Journal of Innovation & Knowledge 8 (2023) 100418

Journal of Innovation & Knowledge

https://www.journals.elsevier.com/journal-of-innovation-and-knowledge

Assessing the effectiveness of open innovation implementation strategies in the promotion of ambidextrous innovation in Thai small and medium-sized enterprises

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A R T I C L E I N F O

Article History:
Received 26 July 2022
Accepted 28 July 2023
Available online 4 August 2023

Keywords:
Open innovation implementation (OII)
Open ambidextrous innovation practices (OAIP)
Organizational ambidexterity
Collaborative networks
Knowledge management
Technology transfer

JEL classification codes:
O35
O36 and Q1

A B S T R A C T

The adoption of open innovation practices is becoming increasingly important for SMEs seeking to remain competitive in today's fast-paced business environment. The aim of this study is to understand the implementation of open innovation processes by SMEs while highlighting two critical processes: open innovation implementation (OII) and open ambidextrous innovation practices (OAIP). The study employs a second-order factor analysis incorporating multigroup structural invariance analysis to explore the differences in ambidextrous innovation practices across SME size categories using a sample of 615 SMEs in Thailand. The primary finding reveals and confirms a statistically significant positive relationship between the implementation of open innovation and the advancement of ambidextrous innovation practices. This relationship underlines the importance of embracing open innovation, as it fosters ambidextrous innovation, thereby enabling fresh perspectives, accelerating creativity, and facilitating knowledge exchange. Three categories of MSMEs—microenterprises, small enterprises, and medium-sized enterprises—are shown to be well positioned for adopting open innovation strategies, each demonstrating a significant ability to foster open innovation practices. In the study, practical and policy recommendations for business practitioners and policymakers are presented, emphasizing the importance of understanding the organizational, managerial, technological, and contextual factors that underpin successful open innovation implementation. A novel structural second-order factor model that deepens our understanding of the complex relationships between open innovation processes is also introduced, offering valuable insights for academic researchers. In conclusion, this study emphasizes the importance of SMEs embracing open innovation practices and promoting ambidextrous innovation for sustained success and growth, and key strategic takeaways are proposed based on the empirical item-scale results.

Introduction

The importance of open innovation (OI) has grown due to ongoing globalization and the exponential growth of technology (Obradović et al., 2021; Toroslu et al., 2023). The concept of open innovation has been recognized as an essential element of the United Nations' Sustainable Development Goals (SDGs) for 2030, as they emphasize the role of collaborative partnerships in attaining a sustainable path (Huang, 2023; UN General Assembly, 2015). With the increase in accessible open innovation funding, firms have been driven to reconsider precisely how they produce innovative ideas. The competitive advantage for small and medium-sized enterprises (SMEs) lies partly in their ability to leverage internal and external technological innovations to create new market value. Open innovation gives a competitive edge to small firms through multidisciplinary knowledge, expertise, problem identification, and the discovery of new market opportunities (Lee & Yoo, 2019; Srisathan et al., 2022). The capacity to develop new resources and competencies rapidly enough to

Abbreviations: OII, Open innovation implementation; OAIP, Open ambidextrous innovation practices

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https://doi.org/10.1016/j.jik.2023.100418
2444-569X/

generate new products and services has been shown to be more important than imitation, which carries risk. Both firms and policy-makers must recognize and evaluate the competitive advantage of SME characteristics such as knowledge-transfer and innovation (McGuirk et al., 2015). Due to the ongoing economic downturn and decreased R&D budget allocation, firms and policy-makers face numerous constraints, which implies a need to maximize available resources, and one of these resources is openness to collaboration in innovation processes (Chesbrough & Garman, 2009). Although the concept of open innovation has significantly enriched academic insights for almost two decades, critical questions remain unanswered regarding why, how, and what to implement to enable open innovation in SMEs. The organizational transformation process through which a firm progresses from a closed to an open innovator (Chiaroni et al., 2010) is a topic that requires empirical insight. In the current study, open innovation is evaluated in SMEs to introduce and develop a new construct called open innovation implementation (OII). the impact of the OII concept on SMEs' open innovation practices are subsequently examined and the implications for strategy and public policy are assessed. Two major research questions are addressed to better understand this phenomenon. First, what are the primary characteristics of open innovation implementation (OII) and open ambidextrous innovation practices (OAIP)? Second, how does the OII process influence the open innovation practices of SMEs?

The current research examines the concept of open innovation in SMEs and its impact on organizational ambidexterity in open innovation practices, but there is ongoing debate regarding the factors that contribute to its success. While some researchers argue that the role of open innovation implementation characteristics at the firm level is influenced by internal systemic changes (Bianchi et al., 2009; Lopes & De Carvalho, 2018) and managerial drivers (Boscherini et al., 2010), such as top management's allocation of decision-making rights (Naqshbandi & Jasimuddin, 2022), establishment of business units, management of know-how resources, development of ventures, and evaluation of technology capabilities (Rush et al., 2007), other researchers contend that these factors may not be sufficient to explain the successful implementation of open innovation in SMEs. Critics of this perspective argue that maintaining a sole focus on top management and internal systemic changes leads to overlooking other crucial aspects, such as external collaboration, technology transfer, and the role of industry-specific factors in shaping open innovation practices. Consequently, these researchers advocate for a more comprehensive approach in studying open innovation implementation (OII) that accounts for a broader range of influences. This ongoing debate raises questions about the extent to which the role of top management and internal systemic changes truly captures the complexity of OII and its impact on SME open innovation practices.

Although the identification of organizational and management variables, as well as the shift from a closed to an open innovation paradigm, have been the focus of several research studies, there yet remains a debate about the extent to which these factors contribute to the successful implementation of open innovation. Chiaroni et al. (2010, 2011) found that changes in organizational and management systems had a beneficial impact on the environment in which open innovation takes place, while Naruetharadhol et al. (2020) discovered the positive significance of open innovation implementation in terms of firm-level organizational and managerial assessment to drive open innovation in practice. However, critics argue that neither of these studies incorporated technology transfer into their research models, thus leaving an important aspect of open innovation unaddressed. On the other hand, Chiu and Lin ((2022)) emphasized the role of knowledge creation processes, governance mechanisms, and technology in developing open innovation capability, suggesting that these factors may be more critical to the success of open innovation implementation. This perspective raises the question of whether organizational and management variables alone are sufficient for understanding and promoting open innovation practices or whether a more comprehensive approach, including technology transfer and collaborative networks, is necessary for a deeper understanding of the open innovation phenomenon.

In a rapidly evolving innovation landscape, empirical research on open innovation processes has lagged, leaving gaps in our understanding of how open innovation implementation characteristics contribute to SME innovation systems. This mystery continues to deepen as the characteristics of open innovation remain enigmatic. When an innovation project is poised to resolve market pain points, participants must grapple with the intricate dance of knowledge and technology transfers. Networked SMEs face a high-stakes challenge as they acquire new information and technology, which necessitates the navigation of intellectual property (IP) risks (Drivas et al., 2018) during the implementation phase of open innovation. Adding fuel to the fire, recent changes in the Thai economy have shed light on the shifting dynamics of innovation. As the proportion of investment in innovation inputs climbed from 44.49% in 2018 to 46.58% in 2019, the production of innovation outputs took an unexpected dip of 0.84% (Cornell-University et al., 2018, 2019). This intriguing turn of events suggests that being the first to introduce innovation to the market may no longer guarantee a competitive edge; rather, a more refined business model design has taken center stage in this endeavor (Bigliardi et al., 2012). In a world where the pace of technological change faces steady acceleration, the race for skilled talent and effective innovation processes intensifies. ASEAN countries are now rallying to reinvent citizen knowledge and innovative thinking, thus forging an economy where innovation is the lifeblood of daily economic existence and productivity growth (ADB, 2014). As Thailand's National Strategy 2018–2037 emphasizes the development of national competitiveness, income distribution, and human capital investment (NESDB, 2018), the concept of open innovation is emerging as a powerful driving force, making this the perfect moment to propose the interrelated open innovation process.

Against this backdrop, the objective of this study is to develop the concept of OII as a means of broadening prior assessments of open innovation implementation. This work builds on organizational, managerial, contextual, and technological measures by incorporating the concepts of organizational archetype, knowledge management, collaborative networks, and technology transfer into the open innovation implementation model. The research then proceeds to estimate the impact of OII on SMEs' open ambidextrous practices. The empirical analysis involves structural equation modeling to confirm this impact using a registered firm dataset obtained through conducting surveys across various regions in Thailand.

There are several valuable research contributions to the understanding of open innovation that are advanced in this study. First, the concept of open innovation is disentangled into two distinct yet interconnected processes, namely, open innovation implementation and open (ambidextrous) innovation practices, thus providing a more nuanced understanding of the complex open innovation landscape. Second, open innovation implementation is given dimensional depth by conceptualizing it using four key factors: organizational archetype, knowledge management, technology transfer, and collaborative networks. This multidimensional approach enables a more thorough examination of the mechanisms that drive the implementation of open innovation. Third, this study offers a richer perspective on open ambidextrous innovation practices by accounting for three types of innovation activities: inbound (technology-explorative), outbound (technology-exploitative), and coupled innovation. By considering these activities together, the research captures the ambidextrous nature of open innovation, shedding light on the intricate interplay between different innovation practices in shaping an organization's overall open innovation strategy.

The following is an overview of the remaining sections of the paper: **Section 2** presents the theoretical foundation underpinning the investigation, while **Section 3** describes the research methodology and variables employed in the study. After addressing the empirical research, **Section 4** presents the results, and **Section 5** discusses their implications. Finally, **Section 6** concludes the study, addressing the research limitations and outlining future research directions.

Theory and hypotheses

The open innovation school of thought has continuously evolved in its efforts to understand current innovation relationships and adapt to an ever-changing market. Chesbrough (2003) first introduced the term open innovation, referring to the concept of utilizing both external and internal ideas and combining internal and external routes to market, as a means of helping companies improve their technological capabilities, which is known as Open Innovation 1.0. Chesbrough and Bogers (2014) later defined open innovation as a purposefully distributed innovation process based on information flows across company boundaries, employing both monetary and nonmonetary mechanisms that are aligned with the firm's business model. This contemporary definition of open innovation acknowledges the fact that distributed innovation processes extend beyond firm-centricity, encompassing creative consumers (Berthon et al., 2007) and user innovator communities (West & Lakhani, 2008).

Within the European Commission, open innovation is a crucial component of the European innovation system that has been envisioned as engaging all stakeholders and fostering smooth connections and idea mashups within innovation ecosystems. This system is referred to as Open Innovation 2.0, which is a new paradigm based on quadruple helixes that enables key players to cocreate and drive fundamental changes that remain beyond the reach of individual firms (Curley & Salmelin, 2014). This approach also includes user-oriented innovation models, which capitalize on the cross-fertilization of ideas and lead to testing and prototyping in real-world settings (Curley & Salmelin, 2018). As open innovation shifted toward understanding how (online) communities contribute to knowledge creation, sharing, and transfer, the era of Open Innovation 3.0 emerged, which is characterized as embedded innovation (Hafkesbrink & Schroll, 2011). This framework incorporates digital transformation for SMEs, with businesses pursuing adaptation by creating value from the innovation ecosystem, moving toward Industry 4.0 and implementing Open Innovation 4.0. Consequently, Open Innovation 4.0 is categorized within the context of sustainable innovation ecosystems (Costa & Matias, 2020). With value cocreation at its core, open innovation is positioned to evolve further, focusing on addressing social issues and supporting the transition to Society 5.0 (Aquilani et al., 2020). This shift brings social innovation back into focus and encourages innovators to consider cocreation in the context of a circular economy.

Hossain and Kauranen (2016) identified six major themes to consider when engaging in open innovation: (1) strategic search depth and breadth; (2) collaboration; (3) networking; (4) SME transformation from a closed to an open approach; (5) technology and innovation management; and (6) performance measurement of open innovation for SMEs. Small firms generally have less rigid management structures, enabling them to implement internal and external collaboration for incremental innovation improvement/output.

Measuring open innovation implementation (OII)

The literature on measuring open innovation implementation has attracted significant attention, as researchers aim to identify key variables that shape OII and its practices (refer to Table 1 for a literature summary). The distinction between viewing OII as an organizational transformational change (Boscherini et al., 2013) versus as an openness toward ideation and knowledge sources (Cui et al., 2018) depends on the organizational, managerial, technological, and contextual aspects of the measurement method being used.

In an effort to understand the transition from closed to open innovation, Chiaroni et al. (2010, 2011) investigated managerial factors such as organizational archetype, knowledge management systems, collaborative networks, and technology transfer process assessment. Boscherini et al. (2010) argued that these managerial factors should be considered during the realization phase of an open innovation pilot project, as they help firms adjust their internal structures and procedures to adopt open innovation approach and redefine their business processes.

Naruetharadhol et al. (2020) proposed that organizational archetype, knowledge management, and networks all serve as organizational and managerial means for assessing open innovation implementation. They also discovered that these subdimensions of OII positively influence both inbound and outbound innovation practices. This finding is crucial, as OII has the potential to offer small businesses a competitive edge in innovation.

