of six questions on inbound open innovation (IOI), three questions on outbound open innovation (OOI), and four questions on coupled open innovation (COI), as referenced in Sriram and Hungund [28] and Ahn, et al. [29]. Innovative effectiveness (IE) consists of 26 questions, including four questions on incremental product innovation (IPI), four questions on radical product innovation (RPI), five questions on incremental process innovation (IPRI), five questions on radical process innovation (RPRI), four questions on incremental marketing innovation (IMI), and four questions on radical marketing innovation (RMI), as referenced in Ali, et al. [30]; Aliasghar, et al. [31] and Medrano, et al. [32].

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4. Results

Data analysis was conducted using Jamovi version 2.6.44 for Structural Equation Modeling (SEM). It began with the construct validity analysis, which considers convergent validity, meaning that variables within the same construct should exhibit a suitable relationship. Confirmatory Factor Analysis (CFA) should have a value greater than 0.60, the Average Variance Extracted (AVE) should be greater than 0.50, and the Composite Reliability (CR) should be greater than 0.70. Reliability analysis considers Cronbach's Alpha Coefficient, which should be greater than 0.70. Then, discriminant validity was analyzed using the Heterotrait-monotrait (HTMT) criterion, which should be less than 0.90, and the Fornell-Larcker criterion, where the square root of AVE should be greater than the correlation between variables.

4.1. Construct Validity

The results of the convergent validity analysis are shown in Table 1, indicating that the variables are suitable for SEM analysis. The CFA analysis results for the observed variables indicate that the factor loadings of all variables exceed 0.60. The variables have AVE values greater than 0.50, as well as CR and Cronbach's Alpha values greater than 0.70 for all variables.

Table 1.
Convergent Validity Results.

Factor	Indicator	Estimate	SE	z	p	AVE	CR	α
KBDC						0.637	0.875	0.874
	KAC	0.795	0.0481	16.5	<0.001			
	KCR	0.811	0.0476	17.0	<0.001			
	KCO	0.832	0.0469	17.7	<0.001			
	KS	0.752	0.0492	15.3	<0.001			
OI						0.556	0.788	0.788
	IOI	0.788	0.0493	16.0	<0.001			
	OOI	0.647	0.0528	12.2	<0.001			
	COI	0.793	0.0489	16.2	<0.001			
IE						0.651	0.918	0.916
	IPI	0.704	0.0497	14.2	<0.001			
	RPI	0.784	0.0476	16.5	<0.001			
	IPRI	0.825	0.0464	17.8	<0.001			
	RPRI	0.861	0.0452	19.0	<0.001			
	IMI	0.843	0.0458	18.4	<0.001			
	RMI	0.814	0.0467	17.5	<0.001			

The results of the discriminant validity analysis show that the variables do not overlap, as the HTMT values are less than 0.90 and the square root of the AVE is greater than the correlation values between all the variables, as shown in Table 2.

Table 2.
Discriminant Validity Results.

	KBDC	OI	IE
HTMT			
KBDC			
OI	0.836		
IE	0.827	0.899	
Fornell-Larcker criterion			
KBDC	*0.798*		
OI	0.726	*0.746*	
IE	0.728	0.697	*0.807*

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4.2. Structural Equation Modeling

The results of the measurement model analysis are presented in Table 3, showing the unstandardized factor loading values. The variables in the KBDC structure have values ranging from 0.751 to 0.833, the variables in the OI structure have values ranging from 0.645 to 0.796, and the variables in the IE structure have values ranging from 0.722 to 0.859. The z-test and p-value indicate that the variable's weights are statistically significant.

Table 3.
Measurement Model Result.

				95% Confidence Intervals				
Latent	**Observed**	**Estimate**	**SE**	**Lower**	**Upper**	**β**	**z**	**p**
KBDC	KCO	1.000	0.000	1.000	1.000	0.833		
	KAC	0.954	0.059	0.839	1.068	0.795	16.3	<0.001
	KCR	0.973	0.058	0.859	1.087	0.811	16.8	<0.001
	KS	0.901	0.060	0.784	1.018	0.751	15.1	<0.001
OI	COI	1.000	0.000	1.000	1.000	0.796		
	IOI	0.988	0.067	0.857	1.119	0.786	14.8	<0.001
	OOI	0.811	0.069	0.675	0.947	0.645	11.7	<0.001
IE	RPRI	1.000	0.000	1.000	1.000	0.859		
	IPI	0.993	0.050	0.895	1.090	0.852	19.9	<0.001
	RPI	0.841	0.056	0.732	0.949	0.722	15.2	<0.001
	IPRI	0.935	0.059	0.819	1.050	0.803	15.9	<0.001
	IMI	0.946	0.052	0.845	1.047	0.812	18.3	<0.001
	RMI	0.961	0.051	0.861	1.062	0.826	18.8	<0.001