The concept of *organizational archetype* refers to the underlying patterns of behavior, culture, and values that characterize an organization (Hill, 2021, p. 405; Rubio-Andrés & Abril, 2023). It reflects the organization's unique identity, which is shaped by its history, leadership style, and the beliefs and attitudes of its employees. SME archetype designs, with their ability to embed key behavioral routines supporting innovation, have primarily been categorized as innovation generators or adopters (Pérez-Luño et al., 2011). Recent research has indicated that decentralization, open communication, and employee empowerment are essential elements to the fostering of creativity and innovativeness within organizational archetypes (Çakar & Ertürk, 2010; Min et al., 2016). The decentralization of decision-making aligns with driving employee-driven innovation (Kesting & Ulhøi, 2010). Further, centralization may result in inefficiency in the context of knowledge transfer and sharing (Tsai, 2002), while the coordination and decentralization of opportunity exploitation increase the accessibility and deployment of external knowledge sources (Foss et al., 2013).

Liao et al. (2011) argued that firms can adopt a hybrid decision-making archetype to respond to market changes by utilizing centralization for financial decisions (e.g., capital budgeting and pricing policies) and decentralization for marketing decisions. Organizational design can help facilitate a firm's interactions with external sources, which implies that well-designed organizational archetypes are dedicated to incorporating new knowledge acquisition into the firm's innovation process and supporting communication among project collaborators (Chiaroni et al., 2011). In some cases, reorganization is necessary to pursue external paths to the market for internally developed innovation ideas (Boscherini et al., 2013; Naruetharadhol et al., 2020).

Organizational archetype design for open innovation should address (1) the roles of technological gatekeepers and shepherds in assembling internal and external knowledge and facilitating communication exchange between networks (Ter Wal et al., 2017); (2) the creation and development of innovation champions (Sergeeva, 2016); and (3) the provision of reward systems and incentives to support the new OI paradigm (Burcharth et al., 2017). Adopting a centralized approach and establishing a dedicated business development unit, Lichtenthaler and Ernst (2007) suggested that adequate skills and organizational capabilities are necessary for the effective external knowledge exploitation of proprietary technologies. This implies that SMEs need to ensure that revenues from external technology commercialization and the management of commercialization tasks still occur at the firm level. Thus, the choice of organizational archetype significantly impacts a firm's capacity to innovate and adapt to changing market conditions.

Knowledge is a crucial resource for innovation activities and serves as a form of capital; therefore, effective *knowledge*

Table 1
Summary of previous research fields and contributions of the current study.

Authors	Journals	Variables for open innovation implementation	Open innovation practices	Knowledge type (Methodology)	Main Arguments
Chiaroni et al. (2011)	Technovation	(1) Organizational archetype (2) Knowledge management systems (3) Evaluation process (4) Networks	–	Case study (Interview)	Based on in-depth case study perception, it is clear that managerial levers such as organizational archetype, knowledge management systems, evaluation processes, and networks are important to the implementation phase of the open innovation path. When developing an open innovation approach, four key drivers are required to operationalize two core dimensions of the open innovation approach.
Chiaroni et al. (2010)	R&D Management	(1) Organizational archetype (2) Knowledge management systems (3) Evaluation process (4) Networks	–	Case study (Interview)	
Boscherini et al. (2010)	International Journal of Innovation Management	(1) Internal organization (2) Knowledge management systems (3) Evaluation process (4) Networks	–	Case study (Interview)	The three main stages are conception, realization, and the transfer of outcomes; there are four essential managerial variables that occur in the realization phase that might play important roles in enabling the implementation of organizational transformation and the acceptance of the new innovation management paradigm.
Bianchi et al. (2011)	Technovation	(1) Types of partners (2) Organizational modes (3) R&D process phases	–	Empirical (Interview and longitudinal)	Inbound open innovation tends to occur during the first three phases of the innovation creation process, which include target identification and validation, lead discovery and optimization, and preproduct testing. This is because firms may not master all of their tasks and may lack all of the skills required to carry out such innovation activities. As a result, firms form partnerships with external organizations, either to leverage their innovation efforts or to gain access to highly specialized knowledge and competencies. Outbound open innovation, on the other hand, occurs mostly in the second stage of the process, namely, innovation trials and post-approval activities. Firms are more inclined to open their doors to external groups throughout these phases to capitalize on the outcomes of their innovation efforts, thus resulting in a quicker and wider market entrance. External commercial exploitation leads to opportunities being discovered and pursued.
De Oliveira et al. (2018)	Journal of Organizational Change Management	(1) Culture (2) Technology management (3) Leadership (4) Network and relationships (5) Strategy (6) Internal innovation capability	–	Systematic literature review (Documents)	This recursive and cyclical interpretative-oriented content analysis uncovered some evidence concerning the key success criteria for the implementation of open innovation initiatives. The emergence of open innovation is strongly influenced by key dimensions such as efficient management of external and internal knowledge flows, attitude, leadership, organizational culture, competence, knowledge accumulation and utilization, communication, organizational learning, human resource capacity, and an organizational archetype that is appropriate for innovation. The capacity to develop and sustain successful relationships with external partners, on the other hand, is one of the most important essential success elements for OI adoption.
Mortara and Minshall (2011)	Technovation	Phrases of implementation: (1) General issues for open innovation implementation (i.e., challenges) (2) Culture for open innovation (3) Skills for open innovation	–	Qualitative constructivist approach (Interview)	Two alternative ways of putting OI activities into action were explored according to the reasons for putting them in place, i.e., whether it was meant to complement current innovation efforts focused on core markets or whether it was introduced because of the firm's need for ambidexterity. The findings indicate that open innovation activities, both inbound and outbound, can be used to achieve ambidexterity in the workplace.
Aloini et al. (2017)	Business Process Management Journal	(1) Technological tool (2) Managerial tool (3) organizational tool	–	Conceptual	The findings reveal that SMEs facing market and technological uncertainty appear to employ innovation competitions to foster organizational ambidexterity. Technological, managerial, and organizational tools are important for implementing innovation competitions.

(*continued*)

Table 1 (*Continued*)

Authors	Journals	Variables for open innovation implementation	Open innovation practices	Knowledge type (Methodology)	Main Arguments
Hosseini et al. (2017)	Business Process Management Journal	Open innovation capability framework (1) Culture (2) People (3) Governance (4) Information technology (5) Methods (6) Strategic alignment	–	Structured review (Documents)	The findings show that the OICF categorizes OI capabilities into the following factors: culture, governance, people, methods, strategic alignment, and IT. To properly implement open innovation, there must be a synergetic interplay among these components.
Cui et al. (2018)	Information & Management	(1) Implementation openness of knowledge source (2) Idea implementation	–	Empirical (Field survey)	The findings demonstrate the intersection between IT capacity and openness to collaboration. Absorptive capacity and openness derived from information technology may improve companies' access to technology generated elsewhere as well as the level of cooperation with the appropriate partners to codevelop the necessary product components. In the idea implementation phase, the product speed to market is enhanced as a consequence of the interaction between IT-enabled absorption capacity and implementation openness.
Naruetharadhol et al. (2020)	Frontiers in Artificial Intelligence and Applications	Open innovation implementation: (1) Organizational archetype (2) Knowledge management systems (3) Networks	Open innovation practices: (1) Inbound open innovation (2) Outbound open innovation	Empirical (Field survey)	The implementation of open innovation, as second-order model, provides substantial insight into knowledge management, organizational archetype, and networks. The findings reveal that open innovation implementation can be described by three managerial and organizational dimensions. The results clearly show that implementing open innovation has a positive effect on open innovation practices, with both phases being highly significant.
Chiu and Lin (2022)	Journal of Innovation and Knowledge	Implementing open innovation capability in supply chains: (1) Contractual governance (2) Relational governance (3) Supply chain technology (4) knowledge creation process	Open innovation capability (collaborators accelerate internal innovation by leveraging the influx and efflux of knowledge.)	Empirical (Survey)	In this study, the way that companies can develop their capabilities to engage in open innovation in their supply chain is explored. The findings highlight the mediating role of the knowledge creation process, governance mechanism, and technology in facilitating supply chain open innovation. The importance of developing these capabilities to successfully implement open innovation practices in the supply chain is emphasized, being an essential aspect of open innovation implementation. Thus, the findings provide insights into the strategies and factors that firms should consider when implementing open innovation practices in their supply chain.
This study		Open innovation implementation: (1) Organizational archetype (2) Knowledge management systems (3) Collaborative networks (4) Technology transfer process assessment	Organizational ambidexterity as a form of open innovation practice: (1) Inbound open innovation (technology exploration) (2) Outbound open innovation (technology exploitation) (3) Coupled activities of exploration and exploitation (coupled open innovation)	Empirical (mix of electronic and field surveys)	The focus of the current study is the understanding of open innovation implementation in SMEs and its effect on the organizational ambidexterity of open innovation practices. **Research gap 1:** The way in which SMEs implement open innovation in practice (Naruetharadhol et al., 2020). **Contribution 1:** Developing and testing the dimensionality of *Open Innovation Implementation* (OII) as a second-order model conceptualized through the organizational, managerial, technological, and contextual dimensions by adding the construct of technology transfer. **Research gap 2:** Identifying the critical dimensions of the key theoretical components of open innovation through organizational ambidexterity is another research gap in the literature. **Contribution 2:** The theoretically conceptualization of an ambidextrous model for *Open Ambidextrous Innovation Practices* (OAIP), including inbound (explorative), outbound (exploitative), and coupled activities. **Research gap 3:** The extant research is limited concerning SMEs, and there is a need for empirical support of the relevance of Open Innovation Implementation (OII) and Open Ambidextrous Innovation Practices (OAIP). **Contribution 3:** Quantitatively, SME industry investigation and validation of a conceptual model of the two relevant phenomena of open innovation processes are developed for the OI literature.

management is considered vital for a firm's ability to innovate (Gold et al., 2001). While there is no universally accepted measure of knowledge management for innovation in the literature, firms' focus on knowledge management activities (such as creating, sharing, utilizing (Liao et al., 2011), and retaining knowledge (Adamides & Karacapilidis, 2020)) has long been considered to be a suitable proxy. Other measures include knowledge management enablers and processes (Yeh et al., 2006). Lopes et al. (2017) found that knowledge management promotes open innovation, and Naqshbandi and Jasimuddin (2018) discovered that developing knowledge management capabilities encourages firms to continuously perform open innovation by supporting their infrastructure and processes.

To search for new ideas and technologies, Chiaroni et al. (2010, 2011) recommended that open innovation firms increase the breadth and depth of their innovation networks. However, the evidence regarding the effect of collaborative networks on open innovation is mixed. An empirical study of high-to-low technology firms found that the search breadth of external innovators is a key consideration in explaining the exploration process involved in knowledge learning. Nevertheless, firms' acquisition and assimilation capabilities can begin to decrease due to overextended external partners (Ferreras-Méndez et al., 2016), leading to the so-called paradox of openness to collaboration (Laursen & Salter, 2014).

To establish and profit from a value *network*, Lee et al. (2010) emphasized the importance of collaboration in both exploration and exploitation stages. They proposed a collaboration model using various combined networks, including the following: (1) supplier-customer relations as outsourcing; (2) strategic alliances as partnerships; and (3) interfirm alliances as networks. Furthermore, SMEs need to interact with a variety of stakeholders, including industry, research institutions and universities, suppliers, customers and users, community, and society (Yun & Liu, 2019). Nieto and Santamaría (2007) found that technological collaborative networks positively influence innovation novelty, providing a direct source of technological knowledge and skills with which to improve a firm's innovation process.

SMEs must position *technology transfer* as an implementation aspect of open innovation process that is used to evaluate project-based innovation for intellectual property (Drivas et al., 2018) and the commercialization of new technologies (Rahal & Rabelo, 2006). Technology transfer refers to the movement of technical knowledge, know-how, or technology from one organizational environment to another (Rambe & Khaola, 2022; Scarrà & Piccaluga, 2022). Huang et al. (2010) classify the technology transfer determinants into (1) having a technology transfer office; (2) cooperation and inventor involvement; (3) nature and sophistication of technology; (4) commercialization; (5) intellectual property exclusivity; and (6) university-industry technology transfer facilitation and organizational psychological factors. Hess and Siegwart (2013) proposed large corporate technology transfer models (e.g., corporate R&D, corporate venturing, and corporate mergers & acquisitions) for systematically scanning and monitoring the spectrum of technologies that are accessible in the external environment. These appear to be growing in importance in regard to the outside-in direction of open innovation, suggesting business value propositions for implementation. The literature also suggests that external exploitation alternatives such as selling patents, out-licensing deals, cross-licensing patents, and spinouts are necessary (Hung & Chou, 2013). Yun et al. (2018) further indicated that the technological value of firms such as SMEs can only grow as a result of open innovation. Adamides and Karacapilidis (2020) highlighted the fact that information technology can support open innovation implementation by facilitating knowledge sharing, collaboration, and coordination among internal and external stakeholders. However, the beginning of the technology transfer process, as well as SMEs' potential profits due to innovation, could be affected.

Based on all arguments, organizational archetype, knowledge management, collaborative networks, and technology transfer are essential in implementing the adoption of open innovation, which leads to the following hypothesis:

H1. Open innovation implementation (OII) is a second-order factor comprising the subdimensions of organizational archetype, knowledge management, technology transfer, and collaborative networks.

H1a. Organizational archetype positively facilitates open innovation implementation.

H1b. Knowledge management systems positively facilitate open innovation implementation.

H1c. Technology transfer positively facilitates open innovation implementation.

H1d. Collaborative networks positively facilitate open innovation implementation.

Open innovation practices: open ambidextrous innovation

The current research considers open innovation through two relevant processes: (1) the process of implementation and (2) open innovation practices. Huizingh (2011) describes the first process as a paradigm shift toward open innovation; this is framed as the process of opening up (more) closed innovation processes. The OI process is referred to in this research as open innovation implementation (OII). The second process is concerned with open innovation practices: how can open innovation be conducted? Now that the first process of open innovation is set up and addressed in the prior section, this section proceeds to provide an understanding of open innovation practices for SMEs.

Small firms are more persistent and attempt to survive longer when they are open to new knowledge and able to adapt to new ideas of innovation development while being united by a shared goal. Innovation is a complex system; its success relies on striking a balance between exploiting knowledge resources and exploring new ones. Thus, the concepts of exploration and exploitation are necessary for innovation and the operation of new ventures, meaning that both exploration and exploitation may be the single most essential strategic task for any firm's management.

Ambidextrous innovation refers to a firm's ability to simultaneously pursue both exploratory and exploitative innovations (O'Reilly & Tushman, 2013). By adopting open innovation practices, SMEs can enhance their ambidexterity, leveraging external knowledge and resources to explore new opportunities while also exploiting their existing capabilities. These practices include collaborating with external partners, such as suppliers, customers, universities, and research institutions, to cocreate value and foster knowledge exchange. They also involve integrating various open innovation mechanisms, such as crowdsourcing, open source software, and open data, to facilitate knowledge sharing and ideation.

This concept of open ambidextrous innovation essentially refers to organizational ambidexterity, which is cited as a key antecedent of structure, context, and leadership in open innovation performance (Bodwell & Chermack, 2010). The exploration-and-exploitation model posits that within organizational change processes, firms adapt their organization to new requirements, such as open innovation from the firm environment, by altering their organizational, managerial, contextual, and technological drivers. Consequently, it is understandable why open innovation implementation is required prior to establishing open innovation practices.

Organizational ambidexterity is defined as a company's ability to respond to market demands in an aligned and efficient manner while also being adaptable to changes in the environment (Chang et al., 2019; Hanifah et al., 2019; Kaur et al., 2019). Organizational ambidexterity necessitates the use of both exploration and exploitation techniques to foster open innovation. The ambidexterity model of exploration and exploitation relates to the open innovation process in the form of inbound, outbound (Hung & Chou, 2013), and coupled innovation activities (Cheng & Huizingh, 2014). In this research, a new form of ambidexterity is identified, which is referred to as open ambidextrous innovation. As in the work of Huizingh (2011), our terminology is used interchangeably with open innovation practices, but these are explored here in the context of ambidexterity. Exploration and exploitation efforts based on open innovation initiatives constitute open ambidextrous innovation. Firms' innovation ambidexterity results are derived from open innovation approaches, where firms are no longer restricted to their R&D departments in the exploration and exploitation of technologies. In constructing the idea of open ambidextrous innovation, we attempted to link organizational ambidexterity with open innovation practices. In return, this allows us to classify open innovation practices into three modes of ambidexterity: inbound (exploration), outbound (exploitation), and coupled (exploration and exploitation) open innovations. Gassmann and Enkel (2004) classified the open innovation approach into three core archetypes. Consequently, open ambidextrous innovation practices are defined in this study as an SME's ability to simultaneously pursue and balance both exploratory and exploitative innovation while leveraging external resources and collaboration. This approach enables companies to maintain a competitive advantage by fostering incremental improvements and radical breakthroughs in products, processes, or business models by leveraging open innovation strategies.

First and foremost, inbound open innovation refers to the inflows of technological or knowledge exploration that are related to innovation activities aimed at capturing and leveraging external knowledge sources to improve current technological developments (Burcharth et al., 2014). Second, outbound open innovation refers to the outflows of knowledge or technology exploitation through which a company may benefit from the sale of its intellectual property or the transfer of information and technologies to third-party organizations (Lichtenthaler & Ernst, 2009; Lichtenthaler & Lichtenthaler, 2009). Third, coupled open innovation refers to the integration of these two exploration and exploitation processes through dyadic collaboration (cocreation), cooperation with partners (through strategic partnerships and strategic networks with complementary assets), and collaboration with partners (through strategic partnerships and strategic networks with complementary assets) (West & Bogers, 2014).

In this research, the literature review reveals that Cheng and Huizingh (2014); Greco et al. (2016), and Naruetharadhol et al. (2020) tested the open innovation approach using a unidimensional construct and individual aspects. Our paper contends that each subconstruct of open innovation varies slightly in testing, reflecting the underlying dimensions of these previous studies. We argue that inbound, outbound, and coupled open innovations represent ambidextrous practices in the open innovation approach explored in SME studies, thus warranting empirical investigation. The rationale for this examination is the consideration of open ambidextrous innovation as a second-order factor. As previously mentioned, it appears that these three dimensions can be effectively combined and used to illustrate the concept of open innovation practices; thus, we hypothesize the following:

H2. Open ambidextrous innovation practice is a second-order factor comprising the subdimensions of inbound, outbound, and coupled open innovation activities.

H2a. Inbound open innovation positively facilitates open ambidextrous innovation practice.

H2b. Outbound open innovation positively facilitates open ambidextrous innovation practice.

H2c. Coupled open innovation positively facilitates open ambidextrous innovation practice.

Chiu and Lin (2022) argued that supply chain open innovation capabilities are essential for organizations aiming to achieve a competitive advantage in today's rapidly evolving business landscape. By implementing open innovation practices, firms can tap into external knowledge sources and resources, thereby enhancing their innovation capacity and accelerating new product development. Chiu and Lin (2022) highlighted the importance of understanding the underlying mechanisms that drive open innovation implementation within supply chains. By linking these findings to open innovation implementation and open innovation practices, it becomes evident that the research underscores the importance of understanding the interplay among knowledge creation, internal mechanisms, and technology within supply chains. By doing so, SMEs can effectively implement open innovation practices and enhance their innovation capabilities.

The necessity of formalizing the link between open innovation implementation and ambidextrous practices is a point of debate. Such a link can be used to form a theoretical framework, as illustrated in Fig. 1, which is tested in this study. Although some studies have already identified the importance of certain open innovation implementation activities (Bianchi et al., 2011; Chiaroni et al., 2011), there is still room for further examination of the specific link between open

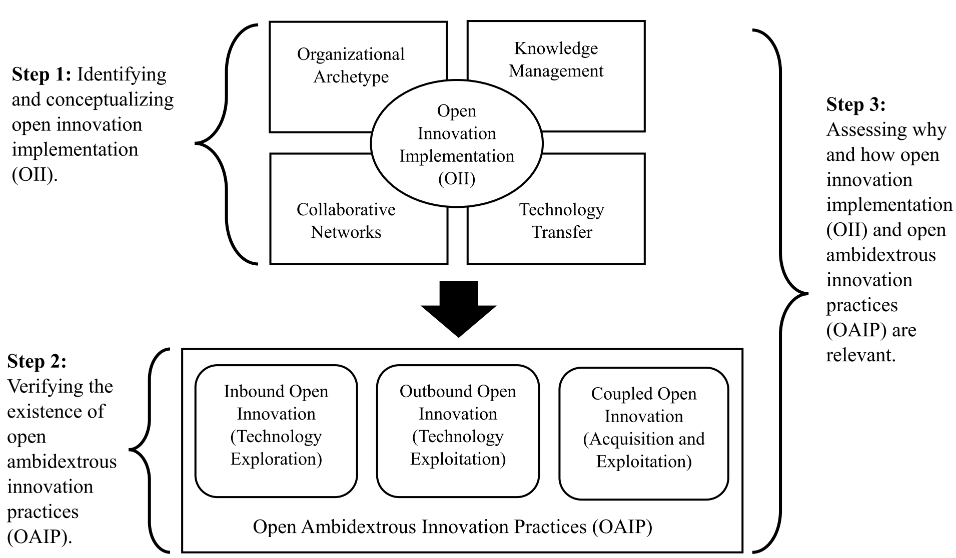

Fig. 1. Conceptual research model.

innovation implementation (OII) and open ambidextrous innovation. The connection between these two processes of open innovation is not yet fully understood, thus requiring further investigation.

To gain a comprehensive understanding of the implementation enablers, it is necessary to scrutinize the organizational, managerial, technical, and contextual factors within open innovation environments. Despite its importance, the open innovation literature (e.g., Aloini et al., 2017; Biagini et al., 2014; Bianchi et al., 2011; Boscherini et al., 2010; Chiu & Lin, 2022; De Oliveira et al., 2018; Naruetharadhol et al., 2020; Ukko & Saunila, 2020) has predominantly neglected to explore the influence of open innovation implementation on open ambidextrous innovation practices. Furthermore, a more profound understanding of the key implementers and the interplay between exploration and exploitation in the context of coupled open innovation is necessary. Given these gaps, our study is meant to provide valuable insights into the critical factors and mechanisms that contribute to the successful adoption of open ambidextrous innovation practices, thereby enriching the open innovation literature and guiding practitioners in their pursuit of effective innovation strategies. Given the gaps in the literature, the following hypothesis should be considered:

H3. Open innovation implementation is positively related to open ambidextrous innovation practices.

Research design and methodology

Innovation has long been recognized as a driver of economic growth, competitiveness, and sustainability (Swann, 2009). In response to the global financial crisis of 2009, Thailand shifted its focus toward an innovation-driven approach. Despite this, the country has only recently attained the status of an upper-middle-income economy. The national agenda, implemented from 2017 to 2021, has fostered the widespread adoption of scientific knowledge, technology, and innovation as tools for expanding value chains in agriculture, manufacturing, and service industries (NESDB, 2017). Although Thailand has not directly addressed or advanced open innovation, embracing this concept has now become crucial. Given the country's current position as an upper-middle-income economy, an investigation into its innovation landscape could provide valuable insights for other emerging economies striving to balance growth and sustainability. Thus, Thailand serves as an ideal location for research investigation.

This research is based on a fixed-design survey. Adopting this structured approach enables standardized data collection and the consistency and comparability of responses across different regions of Thailand. Research data were collected from various regions across Thailand. This approach ensures a comprehensive understanding of the country's innovation landscape, accounting for regional differences and providing insights into the diverse economic sectors throughout the country. By examining data from different regions, a more nuanced and accurate representation of the innovation ecosystem in Thailand is offered in this study, which can then be used to inform strategies for other emerging economies seeking to balance growth and sustainability.

The minimum sample size for this study was 384, as suggested by Krejcie and Morgan (1970), and it uses a 95% confidence level and a 5% margin of error. The population size included 680,269 SMEs that have maintained their business operations in the target population[1]. In this study, surveys were distributed via electronic and postal mail and were accompanied by a formal cover letter outlining the study's objectives. A QR code was provided that enabled SME respondents to access the survey on Google Forms, and this code was included in both postal and electronic mail.

The decision to distribute surveys was made to account for potential issues such as excessive responses, nonresponses, undelivered surveys, incorrect addresses, and other unforeseen challenges. Finally, 615 valid surveys were obtained for this study.

To add a layer of intrigue and rigor to the study, the respondents were carefully selected to include only those in senior positions that were directly involved in shaping their companies' strategic orientation. By focusing on SME managers, business owners, entrepreneurs, CEOs, and others figures with significant responsibility for firm-level innovation activities, the insights gathered are ensured to be derived from the very individuals responsible for driving the innovation process. This strategic choice not only guarantees the authenticity of the responses but also highlights the importance of obtaining first-hand knowledge from key decision-makers, thus elevating the study's credibility and overall impact.

Purposive sampling based on geographical area is a nonprobability sampling technique where respondents are selected for a study based on specific characteristics or criteria; in this case, that criterion is their geographical location. Purposive sampling was used in the study to target a specific population, thus ensuring that the study sample represented individuals or organizations within the defined geographical region. The study employed a purposeful random sampling design to select SMEs from among the population, focusing on their geographical distribution across Thailand's six distinct regions as follows: the central region, the northern region, the northeastern region, the eastern region, the western region, and the southern region. When conducting a study on SMEs in Thailand, it is important to define the inclusion and exclusion criteria to ensure that the sample is representative and relevant to the research objectives. Below are the criteria that researchers used for selecting registered SMEs and geographical regions in Thailand:

1. Selected SMEs must be officially registered.
2. Selected SMEs must have fewer than 250 employees.
3. Selected SMEs must be in one of six regions of Thailand.