The results of the structural model analysis, covariance lines between IPI and RMI, as well as between RPI and IMI, were drawn in the Jamovi program, as shown in Figure 2., indicate that when considering the fit indices, X^2/df = 2.82, CFI = 0.962, TLI = 0.951, NNFI = 0.951, RNI = 0.962, NFI = 0.943, RFI = 0.925, IFI = 0.962 are all greater than 0.90, SRMR = 0.036, RMSEA = 0.075 are less than 0.80, showing that the model fits well [33, 34]. PNFI = 0.725, greater than 0.50, indicates that the model fits even better [35] as shown in Table 4.

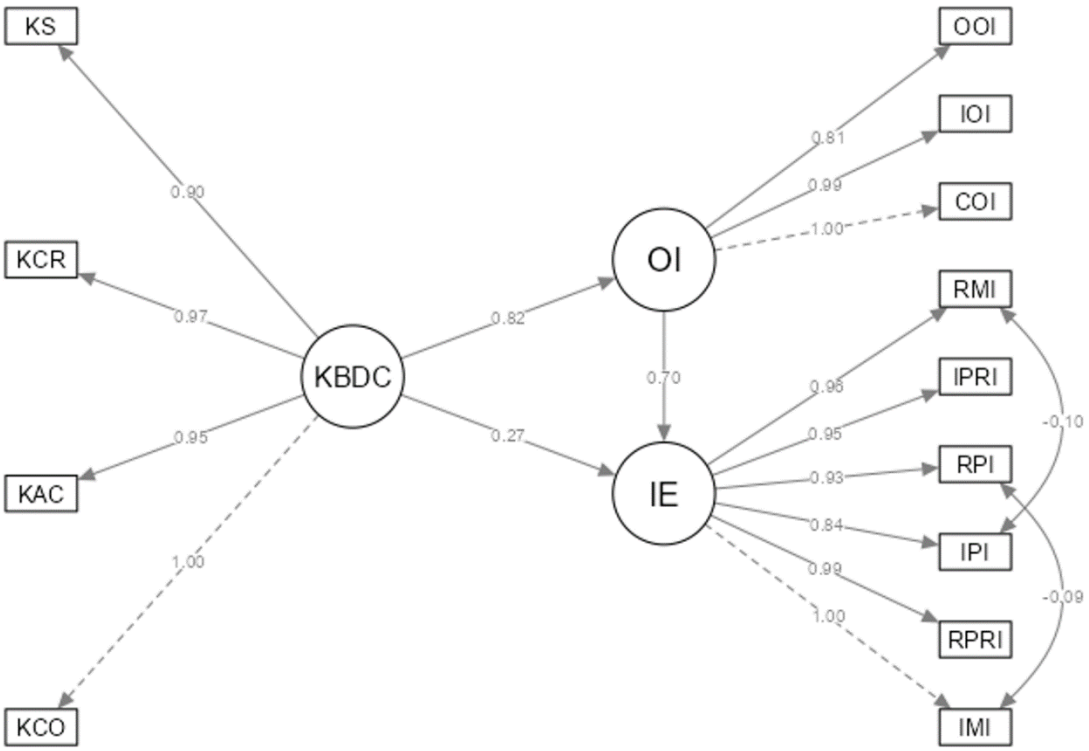

Figure 2.
Structure Model Analysis.

Table 4.
Structural Model Results.

	X^2	df	p-value
Model test			
User Model	169	60	<0.001
Baseline Model	2949	78	<0.001
Fit indices			
SRMR	0.036	RNI	0.962
RMSEA	0.075	NFI	0.943
CFI	0.962	RFI	0.925
TLI	0.951	IFI	0.962
NNFI	0.951	PNFI	0.725

Note: Standardized Root Mean Square Residual (SRMR), Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Bentler-Bonett Non-normed Fit Index (NNFI), Relative Noncentrality Index (RNI), Bentler-Bonett Normed Fit Index (NFI), Bollen's Relative Fit Index (RFI), Bollen's Incremental Fit Index (IFI), Parsimony Normed Fit Index (PNFI).