If an SME did not meet the inclusion criteria outlined above, they were excluded from the study. This ensures that the sample remains representative and relevant to the research objectives, allowing for more accurate and reliable findings. By maintaining strict adherence to the inclusion and exclusion criteria, the study's credibility and generalizability are enhanced, ultimately providing valuable insights into the SME landscape and innovation ecosystem in Thailand.

Measures

A seven-point Likert scale was employed in the questionnaire design, with response options ranging from 1 to 7 indicating significant disagreement or agreement. Because the seven-point scale is the most accurate and representative reflection of a participant's assessment (Finstad, 2010), it tends to include a broader variety of response options, increasing the probability of aligning well with participants' objective reality. Appendix 1 contains the specifics of all major structures and questions (with minimal modifications) from prior research. The *(re)definitions* of each construct as constructed to fit the research context are presented in Table 2.

The latent exogenous variable, open innovation implementation, represents the degree to which SMEs implement open innovation internally, particularly in within the dimensions of organizational archetype, knowledge management, technology transfer, and collaborative networks. To measure the construct of open innovation implementation, four latent endogenous variables are used in this study as follows: organizational archetype, knowledge management, technology transfer, and collaborative networks.

[1] This contact population list is not available for use; hence this population figure was used only to identify the number of whole populations for this study. The population size is calculated using the information included in the following DBD report: https://www.dbd.go.th/download/document_file/Statisic/2560/H26/H26_2017.pdf

Table 2
Operational definitions of key constructs.

Construct	Operational Definitions	Resources
Open innovation implementation	The degree to which SMEs internally implement open innovation, particularly in terms of organizational archetype, knowledge management, technology transfer, and collaborative networks.	Defined by the current study
Organizational archetype	A pattern that characterizes the structure, behavior, and operational features of a firm, which aims to facilitate a balance between optimizing efficiency within existing operations and fostering innovation by investing in new ideas or technologies.	Chiaroni et al. (2011) and Liao et al. (2011)
Knowledge management	A crucial process that involves creating, sharing, utilizing, and retaining knowledge within an organization to enhance its innovation capabilities.	Chiaroni et al. (2011), Liao et al. (2011), and Naruetharadhol et al. (2020)
Technology transfer	The movement of technical knowledge, know-how, or technology from one organizational environment to another as a crucial aspect of implementing an open innovation process.	Yun et al. (2018) and Chiaroni et al. (2011)
Collaborative networks	The interconnected relationships among various stakeholders, such as industry, research institutions, universities, suppliers, customers, and users, that firms adopting open innovation establish to search for new ideas and technologies.	Laursen and Salter (2014) and Ferreras-Méndez et al. (2015)
Open ambidextrous innovation practices	The strategies and processes by which businesses collaborate with external partners, such as customers, suppliers, universities, and research institutions, which involve balancing both exploitative and exploratory innovation activities to generate, share, and apply knowledge for the development of new products, services, and processes.	Defined by the current study
Inbound open innovation	The inflows of technological or knowledge exploration as related to innovation activities. These activities aim to leverage external sources of knowledge to improve current technological developments.	Hung and Chou (2013) and Cheng and Huizingh (2014)
Outbound open innovation	The outflows of knowledge or technology exploitation, in which a company benefits from the sale of its intellectual property or the transfer of information and technologies to third-party organizations.	Hung and Chou (2013) and Cheng and Huizingh (2014)
Coupled open innovation	The integration of both inbound (exploration) and outbound (exploitation) processes.	Hung and Chou (2013) and Cheng and Huizingh (2014)

The term organizational archetype refers to a pattern that characterizes the structure, behavior, and operational features of a firm, with the aim of achieving a balance between maintaining optimizing efficiency within existing operations and fostering innovation by investing in new ideas or technologies. The organizational archetype concept is derived from four 7-point rating items adapted from Chiaroni et al. (2011) and Liao et al. (2011), which are used to measure SMEs' behavior (OA1) emphasizing new product or service introductions, (OA2) establishing knowledge network integration, (OA3) creating a gatekeeping role, and (OA4) being open to change.

The term knowledge management can be defined as a crucial process involving creating, sharing, utilizing, and retaining knowledge within an organization to enhance its innovation capabilities. Knowledge management is measured using four 7-point rating items as adapted from Chiaroni et al. (2011), Liao et al. (2011), and Naruetharadhol et al. (2020), which are used to assess firm activities such as (KM1) creating new knowledge to improve the firm's level of innovation, (KM2) sharing useful knowledge both within firm boundaries and with external partners, (KM3) engaging in knowledge utilization processes to develop scalable solutions, and (KM4) maintaining a knowledge database within firm boundaries.

Technology transfer can be defined as the movement of technical knowledge, know-how, or technology from one organizational environment to another, which is a critical aspect in implementing an open innovation process. Technology transfer is measured using four 7-point rating items adapted from Yun et al. (2018) and Chiaroni et al. (2011), which is used to assess firm activities such as (TT1) the evaluation process of technological knowledge acquisition and licensing (e.g., patents, industrial design rights, copyrights) for creating or improving (new) innovations based on existing resources, (TT2) preparing for intellectual property registration; (TT3) evaluating knowledge assets for commercialization in the market; and (TT4) implementing an IT skill base and IT infrastructure.

Collaborative networks can be defined as interconnected relationships among various stakeholders, such as industry, research institutions, universities, suppliers, customers, and users, that open innovative firms establish to search for new ideas and technologies. A four 7-point rating item scale, based on Laursen and Salter (2014) and Ferreras-Méndez et al. (2015), is used to measure potential collaborators, including (NWK1) partner firms (e.g., competitors, enterprises from the same industry or business group, software or material suppliers, or other large corporations), (NWK2) clients or customers, (NWK3) higher education institutions or universities, and (NWK4) public or government institutions.

The latent exogenous variable, open innovation practices, represents the degree to which SMEs use collaboration strategies and processes with their external partners, such as customers, suppliers, universities, and research institutions, to generate, share, and apply knowledge for the development of new products, services, and processes. To measure the construct of open innovation practices, this paper utilizes three latent endogenous variables: inbound open innovation, outbound open innovation, and coupled open innovation.

Three items were adapted from Hung and Chou (2013) and Cheng and Huizingh (2014) to assess respondent perceptions of agreement and disagreement concerning their potential inbound open innovation activities. These activities include (IOI1) engaging with external partners, such as consultants, research institutes, government, customers, competitors, universities, or suppliers in innovation projects; (IOI2) acquiring licenses, intellectual property, or know-how from external sources, such as R&D-related services, technological knowledge, or online technical course platforms; and (IOI3) utilizing the internet to explore new trends or technologies. In this study, inbound open innovation can be defined as inflows of technological or knowledge exploration that relate to innovation activities. These activities aim to leverage external sources of knowledge to improve current technological developments.

Three items were adapted from Hung and Chou (2013) and Cheng and Huizingh (2014) to assess respondent perceptions of agreement and disagreement regarding their potential outbound open innovation activities. These activities include (OOI1) selling licenses to other companies in the market for patents, copyrights, or know-how; (OOI2) operating divisions, product lines, and/or specialized business units (e.g., promoters, gatekeepers) with the purpose of commercializing knowledge assets, such as through spin-offs, cross-licensing patents, or selling; and (OOI3) actively participating in externally funded innovation projects. Consequently, outbound open innovation refers to the outflows of knowledge or technology exploitation, where a company benefits from the sale of its intellectual property or the transfer of information and technologies to third-party organizations.

Three items were based on Hung and Chou (2013) and Cheng and Huizingh (2014) and used to evaluate respondent perceptions of agreement and disagreement concerning their potential coupled open innovation activities. These activities consisted of (COI1) coordinating comarketing activities; (COI2) cooperating with partners to synchronize their information-sharing efforts; and (COI3) participating in collaborative R&D arrangements, such as R&D joint ventures or alliances. Coupled open innovation encompasses the integration of both inbound (exploration) and outbound (exploitation) processes.

In this study, firm size is considered to be a control variable used to examine differences among key variables while accounting for the potential influence of a company's size. Demographic indicators such as the number of employees and annual revenue or fixed assets can be used to measure firm size. In Thailand, the Office of Small and Medium Enterprises Promotion (OSMEP) defines these enterprises based on their number of employees (European Commission, 2015; OSMEP, 2019). Further, the terms SMEs and MSMEs are used interchangeably in this study. The classification of businesses into micro, small, medium, and large enterprises depends on various criteria, including the number of employees and the annual revenue or fixed assets of the firm. For instance, microenterprises have up to 5 employees or fixed assets of up to THB 5 million, while small enterprises have 6–50 employees or fixed assets between THB 5–50 million. In the manufacturing sector, medium-sized enterprises have 51–200 employees or fixed assets between THB 50–200 million. By controlling for firm size, the study isolates the effects of other variables of interest and makes more accurate comparisons across companies of different sizes. Consequently, there was no need to develop a separate hypothesis for firm size, as the main focus was to investigate the relationships between open innovation implementation and practices.

Results and analysis

Second-order factor analysis is a statistical technique used to examine the relationships between a set of subdimensions or factors that make up a higher-order construct (Hair et al., 2017; J.F. 2018; Kline, 2015). Second-order factor analysis was found to be suitable for testing H1 and H2 because they both involve the examination of higher-order constructs that are composed of multiple subdimensions or factors. In the case of MSME size, multigroup analysis can be used to examine whether the relationships among the variables under study (such as open innovation implementation or ambidextrous innovation practices) differ across different size categories of MSMEs (i.e., micro, small, and medium).

Table 3 presents the characteristics of the 615 SMEs contained in the sample, as grouped by firm size. There are 139 firms categorized as micro, 227 firms categorized as small, and 249 firms categorized as

Table 3
The characteristics of the sample as grouped by firm size.

		Firm size			Cross-tabulation Pearson Chi-Square test
		Micro (n = 139)	Small (n = 227)	Medium (n = 249)	
Firm age	0–10 years	71	83	42	Pearson Chi-Square = 138.895; p value < 0.001***
	11–20 years	53	77	67	
	21–30 years	9	41	30	
	31–40 years	4	13	25	
	Above 40 years	2	13	85	
Position of respondents	Business owners, managers, entrepreneurs, CEO, or other top or middle positions	115	187	195	Pearson Chi-Square = 1.693; p value = 0.429
	Positions lower than those listed above	24	40	54	
Geographical region	The Northern region	28	22	6	Pearson Chi-Square = 92.176; p value < 0.001***
	The Northeastern region	78	77	93	
	The Central region	20	72	114	
	The Eastern region	5	19	19	
	The Western region	3	6	8	
	The Southern region	5	31	9	
Industry types	Food & beverage/Agriculture	33	41	26	Pearson Chi-Square = 87.46; p value < 0.001***
	Plastic	21	12	3	
	Medical devices & pharmaceutical	15	14	6	
	Auto parts and Machinery	4	15	12	
	Material science & Chemicals	3	10	15	
	Retail/wholesale	2	7	7	
	Steel	4	10	10	
	Rubber	3	12	9	
	Transportation	7	9	3	
	Electronics	5	10	9	
	Electronics/Automation/Robotics	3	9	11	
	Others	39	78	138	
Seniority	0–5 years	58	82	60	Pearson Chi-Square = 37.818; p value < 0.001***
	6–10 years	44	63	54	
	11–15 years	20	34	44	
	Above 15 years	17	48	91	

medium. A significant relationship was found between firm age and firm size (Pearson Chi-Square = 138.895; p value < 0.001***). The majority of microsized firms were aged 0–10 years (71) or 11–20 years (53). In small-sized firms, most were aged 0–10 years (83) or 11–20 years (77), while in medium-sized firms, the largest proportion comprised those aged above 40 years (85) and those aged 11–20 years (67).

The majority of respondents held senior positions (business owners, managers, entrepreneurs, CEOs, or other top or middle positions) across all firm sizes: 115 in micro, 187 in small, and 195 in medium-sized firms. The Pearson chi-square test revealed no significant relationship between the position of respondents and firm size (p value = 0.429).

Geographically, a significant relationship was observed between the regions and firm sizes (Pearson Chi-Square = 92.176; p value < 0.001***). The majority of microsized firms were located in the Northeastern region (78), small-sized firms in the Central region (72), and medium-sized firms in the Central (114) and Northeastern (93) regions.

In terms of industry types, a significant relationship was found between the industries and firm sizes (Pearson chi-square = 87.46; p value < 0.001***). The majority of microsized firms were in the food and beverage/agriculture sector (33), small-sized firms in other sectors (78), and medium-sized firms were also in other sectors (138).

Last, a significant relationship was found between seniority and firm size (Pearson Chi-Square = 37.818; p value < 0.001***). The majority of microsized firms had 0–5 years of seniority (58), small-sized firms had 0–5 years (82) and 6–10 years (63), and medium-sized firms had more than 15 years of seniority (91).

To confirm data validity and reliability, this study proceeded through several stages, as outlined below:

Step 1: Harman's single-factor approach, a method used to assess the presence of common method variance (CMV) in survey-based research, was applied in this step. When conducting an exploratory factor analysis, Harman's single-factor approach requires that all items loading on a single factor account for no more than 50% of the explained variance (Podsakoff et al., 2003). In this study, the explained variance was 44.313%, indicating that common method variance is unlikely to be an issue.

Step 2: The measurement model, a statistical representation of the relationships between observed variables and the latent variables they are intended to measure, was applied in this step. To estimate the measurement model, SPSS Amos v26 (Arbuckle, 2019) was used in conjunction with confirmatory factor analysis (CFA). The results of convergent validity, which are presented in Table 4, indicated that each construct was convergent, and the measures belonged to their respective constructs. The factor loadings exceeded 0.7 (ranging from 0.696 to 0.915), demonstrating strong relationships between the observed variables and the latent constructs. Additionally, the average variance extracted (AVE) values indicated that more than 50% of the variance was captured by each construct (with values ranging from 0.596 to 0.794). The composite reliability values were also above 0.7 (ranging from 0.855 to 0.92) (Hair et al., 2017; Pesämaa et al., 2021), signifying the consistency and stability of the measurements.

Interpreting these results suggests that the measurement model effectively captures the relationships between the observed variables and their corresponding latent constructs. Moreover, the high convergent validity, AVE, and composite reliability values demonstrate that the constructs are well defined and accurately measured, providing a solid foundation for further analysis and further interpretation of the study's findings.

Table 4
Psychometric properties of the second order CFA model.

Second order factor	First order factor	Items	Bootstrap 95% confidence interval				AVE	CR	VIF
			λ	Lower	Upper	P value			
Open Innovation Implementation							0.726	0.914	
	Organizational Archetype		0.865	0.823	0.901	0.004	0.734	0.917	3.968
		OA1	0.832	0.796	0.859	0.004			3.676
		OA2	0.843	0.81	0.872	0.004			4.032
		OA3	0.884	0.856	0.905	0.004			2.257
		OA4	0.866	0.837	0.891	0.004			2.160
	Knowledge Management		0.904	0.865	0.938	0.004	0.682	0.895	5.464
		KM1	0.813	0.776	0.843	0.004			2.404
		KM2	0.869	0.838	0.89	0.004			2.967
		KM3	0.862	0.833	0.885	0.004			2.882
		KM4	0.755	0.716	0.786	0.004			1.942
	Technology Transfer		0.787	0.685	0.882	0.004	0.596	0.855	2.632
		TT1	0.764	0.715	0.808	0.004			2.950
		TT2	0.814	0.774	0.847	0.004			4.082
		TT3	0.808	0.754	0.851	0.004			3.891
		TT4	0.696	0.625	0.755	0.004			2.326
	Collaborative Networks		0.848	0.781	0.907	0.004	0.643	0.878	3.559
		NWK1	0.853	0.822	0.881	0.004			3.257
		NWK2	0.867	0.836	0.894	0.004			3.460
		NWK3	0.746	0.7	0.788	0.004			4.587
		NWK4	0.733	0.681	0.781	0.004			4.000
Open (Ambidextrous) Innovation Practices (OAIP)							0.794	0.92	
	Inbound Open Innovation		0.915	0.867	0.952	0.004	0.74	0.895	6.135
		IOI1	0.781	0.726	0.825	0.004			2.558
		IOI2	0.904	0.877	0.928	0.004			5.495
		IOI3	0.891	0.86	0.918	0.004			4.854
	Outbound Open Innovation		0.861	0.812	0.905	0.004	0.702	0.876	3.861
		OOI1	0.805	0.763	0.841	0.004			2.841
		OOI2	0.886	0.857	0.911	0.004			4.651
		OOI3	0.82	0.777	0.854	0.004			3.049
	Coupled Open Innovation		0.896	0.847	0.938	0.004	0.716	0.883	5.076
		COI1	0.8	0.747	0.843	0.004			2.778
		COI2	0.874	0.839	0.902	0.004			4.255
		COI3	0.863	0.81	0.897	0.004			3.906

Table 5
Discriminant validity matrix.

Fornell−Larcker Criterion			Heterotrait−Monotrait Ratio (HTMT)		
	OAIP	OII		OAIP	OII
OAIP	**0.891**		OAIP		
OII	0.545	**0.852**	OII	0.510	

Note: The square root of the average variance extracted for the respective constructs are displayed in bold.
OAIP = Open (Ambidextrous) innovation practices.
OII = Open innovation implementation.

Step 3: Discriminant validity and the variance inflation factor (VIF), two important statistical measures used to evaluate the quality of a measurement model, specifically in the context of factor analysis and structural equation modeling, were applied in this step. As shown in Table 5, the results of discriminant validity indicate that each construct was distinct from the others. The average variance extracted (AVE) values exceeded the squared latent variable correlations, thus satisfying the Fornell-Larcker criterion. Additionally, the heterotrait-monotrait (HTMT) values were below 0.90 (ranging from 0.236 to 0.818) (Henseler et al., 2015), demonstrating discriminant validity between the reflective constructs (Hair et al., 2017). Furthermore, an inspection of the variance inflation factor (VIF) illustrated in Table 4 revealed no multicollinearity issues among the variables, as the VIF scores were below the threshold of 10 (ranging from 1.942 to 6.135) (O'Brien, 2007).

These results suggest that the constructs within the measurement model are distinct and separate from one another, thus ensuring that each construct measures a unique aspect of the phenomenon under investigation. The absence of multicollinearity further supports the model's robustness and validity, allowing for the accurate interpretation and analysis of the study's findings.

Step 4: A goodness-of-fit index is a statistical measure used to assess how well a proposed model fits the observed data in structural equation modeling (SEM) and other multivariate data analysis methods. The fit indices used in this study include the SRMR (Standardized Root Mean Square Residual), IFI (Incremental Fit Index), TLI (Tucker–Lewis Index), CFI (Comparative Fit Index), RMSEA (Root Mean Square Error of Approximation), and PCFI (Parsimony Comparative Fit Index). Here are the cutoff values suggested by Hu and Bentler (1998, 1999), Williams et al. (2009), and Pesämaa et al. (2021) for the indices:

- A chi-square value that is associated with a p value of smaller than 0.05 indicates that the model fits the data well.
- A standardized root mean square residual (SRMR) value of below 0.08 indicates a good fit.
- An incremental fit index (IFI) value of greater than 0.90 indicates an acceptable fit.
- A Tucker–Lewis Index (TLI) value of greater than 0.90 indicates an acceptable fit.
- A comparative fit index (CFI) value of greater than 0.90 is considered to be an acceptable fit.
- A root mean square error of approximation (RMSEA) value of below 0.08 suggests a reasonable fit.
- The Parsimony Comparative Fit Index (PCFI) does not have a strict cutoff value. However, higher PCFI values indicate a more parsimonious model, suggesting a better balance between model fit and model complexity.

The first-order CFA results indicate a good fit: χ^2 = 812.99 (p < 0.001); IFI = 0.952; CFI = 0.952; TLI = 0.943; PCFI = 0.806; RMSEA = 0.06; and SRMR = 0.036. The second-order CFA results also indicate a good fit: χ^2 = 904.872 (p < 0.001); IFI = 0.945; CFI = 0.945; TLI = 0.938; PCFI = 0.841; RMSEA = 0.063; and SRMR = 0.052. The aggregate structural model results show a good fit as well: χ^2 = 904.872 (p < 0.001); IFI = 0.945; CFI = 0.945; TLI = 0.938; PCFI = 0.841; RMSEA = 0.063; and SRMR = 0.052. Thus, the model fit indices for the measurement models, which are shown in Table 6, suggest a good fit from the perspective of all indices (Hair et al., 2017; Hu & Bentler, 1998, 1999; Pesämaa et al., 2021; Williams et al., 2009).

Based on the CFA model, the measurement invariance method further reveals that the CMIN/df values of the configural invariance, metric invariance, and scalar invariance models were all below the threshold of 3.00 (i.e., 1.938, 1.924, and 1.883, respectively), as displayed in Table 7 (Kline, 2015). The nested model comparison shows that an unconstrained model can be obtained by constraining the models of measurement weights and measurement intercepts. As long as the nested models are conducted, the difference between the χ^2 values is 57.626 for the measurement weight model and 119.63 for the measurement intercept model. These chi-square differences ($\Delta\chi^2$) resulted in a p value that fell below the 5% significance level. Overall, the model fit indices of configural invariance, metric invariance, and scalar invariance indicate a good model fit for the proposed model (i.e., the measurement invariance is fully claimed).

As shown in Table 6, the multigroup moderation analysis results indicate a good fit: $\chi2$ = 1606.415*** (p < 0.001); IFI = 0.932; CFI = 0.932; TLI = 0.924; PCFI = 0.829; RMSEA = 0.041; and SRMR = 0.069 (Kline, 2015). The difference between the chi-square values ($\Delta\chi^2$) was 142.693 for the structural weights model. Since the p value associated with the chi-square difference is less than 0.05

Table 7
Measurement invariance across group sample by firm size.

Fit Indices	χ^2/df	df	SRMR	IFI	TLI	CFI	RMSEA
Unconstrained model (Configural invariance)	1.938	762	0.059	0.94	0.929	0.94	0.039
Measurement weights (Metric invariance)	1.924	798	0.062	0.938	0.93	0.938	0.039
Measurement intercepts (Scalar invariance)	1.883	848	0.063	0.937	0.933	0.937	0.038
Structural weights	1.946	899	0.072	0.928	0.928	0.928	0.039
Thresholds	< 3.00		< 0.08	> 0.90	> 0.90	> 0.90	< 0.08

Table 6
Overall measurement model indices.

Fit Indices	χ^2	df	SRMR	IFI	TLI	CFI	RMSEA	PCFI
First-order CFA	812.99***	254	0.036	0.952	0.943	0.952	0.06	0.806
Second-order CFA	904.872***	267	0.052	0.945	0.938	0.945	0.062	0.841
Aggregate model	904.872***	267	0.052	0.945	0.938	0.945	0.062	0.841
Multigroup model	1606.415***	801	0.069	0.932	0.924	0.932	0.041	0.829
Thresholds	p < 0.05*		< 0.08	> 0.90	> 0.90	> 0.90	< 0.08	> 0.50

*** Significant at < 0.001.
* Significant at < 0.05.

(i.e., 0.002), the null hypothesis that the constrained model (structural weights) fits the data as well as the unconstrained model can be rejected. Therefore, the unconstrained model is a better fit to the data than the structural weights model. In accordance with the above measurements, the group measurement model is adequate to present a good fit of samples across firm sizes. All four steps were supported and confirmed, thus allowing for the testing and discussion the hypotheses in the next section.

Hypothesis testing

The use of bootstrap 95% confidence intervals can be a valid approach to estimating the precision of the parameter estimates and evaluating the fit of the model (Cheung & Lau, 2015). Fig. 2 illustrates the results of a structural model. We pose the following question: what are the primary characteristics of open innovation implementation (OII) and open ambidextrous innovation practices (OAIPs)? This result suggests that the variable organizational archetype has a significant positive effect (as represented by the standardized regression coefficient β = 0.858) on the open innovation implementation variable. In other words, an increase in the level of a firm's organizational archetype is associated with an increase in the level of open innovation implementation. A p value of less than 0.004 indicates that this relationship is statistically significant, and **Hypothesis 1a** is supported. Additionally, the R-squared value of 0.735 suggests that the organizational archetype variable can explain 73.5% of the variance in open innovation implementation. The result indicates that there is a positive relationship between knowledge management and open innovation implementation. The beta coefficient of 0.905 suggests that for every one-unit increase in knowledge management, open innovation implementation increases by 0.905 units. A p value of less than 0.004 indicates that the relationship between knowledge management and open innovation implementation is statistically significant, thus **Hypothesis 1b** is supported. The R-squared value of 0.82 suggests that 82% of the variance in open innovation implementation can be explained by knowledge management. Therefore, this result implies that organizations that prioritize knowledge management are more likely to successfully implement open innovation practices than those that do not. The result suggests that there is a significant positive relationship between technology transfer and open innovation implementation. Specifically, for every one-unit increase in technology transfer, open innovation implementation is expected to increase by 0.773 units. A p value of less than 0.004 indicates that this relationship is statistically significant, providing evidence to support **Hypothesis 1c**. The R-squared value of 0.597 indicates that technology transfer can explain 59.7% of the variance in open innovation implementation. A p value of less than 0.004 indicates that the relationship between collaborative networks and open innovation implementation is statistically significant. Therefore, **Hypothesis 1d** is supported. The beta coefficient of 0.863 suggests that for every one-unit increase in collaborative networks, there is an estimated 0.863-unit increase in open innovation implementation. The R-squared value of 0.745 indicates that collaborative networks can explain approximately 74.5% of the variance in open innovation implementation. The analysis confirms **Hypothesis 1**, which is the first research question, indicating that open innovation implementation (OII) is a second-order factor consisting of the subdimensions of organizational archetype, knowledge management systems, collaborative networks, and technology transfer. This is supported by the confirmation of H1a to H1d, which verifies that each subdimension has a statistically significant and positive influence on OII.