The results of the hypothesis testing are shown in Table 5. This research set up four hypotheses, all of which were accepted. The direct influence H1: KBDC positively influences IE (Estimate = 0.274, z = 2.48, $p < 0.013$). H2: KBDC positively influences OI (Estimate = 0.816, z = 13.47, $p < 0.001$). H3: OI positively influences IE (Estimate = 0.702, z = 5.60, $p < 0.001$)

The hypothesis test results accept H4: OI is a mediator variable between KBDC and IE (Estimate = 0.572, z = 5.41, $p < 0.001$). When considering the Variance Accounted For (VAF) value, which is calculated by dividing the indirect effect by the total effect, the interpretation is as follows: VAF < 0.20 = no mediation, 0.20 ≤ VAF ≤ 0.80 = partial mediation, ≥ 0.80 = full mediation [27]. Table 6 shows that OI is a partial mediator (VAF = 0.676).

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Table 5.
Direct Effect Results.

		95% Confidence Intervals					
Paths	**Estimate**	**Lower**	**Upper**	**β**	**z**	**p**	**Decision**
H1: KBDC → IE	0.274	0.058	0.490	0.266	2.48	0.013	Support
H2: KBDC → OI	0.816	0.697	0.934	0.855	13.47	<0.001	Support
H3: OI → IE	0.702	0.456	0.947	0.650	5.60	<0.001	Support

Table 6.
Indirect Effect Result.

		95% Confidence Intervals						
Paths	Estimate	Lower	Upper	β	z	p	VAF	Decision
H4: KBDC → OI → IE	0.572	0.365	0.780	0.556	5.41	<0.001	0.676	Support

5. Discussion

The research findings indicate that KBDC and OI have a direct influence on IE, which aligns with the findings of Shi, et al. [36]. Companies that can quickly apply external information and integrate that knowledge with existing knowledge can deliver commercial innovations rapidly. Chen, et al. [37] found that companies using OI strategies, formal (contracts, joint ventures, and research) and informal (discussions, networking, and seminars), positively impact IE.

KBDC has a direct influence on OI. Companies that can quickly identify external sources of knowledge can access scarce knowledge and resources promptly [38]. A sound knowledge management system will help the company integrate external and internal knowledge to create new knowledge, positively impacting the OI strategy [39]. The company's knowledge base is crucial in managing the flow of knowledge within OI. Therefore, companies with high KBDC can fully adapt and leverage opportunities from OI.

OI partially mediates the relationship between KBDC and IE because companies in an open ecosystem consistently seek and utilize external knowledge, which provides new ideas and methods, driving the company to be eager to develop new things in line with the research findings of Ismail [40] which suggest that companies with KBDC may not efficiently convert knowledge into innovation, companies need to have an innovation culture to drive the effective use of knowledge for innovation development. Additionally [41] suggests that OI is a strategy that promotes the transformation of companies' knowledge sharing into innovation by allowing companies to disseminate knowledge to external players who have the potential to develop innovations collaboratively.

The results of this research have expanded the understanding of the roles of KBDC and OI, highlighting their significant contributions to innovation development. Consequently, it affects IE, especially in the context of SMEs in developing countries, which face company limitations and lack access to the knowledge and resources necessary for innovation development. This research suggests that SMEs should prioritize and invest in organizational knowledge management to enhance their potential to apply internal and external knowledge in creating innovations that continuously respond to changes. The key is forming partnerships and joining networks with organizations that can allocate knowledge or resources in areas where SMEs are lacking, thereby enhancing SMEs' innovation capabilities.

6. Conclusions

This research presents empirical evidence regarding the factors affecting the IE of SMEs in Thailand. Focusing on the impact of KBDC and OI, the research results demonstrate the significant role of these factors as key drivers of IE. Firstly, companies with KBDC or sound knowledge management

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systems in a changing environment will directly impact the increase in IE. Secondly, companies with high-level KBDC will directly impact the implementation of OI strategies. The ability to rapidly acquire, create, integrate, and disseminate knowledge both internally and externally drives the success of OI strategies. Thirdly, OI is a strategy for seeking and leveraging external networks directly impacting innovation development. Finally, OI is crucial in promoting the relationship between KBDC and IE, particularly in sourcing knowledge and partners from outside to enhance the company's innovation development potential.

This research has certain limitations that pose challenges for future studies. First, it used a sample group in Thailand, which may limit its applicability globally. Second, the sample group comprised participants from various industries rather than a single one, which may have different business operations and innovation characteristics. Lastly, this research was conducted solely using quantitative research methods. Therefore, future research should employ a mixed-methods approach, combining both quantitative and qualitative methods, with specific samples from the target industry to gain deeper insights into various factors. Additionally, factors related to sustainable environmental preservation that affect the innovative effectiveness of SMEs should also be considered.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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