Furthermore, the results indicate that there is a statistically significant and positive relationship between inbound open innovation and open ambidextrous innovation practice. The β value of 0.91 indicates that for every one-unit increase in inbound open innovation, there is a 0.91-unit increase in open ambidextrous innovation practice. A p value of less than 0.004 indicates that this relationship is statistically significant, meaning that we can reject the null hypothesis and accept the alternative hypothesis that inbound open innovation positively influences open ambidextrous innovation practice. The R-squared value of 0.828 suggests that 82.8% of the variance in open ambidextrous innovation practice can be explained by inbound open innovation. Overall, these results support **Hypothesis 2a**. The results of the analysis support **Hypothesis 2b**, which proposes a positive relationship between outbound open innovation and open ambidextrous innovation practice. The beta coefficient of 0.867 indicates that outbound open innovation has a strong positive influence on open ambidextrous innovation practice. The R-squared value of 0.752 indicates that 75.2% of the variance in open ambidextrous innovation practice can be explained by outbound open innovation. Finally, a p value of less than 0.004 suggests that this relationship is statistically significant. Thus, the results suggest that there is a positive relationship between coupled open innovation and open ambidextrous innovation practice, and this relationship is statistically significant with a p value of less than 0.004. **Hypothesis 2c** is supported. The beta coefficient of 0.897 indicates that coupled open innovation has a strong

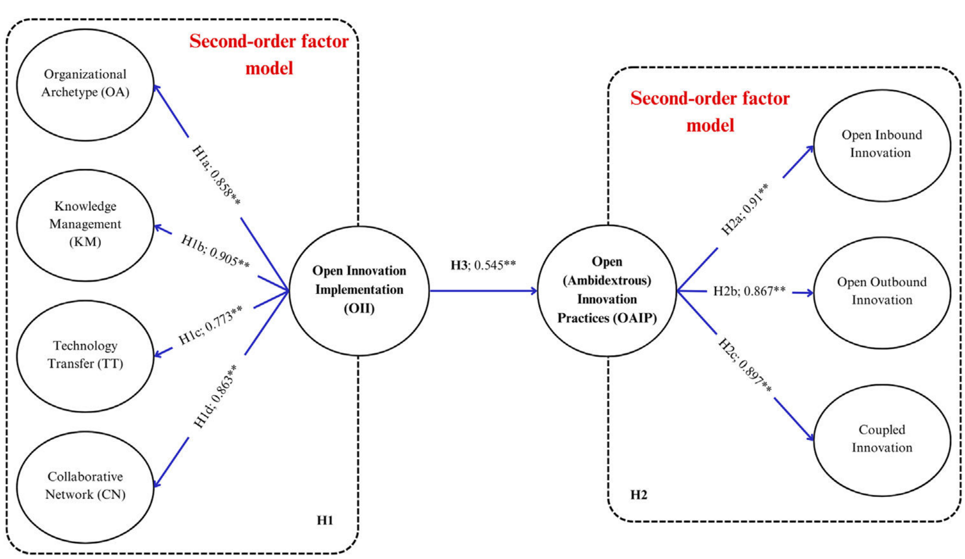

Fig. 2. Baseline model (Aggregate group).

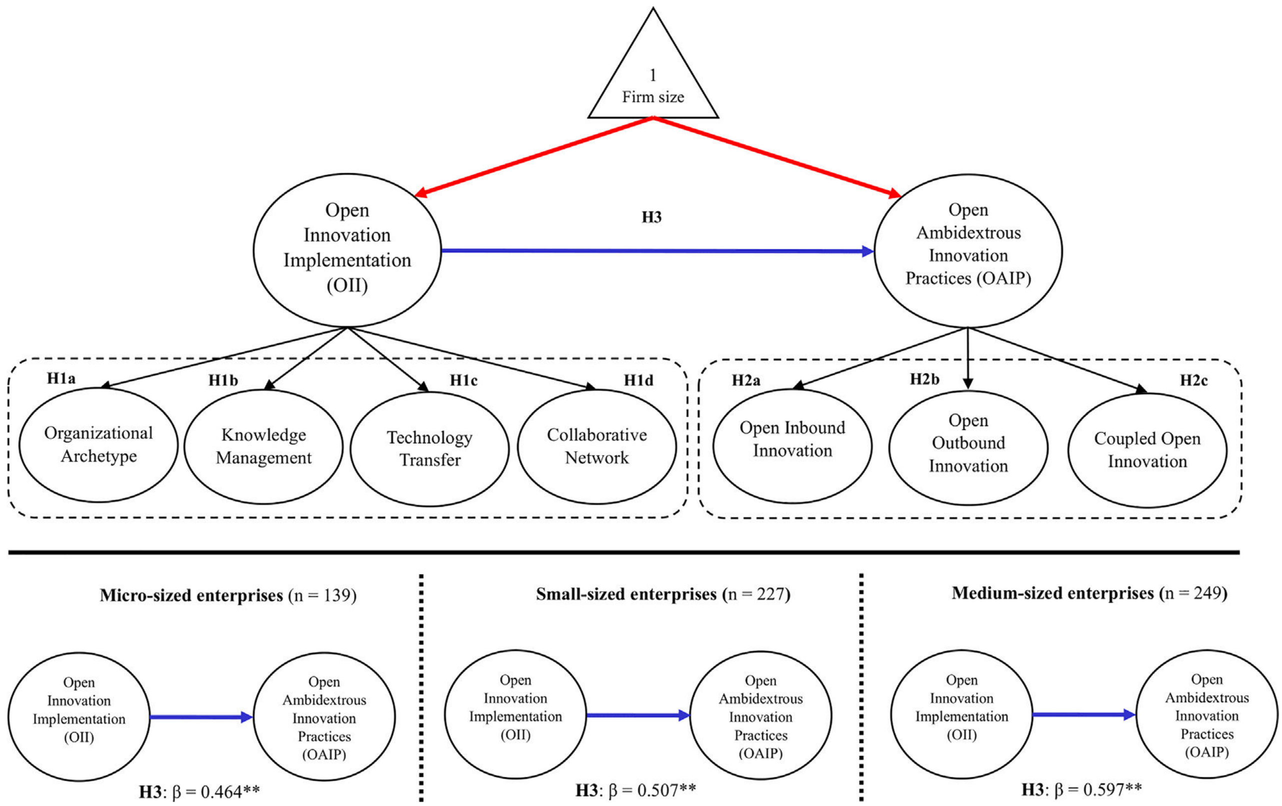

Fig. 3. Conceptual framework and the multigroup structural model.

positive influence on open ambidextrous innovation practice. The R-squared value of 0.804 suggests that coupled open innovation explains 80.4% of the variance in open ambidextrous innovation practice. **Hypothesis 2** is thus confirmed by the analysis indicating that open ambidextrous innovation practice is a second-order factor consisting of inbound, outbound, and coupled open innovation activities. The confirmations of H2a through H2c provide support for this finding.

How does the OII process influence SME open innovation practices? To answer our second research question, the results indicate that there is a positive relationship between open innovation implementation and open ambidextrous innovation practices, and this relationship is statistically significant with a p value of less than 0.004. The beta coefficient of 0.545 suggests that open innovation implementation has a moderate positive influence on open ambidextrous innovation practices. The critical ratio of 0.297 is not commonly used as a measure of statistical significance, but it does suggest that the effect size is relatively large. Overall, **Hypothesis 3** is supported by the analysis, which supports the idea that there is a positive relationship between open innovation implementation and open ambidextrous innovation practices, thus addressing the second research question. Table 7 shows the results of a statistical analysis conducted to examine whether the relationships among the variables used in the models are the same across different firm sizes. The size characteristics of SMEs, such as micro, small, and medium-sized enterprises, are also considered in the study. The results showed a significant and positive relationship between open innovation implementation and open ambidextrous innovation practices across all SME sizes. The beta coefficients of 0.464, 0.507, and 0.597 for micro, small, and medium-sized enterprises, respectively, suggest that open innovation implementation exerts a positive influence on open ambidextrous innovation practices across all SME sizes, as shown in Fig. 3. The R-squared values of 0.215, 0.257, and 0.357 indicate that open innovation implementation explains a significant portion of the variance in open ambidextrous innovation practices for micro, small, and medium-sized enterprises, respectively. The p value of less than 0.004 suggests that these relationships are statistically significant. The results of the multigroup moderation analysis shown in Table 8 indicate that there were significant behavioral differences among Thai microsized and small-sized enterprises regarding their organizational archetype, their knowledge management, and their coupled open innovation activities. This is supported by the critical ratio differences, which were found to be statistically significant (Z test > 1.96). This could be because microsized enterprises may have limited resources compared to small-sized enterprises, which could impact their ability to implement certain organizational archetypes or knowledge management practices.

To understand how the OII process has an impact on SMEs' open ambidextrous innovation practices, we explored these effects *statistically* using key item scale activities that are discussed in the next section.

Discussion and implications

This section covers the discussion by comparing it to the previous literature and dividing it into three distinct streams: (1) identifying and conceptualizing open innovation implementation; (2) verifying the existence of open ambidextrous innovation practices; and (3) assessing the relevance of the following open innovation processes: open innovation implementation (OII) and open ambidextrous innovation practices (OAIP).

Through the incorporation of organizational, managerial, technological, and contextual factors and employing a second-order model, the aim of this paper is to develop and examine the dimensionality of open innovation processes in the relationship between open innovation implementation (OII) and open ambidextrous innovation practices (OAIP). The significance of open innovation in practice, as well as the challenges arising from the exponential growth in the innovation

Table 8
Structural results of multigroup analysis by firm size.

H	Relationships		Baseline model				Multigroup Moderation Analysis						Critical ratio difference			Path coefficient difference			Remarks
			Bootstrap 95% confidence interval				Micro		Small		Medium								
			β	Lower	Upper	r^2	β	r^2	β	r^2	β	r^2	Micro vs. Small	Small vs. Medium	Medium vs. Micro	Micro vs. Small	Small vs. Medium	Medium vs. Micro	
H1a	Organizational archetype	Open implementation	0.858**	0.816	0.891	0.735	0.798**	0.637	0.834**	0.696	0.904**	0.818	|-2.14|*	|1.009|	|-1.555|	|-0.036|	|-0.07|	|-0.106|	Supported
H1b	Knowledge management	Open innovation implementation	0.905**	0.867	0.939	0.82	0.857**	0.734	0.945**	0.893	0.905**	0.818	|2.442|*	|-0.988|	|1.766|	|-0.088|	|0.04|	|-0.048|	Supported
H1c	Technology transfer	Open implementation	0.773**	0.665	0.873	0.597	0.758**	0.575	0.841**	0.707	0.741**	0.549	|-0.257|	-0.252|	|-0.482|	|-0.083|	|0.1|	|0.017|	Supported
H1d	Collaborative networks	Open implementation	0.863**	0.797	0.922	0.745	0.85**	0.723	0.766**	0.587	0.924**	0.854	|-0.701|	0.887|	|-0.059|	|0.084|	|-0.158|	|-0.074|	Supported
H2a	Inbound Open innovation	Open (ambidextrous) innovation practices	0.91**	0.865	0.946	0.828	0.888**	0.788	0.916**	0.839	0.906**	0.821	|-0.469|	|-1.152|	|0.391|	|-0.028|	|0.01|	|-0.018|	Supported
H2b	Outbound Open innovation	Open (ambidextrous) pnnovation practices	0.867**	0.823	0.906	0.752	0.958**	0.918	0.869**	0.754	0.816**	0.666	|-1.322|	|0.001|	|-1.325|	|0.089|	|0.053|	|0.142|	Supported
H2c	Coupled open innovation	Open (ambidextrous) innovation practices	0.897**	0.849	0.936	0.804	0.939**	0.881	0.885**	0.784	0.885**	0.783	|-2.039|*	|1.307|	|-0.956|	|0.054|	|0|	|0.054|	Supported
H3	Open (ambidextrous) innovation practices	Open innovation implementation	0.545**	0.454	0.613	0.297	0.464**	0.215	0.507**	0.257	0.597**	0.357	|0.759|	|0.817|	|-0.012|	|-0.043|	|-0.09|	|-0.133|	Supported

*** Significant at < 0.001;.
** Significant at < 0.01; and.
* Significant at < 0.05 (the two-tailed z score for 0.05 significance level is approximately 1.96.).
β = Standardized loading or path coefficient.
r^2 = Squared Multiple Correlations.
H = Hypothesis.

profile of the SME population, are emphasized in the literature by Aloini et al. (2017); Bianchi et al. (2011); Boscherini et al. (2010); (Chiaroni et al., 2010, 2011); Cui et al. (2018); Hosseini et al. (2017); Mortara and Minshall (2011); Naruetharadhol et al. (2020); and De Oliveira et al. (2018).

To enhance our understanding of the different dimensions within the open innovation funnel, two new standard measures, namely, OII and OAIP, are introduced in this study accompanied by a discussion of these literature streams. However, the internal implementation of open innovation remains less understood. This paper fits in the related literature emphasizing the necessity of examining the underlying mechanisms from the perspective of open innovation processes. The empirical observations are significant enough to drive open innovation in Thai SMEs.

The aim of open innovation is to integrate close interaction and relationships with external partners, wherein SMEs are fundamentally seen as independent of one another. This approach views collaborative and cooperative relationships as exceptions to the closed-innovation norm. The most critical implication of this perspective for managing open innovation implementation and ambidextrous SMEs is that quadruple-helix network relationships can be valuable in specific situations if properly managed by an individual SME. These situations include research and development collaborations, funding and resource access, and new market and partnership access. For example, quadruple-helix networks, which involve collaboration among academia, industry, government, and civil society, can be valuable for SMEs involved in research and development activities.

Identifying and conceptualizing open innovation implementation

Recent research findings demonstrate a positive relationship among organizational archetypes, knowledge management, technology transfer, and collaborative networks, as evidenced by the confirmation of **Hypothesis 1**. These primary latent constructs contribute to explaining the secondary latent formation of open innovation implementation. This discovery supports the findings of (Naruetharadhol et al., 2020); however, the unique contribution offered here concerns the role of technology transfer. The current research findings emphasize that technology transfer is one of the key components for implementing open innovation, as evidenced by the confirmation of **Hypothesis 1c**. Comparing this finding with those of Chiaroni et al. (2010, 2011), and Boscherini et al. (2010), who identified organizational archetype, knowledge management systems, evaluation processes, and networks as key components, it can be argued that technology transfer complements and interacts with these factors to promote open innovation. For instance, technology transfer is an essential component of open innovation implementation, as it involves the exchange of technological knowledge, expertise, and innovations between different organizations or stakeholders (Hess & Siegwart, 2013; Yun et al., 2018).

The research findings show that organizational archetype exerts a positive influence on open innovation implementation, as evidenced by the confirmation of **Hypothesis 1a**. Although Chiaroni et al. (2010, 2011), Boscherini et al. (2010), and Naruetharadhol et al. (2020) emphasized the importance of organizational archetypes, this research suggests that Thai SMEs, particularly family-owned SMEs, should focus on addressing the underlying patterns of behavior, culture, and values that characterize an organization. These Thai SMEs should not concentrate solely on the formal arrangement of roles and responsibilities.

The research findings that show the positive influence of knowledge management on open innovation implementation (as evidenced by the confirmation of **Hypothesis 1b**) align with the findings of Chiaroni et al. (2010, 2011), Boscherini et al. (2010), Cui et al. (2018), and Naruetharadhol et al. (2020). These studies collectively underscore the importance of knowledge management, organizational archetype, and archetype in shaping an organization's approach to innovation and its ability to successfully implement open innovation practices. The results of this research suggest that knowledge management should (1) promote the efficient transfer of technological expertise and know-how, which in turn supports open innovation efforts, and (2) create an environment that promotes communication, collaboration, and knowledge sharing among different departments, teams, and external partners.

As evidenced by the confirmation of **Hypothesis 1d**, collaborative networks have a positive influence on open innovation implementation because they facilitate the exchange of ideas, knowledge, and resources among organizations, partners, and other stakeholders. These networks play a crucial role in creating connections that enable organizations to access external sources of innovation and expertise, thereby enhancing their ability to innovate and compete effectively in the marketplace. Studies such as Chiaroni et al. (2010, 2011), Boscherini et al. (2010), De Oliveira et al. (2018), Bianchi et al. (2011) and Naruetharadhol et al. (2020) have persistently emphasized the significance of collaborative networks in the successful implementation of open innovation. The positive relationship between collaborative networks and open innovation implementation suggests that the connections and interactions among organizations, partners, and other stakeholders are crucial for facilitating the exchange of ideas, knowledge, and resources. This finding can be further enhanced by adopting the quadruple helix model of innovation rather than using the triple helix model. The quadruple helix model emphasizes users or customers in the innovation process (Yun & Liu, 2019). By adopting the quadruple helix model of innovation, Thai SMEs can better involve their customers or users in the innovation process, which ensures that the needs and expectations of end users are better understood and addressed.

Verifying the existence of open ambidextrous innovation practices

Hypothesis 2 recognizes the importance of open innovation in the success of modern organizations and suggests that an open ambidextrous innovation practice can serve as a framework for effectively implementing open innovation strategies. **Hypothesis 2** proposes that an open ambidextrous innovation practice is a second-order factor comprising the subdimensions of inbound, outbound, and coupled open innovation activities. This leads to the support of Huizingh (2011) and Naruetharadhol et al. (2020). Huizingh (2011) identifies various open innovation practices, such as inbound open innovation (e.g., external knowledge acquisition), outbound open innovation (e.g., external knowledge exploitation), and coupled open innovation (e.g., collaboration with external partners). By considering open ambidextrous innovation practice as a second-order factor, a more comprehensive understanding of the complex dynamics of open innovation can be gained. The interplay between different open innovation activities is examined in this research and the most effective combinations of inbound, outbound, and coupled open innovation practices are identified.

The findings of the current research provide empirical evidence to support the theoretical framework outlined in the literature and further emphasize the importance of open innovation practices in promoting the ambidexterity of firms. While previous studies such as Cheng and Huizingh (2014) and Naruetharadhol et al. (2020) have focused on the individual dimensions of open innovation, this research highlights the importance of considering open innovation practices as a holistic approach of the second-order factor model to innovation that requires ambidexterity. Inbound, outbound, and coupled open innovation practices can be leveraged together to facilitate a firm's ability to explore and exploit new knowledge resources and effectively respond to market demands. As evidenced by the confirmation of **Hypothesis 2a**, inbound open innovation positively influences (explains) open ambidextrous innovation practice. This finding suggests that when small firms engage in inbound open innovation activities, such as collaborating with external partners or seeking external knowledge sources, they are more likely to take an open ambidextrous innovation approach. This is because inbound open innovation activities facilitate the acquisition of new knowledge and ideas, which can then be explored and exploited by the firm through ambidextrous practices. In other words, inbound open innovation provides a foundation that enables open ambidextrous innovation practices.

West and Bogers (2014) suggest that outbound open innovation can involve collaboration with partners through strategic partnerships and strategic networks with complementary assets. This indicates that outbound open innovation can facilitate the exchange of knowledge and resources with external partners, which can enhance a firm's ability to innovate and compete effectively in the marketplace. Therefore, the confirmation of **Hypothesis 2b**, which states that outbound open innovation positively influences open ambidextrous innovation practice, is supported by the idea that outbound open innovation can be a key factor in promoting collaboration and knowledge exchange with external partners that contributes to a firm's ability to conduct both exploration and exploitation activities in their innovation efforts. For example, Chesbrough (2003) argues that firms should look beyond their internal resources and capabilities and leverage external sources of innovation to enhance their competitive advantage. Similarly, Lichtenthaler (2009) suggests that firms that engage in outbound open innovation activities are more likely to achieve superior innovation performance. This research finding is consistent with the previous research of West and Bogers (2014) that emphasizes the importance of outbound open innovation in promoting firms' innovative capabilities.

The results of this research provide compelling evidence that coupled open innovation is a critical aspect of open ambidextrous innovation practices. The integration of both inbound and outbound open innovation activities is essential for successful innovation outcomes. This finding is consistent with those of the Cheng and Huizingh (2014) and Greco et al. (2016), which acknowledge the importance of coupled open innovation. Cheng and Huizingh (2014) proposed the concept of coupled open innovation, while Greco et al. (2016) emphasized the role of collaboration in open innovation. Both studies underscore the advantages of collaboration among different organizations and stakeholders in open innovation initiatives, which is a critical aspect of coupled open innovation. The current research expands on these findings by providing empirical evidence that coupled open innovation positively influences open ambidextrous innovation practice. The confirmation of **Hypothesis 2c** highlights the significance of integrating inbound and outbound open innovation activities through collaboration to achieve innovation success. This emphasizes the need for SMEs to engage in collaborative efforts to access external sources of innovation and expertise, promoting their ability to innovate and compete effectively in the market. Thus, coupled open innovation can be considered to be a strategic tool that enables firms to leverage external sources of innovation and internal knowledge resources to achieve a competitive advantage.

Assessing the relevance of open innovation processes: open innovation implementation (OII) and open ambidextrous innovation practices (OAIP)

The results of this research support **Hypothesis 3**, which states that open innovation implementation is positively related to open ambidextrous innovation practices. This research provides evidence supporting the idea that open innovation implementation is positively linked to open ambidextrous innovation practices, as is hypothesized. This finding is consistent with those of previous studies such as Chiaroni et al. (2010, 2011), Boscherini et al. (2010), and Mortara and Minshall (2011), who have also found that implementing open innovation practices can enhance a firm's ability to engage in both exploration and exploitation activities. Mortara and Minshall (2011) highlight the importance of culture and skills for open innovation, which are key components of organizational archetypes and knowledge management systems.

Furthermore, our study adds to the literature by conceptualizing open innovation implementation as a second-order factor comprising four subdimensions: organizational archetype, knowledge management systems, collaborative networks, and technology transfer. This approach is in line with previous research by Naruetharadhol et al. (2020), who also emphasize the importance of considering multiple aspects in open innovation implementation.

Similarly, the findings support the idea that an open ambidextrous innovation practice is a second-order factor comprising the subdimensions of inbound, outbound, and coupled open innovation activities. This aligns with the work of Huizingh (2011), who first proposed the concept of open innovation as a paradigm shift toward more collaborative and open practices, and with subsequent research conducted by Naruetharadhol et al. (2020), who investigated the impact of open innovation implementation on small firms' propensity for inbound and outbound open innovation practices. The importance of both open innovation implementation and open ambidextrous innovation practices for firms seeking to effectively engage in innovation activities is clear. By recognizing the multidimensional nature of these concepts, Thai SMEs can better assess their innovation capabilities and design strategies that maximize their ability to explore and exploit new knowledge and technologies. Nevertheless, in comparison to Chiu and Lin's (2022) findings, which emphasize that developing open innovation capability in the context of supply chain management is crucial for supporting collaborative learning, idea generation, and problem solving among supply chain partners, our results demonstrate that open innovation achieved through ambidexterity is essential, as it can lead to a balance between exploitative and exploratory innovation activities, ultimately creating a supportive pattern for supply chain management.

Theoretical contributions

The results of this research support the hypothesis that open innovation implementation is positively related to open ambidextrous innovation practices. The theoretical contributions of this study are noteworthy. First, it adds to the open innovation literature by examining how SMEs implement open innovation internally. The dimensionality of open innovation implementation (OII) and its effect on open ambidextrous innovation practices (OAIP) in six regions of Thailand were identified, contributing to the literature's identification of organizational archetype, knowledge management, and networks as key implementations for open innovation (Naruetharadhol et al., 2020). The conceptual development of open innovation implementation should also consider the role of technology transfer. Additionally, our emphasis on open innovation activities supported by the idea of ambidexterity is crucial, as ambidexterity is the ability to balance explorative and exploitative innovation processes. The direction of innovation exploration and exploitation is also a common element in defining open innovation practices (Hung & Chou, 2013). Another key theoretical contribution based on our empirical results is the new terminology of "open ambidextrous innovation practice," which incorporates insights from ambidexterity and open innovation practices. Our study's findings support similar arguments made by Huizingh (2011) regarding the relevance of these two open innovation processes.

Implications for policy-makers

The Thai government is committed to promoting integrated innovation strategies within the country. The first five years of the 20-year National Strategy (2017–2036) are outlined in the Twelfth Plan, and their aim is to:

> "...encourage collaboration and partnerships among all stakeholders, including government, academia, industry, and communities, in order to create an environment and system that supports research and fosters innovation development" (NESDB, 2017).

Our research findings, derived from a sample of Thai SMEs, offer compelling evidence of the positive relationship among organizational archetypes, knowledge management, technology transfer, and collaborative networks. These endogenous variables provide valuable insights into the internal implementation of open innovation. Additionally, the findings reveal that open innovation practices can be considered ambidextrous when they effectively incorporate a balanced blend of subdimensions, such as inbound, outbound, and coupled open ambidextrous innovation.

SMEs proactively seek external knowledge, technologies, or resources to bolster their innovation processes. They concurrently share or transfer their internal knowledge, technologies, or resources with external partners to engage in synergistic collaborations, combining their strengths with those of other firms to develop new products, services, or technologies. Therefore, the fostering and supporting of open innovation implementation can significantly contribute to promoting and advancing open innovation practices among Thai SMEs, enhancing their competitiveness and success in the global market.

Based on these findings, we recommend that the Thai government and policy-makers prioritize enhancing SME competitiveness in the international market through the development of innovation (inbound), commercialization (outbound), and value cocreation (coupled), alongside the implementation of collaborative networks. These strategies hold significant potential for driving SME-level open innovation development and adoption in the country. By implementing policies that support and encourage these activities, the Thai government can cultivate an environment conducive to research and open innovation development, aligning with their strategic objectives.

Policy-makers can utilize these research findings to support and enhance open innovation practices among Thai SMEs in several ways, including by:

- providing financial support;
- offering incentives, resources, or training to encourage ambidextrous open innovation;
- developing programs focused on open innovation, knowledge management, and technology transfer; and
- strengthening collaborative networks.

The Thai government plays a crucial role in promoting open innovations, even as the business world is primarily focused on technological advancements. Organizational and institutional shifts often drive these developments, complementing essential technological changes. Many advanced players have already begun implementing new business models or alternate modes of provision.

Given these research findings, the Thai government can further support open innovations by promoting ambidextrous practices, fostering collaborative networks, and enhancing knowledge management and technology transfer. Businesses can gain a broader understanding of innovation effects across their value chain and product lifecycle by using a suitable combination of indicators, including those provided by the government.

The Thai government has the potential to significantly contribute to closing the knowledge gap regarding open innovations, especially those that are more integrated, systemic, and characterized by non-technological aspects. They could also work on developing a common vision for national innovation systems and roadmaps to realize these goals aimed at guiding industry and policy-makers toward more radical, system-wide improvements. The participation of industry experts, academics, and nongovernmental organizations (NGOs) in this endeavor is highly encouraged. By addressing these aspects and overcoming the identified challenges, the government can create a supportive environment enabling open innovations to thrive, ultimately guiding the country toward a more creative and shared future.

Practical implications

The results of this study have implications for Thai SMEs. Based on our empirical evidence gleaned from the key item scale, this study proposes a set of strategies for implementing open innovation:

1. **The recognition and rewarding of activities that are related to technology transfer across business strategies [TT1−4]:** Our results highlight the importance to ambidextrous SMEs of operating in open innovation environments to prepare for intellectual property registration and evaluate knowledge assets for commercialization in the market. This suggests that SMEs should address questions such as what is being transferred, to whom it is being transferred, and how the transfer is being carried out. To demonstrate successful innovation implementation, SMEs should establish clear protocols for the transfer of innovation processes, which can involve intellectual property rights, laws, and regulations. Additionally, our findings suggest that SMEs should consider acquiring and licensing technological knowledge (e.g., patents, industrial design rights, copyrights) as a means of creating or improving new innovations based on the existing innovations.
2. **The fostering of collaboration through networks [NWK 1−4]:** Collaborative networks are crucial for implementing open innovation. Our study supports the literature (e.g., Chiaroni et al., 2011; Huizingh, 2011; Naruetharadhol et al., 2020) in highlighting the importance of collaborative networks for open innovation implementation. This means that SMEs should seek partnerships and strategic alliances with external firms to expand their network and explore opportunities for inbound innovation. Additionally, SMEs should look for partners with business models that complement their own technological strengths to enhance their outbound open innovation activities. Our findings suggest that network interactions should not be limited to using the triple helix model (university-industry-government) but rather should also include the quadruple helix model of innovation that further incorporates civil society as an additional actor. This fourth helix represents nongovernmental organizations, citizen groups, and other actors outside of the scope of the traditional three helixes. The reason for suggesting the use of the quadruple helix model is because it offers a more collaborative and inclusive approach to innovation. This model allows for the involvement of a wider range of stakeholders, including citizens and communities, in the innovation process, which can lead to more socially responsible and sustainable innovation outcomes.
3. **The ensuring of a supportive organizational archetype [OS 1−4]:** In comparison with previous studies (e.g., Boscherini et al., 2013; Chiaroni et al., 2010; Naruetharadhol et al., 2020), we aim to identify the types of organizational archetype that facilitate open innovation practices, transcending the traditional structural forms. However, these studies have focused on the roles of gatekeepers and the creation of a dedicated network management unit. In Thailand, most SMEs are family businesses, where the top-level management or owners hold decision-making powers. This reinforces Liao et al.'s (2011) suggestion that financial-based activities, such as budget planning, price-setting policies, new innovation introduction, and new venture establishment, should involve business owners, employee-managers, entrepreneurs, CEOs, and other top-to-middle positions. Hence, centralization appears to be more conducive to balancing open and closed innovation processes. In summary, the organizational archetype plays a critical role in the capacity of SMEs to acquire and absorb external knowledge (Ali et al., 2018).
4. **The adoption of knowledge management systems [KM1−4]:** The findings of this study indicate that knowledge management plays a crucial role in the ways that SMEs manage internal knowledge flows, while the development of knowledge management capabilities within internal firms through IT infrastructure and procedures fosters open innovation (Adamides & Karacapilidis, 2020; Naqshbandi & Jasimuddin, 2018). The study suggests that SMEs should focus on implementing key strategies to manage knowledge creation, sharing, utilization, and storage. This finding supports the previous studies of Liao et al. (2011) and Yeh et al. (2006) that emphasize the importance of SMEs' knowledge management capabilities and processes. To effectively manage knowledge flows during open innovation implementation, SMEs should consider both knowledge management and technology transfer. Based on the empirical results, implementing an IT skill base and IT infrastructure can help SMEs manage the creation, sharing, utilization, storage, and transfer of knowledge within or between firms and their collaborative partners.
5. **Employ exploration and exploitation of knowledge sources to implement innovation initiatives [IOI 1−3; OOI 1−3; and COI 1−3]:** Our study contributes to the literature on open innovation practices, highlighting the importance of ambidexterity for SMEs in an open innovation environment. SMEs should engage with external partners through collaborative network searching to explore external knowledge for internal improvement, which leads to inbound open innovation. This suggests that SMEs should explore their ecosystem to obtain opportunistic technologies and knowledge assets for internal use, such as R&D-related services, technological knowledge, and online technical course platforms. SMEs use the internet to search for new trends or technologies, and forming relationships and collaborating with other companies in their ecosystem can further improve their existing innovations. These ambidextrous SMEs focus on technology exploitation (outbound) activities by systematically interacting with their external environment. Our findings indicate that exploitative SMEs are more likely to sell their know-how, licenses, copyrights, or patents to other market participants. This implies that SMEs should involve all stakeholders, especially employees and customers, in their new product development processes. SMEs can utilize product lines and dedicated business units/divisions, such as promoters and gatekeepers, to commercialize knowledge assets when reorganizing their current inventions. Combining inbound and outbound processes results in the coordination of information exchange activities among partners and engagement in R&D joint ventures. SMEs can also use comarketing partnership strategies to create positive relationships between brands over time.

All of these discussions indicate how ambidextrous SMEs engage in technology exploration and exploitation as part of implementing their open innovation strategies.

Conclusion, limitation, and research directions

This study contributes to the understanding of open innovation practices among SMEs by addressing three main research questions. First, the impact of open innovation implementation (OII) on open innovation practices is examined with a focus on SME size. Second, the key characteristics of OII and OAIP are identified. Third, the ways that the OII process influences the open innovation practices of SMEs are investigated.

Through a survey of 615 SMEs in the six regions of Thailand, a significant positive relationship between OII and OAIP is found, indicating that the adoption of open innovation practices can enhance ambidextrous innovation efforts. Additionally, the fact that micro, small-, and medium-sized enterprises are all capable of adopting open innovation strategies, with medium-sized enterprises exhibiting the highest level of variability in fostering open innovation practices, is revealed.

However, it is worth noting that the holistic model used in this study has its limitations. The condition of sustainability has not been added to the OI implementation dimension, which has been pushed into the agenda setting by developed countries, especially Denmark (Garcia et al., 2019). This leads open innovation into different realms, which are characterized by innovation for eco-innovation. Thus, open innovation cannot be directed only at conventional open innovation; the extent of sustainability moves it to how to innovate for the planet, people, and profit. Considering environmentally and socially responsible practices could nevertheless be ethically debatable for future investigation. Additionally, the characteristics of open innovation implementation for eco-innovation can be further addressed.

Based on the limitations mentioned in the conclusion, some additional recommendations for future research could include the following:

- An examination of the roles played by cultural and social factors in open innovation implementation and ambidextrous innovation practices, as these may influence the adoption and success of these practices in different regions and industries.
- An exploration of the impact of different types of collaborations, such as cross-industry collaborations or public–private partnerships, on open innovation practices and performance.
- An investigation into the potential benefits and challenges of incorporating sustainable practices into open innovation processes and an identification of strategies for promoting sustainable open innovation.
- The conducting of longitudinal studies to better understand the long-term effects of open innovation practices on firm performance and competitiveness. As a cross-sectional design is employed in this study, the results capture a snapshot in time. The established positive correlation between open innovation implementation (OII) and organizational ambidextrous innovation practices (OAIP) was inferred using specific statistical models, which are based on certain assumptions, such as linearity.
- An examination of the impact of open innovation practices on different types of SMEs, such as those in emerging industries or those with different levels of resources.

In terms of limitations, this study is focused on SMEs in the six regions of Thailand, which may limit the generalizability of the findings to other regions and contexts. Therefore, the findings might not be representative of MSMEs in other countries or regions, as cultural, economic, and infrastructural differences in innovation practices may affect the applicability of these findings elsewhere. Additionally, the study relies on self-reported data from SMEs, which may be subject to biases or inaccuracies. Finally, only the relationship between OII and OAIP are examined and other potential factors that may influence open innovation practices or performance remain unexplored. The development of item-scale measures for open innovation performance may be called for.

Appendix

Appendix 1
Questionnaire design (25 items).

Constructs	Items	Sources
Organizational archetype (OA)	OS1: Do you agree that your firm stresses new product or service introductions? OS2: Do you agree with establishing a knowledge network integration? OS3: Do you agree with the creation of the gatekeeping role? OS4: Do you agree with maintaining openness to change?	Adapted from Chiaroni et al. (2011) and Liao et al. (2011)
Knowledge management (KM)	KM1: Do you agree with the creation of new knowledge to improve firm's innovation? KM2: Do you agree with sharing useful knowledge within firm boundaries and with the external partners? KM3: Do you agree with engaging in knowledge utilization processes to obtain a scalable solution? KM4: Do you agree with having a knowledge database within firm boundaries?	Adapted from Chiaroni et al. (2011), Liao et al. (2011), and Naruetharadhol et al. (2020)
Technology transfer (TT)	To what extent do you agree with the following activities about your firm? TT1: ... the evaluation process of technological knowledge acquisition and licensing (e.g., a patent, industrial design right, copyright) to create/improve (new) innovations as a basis for using something already existing TT2: ... preparation of intellectual property registration TT3: ... evaluation of knowledge-assets for commercializing them in the market TT4: ... implementation of IT skill base and IT infrastructure	Adapted from Yun et al. (2018) and Chiaroni et al. (2011)
Collaborative networks (NWK)	Please indicate which of the following networks your firm has interacted with... NWK1: ... Partner firms (i.e., competitors; enterprises from the same industry or the business group; software or materials suppliers; or other large corporations etc.) NWK2: ... clients or customers NWK3: ... higher education institutions or universities NWK4: ... public/government institutions	Adapted from Laursen and Salter (2014) and Ferreras-Méndez et al. (2015)
Inbound open innovation (technology exploration)	Please indicate which of the following exploration activities your firm has engaged in... IOI1: ... interacting with external partners in innovation projects, including consultants, research institutes, government, customers, competitors, university, or suppliers IOI2: ... acquiring licenses, intellectual property, or know-how from outside (for example, R&D-related services, technological knowledge, an online technical course platform, and so on). IOI3: ... the use of the internet to look for new trends or technology	Modified from previous research by Hung and Chou (2013) and Cheng and Huizingh (2014)
Outbound open innovation (technology exploration)	Please indicate which of the following exploitation activities your firm has engaged in... OOI1: ... selling licenses to other companies in the market for patents, copyrights, or know-how OOI2: ... having divisions, product lines, and/or a specialized business unit (i.e., promoters, gatekeepers) with the purpose of commercializing knowledge assets (e.g., spin-off, cross-licensing patents, or selling) OOI3: ... actively participating in other's funded innovation projects	Modified from previous research by Hung and Chou (2013) and Cheng and Huizingh (2014)
Coupled open innovation	Please indicate which of the following activities your firm has engaged in... COI1: ... coordinating the activities of comarketing COI2: ... cooperating with partners in order to coordinate their information-sharing efforts. COI3: ... engaging in a cooperative pattern for R&D (e.g., an R&D joint venture or alliance)	Modified from previous research by Hung and Chou (2013) and Cheng and Huizingh (2014)

Author contributions

Authors participated in the drafting of this manuscript as individual experts in their fields, and are solely responsible for the contents. All authors have read and agreed to the published version of the manuscript.

Funding

The Research titled "Assessing the Effectiveness of Open Innovation Implementation Strategies in Promoting Ambidextrous Innovation in Thai SMEs" by Khon Kaen University, International College has received funding support from International College, Khon Kaen University.

Institutional review board statement

Not applicable.

Role of the funding source

The funder has played no role in conducting this research.

Ethical consideration

The Ethics Committee for Human Research at Khon Kaen University reviewed our research protocols. The protocols were approved as an exemption, given the number HE663173.

Declaration of Competing Interest

The authors declare no conflict of interest.

Acknowledgments

The researchers would like to express their gratitude to all anonymous respondents who took the time to complete questionnaires and to their colleagues who helped us complete this research successfully.

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