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Article

Relationship between open innovation and innovation performance within high-tech firms: The mediating role of knowledge management capability

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Abstract: In the current competitive global marketplace, innovation is key for high-tech firms to thrive. Open innovation offers a promising approach, but its effectiveness remains unclear. Therefore, this research explored the connection between open innovation, knowledge management capability, and innovation performance within high-tech firms. We used a mediation approach to highlight the central role of knowledge management capability in the relationship between open innovation and innovation performance. We used a survey questionnaire approach to collect data from the 462 employees of high-tech firms on open innovation, knowledge management capability, and innovation performance using a convenient sampling technique. We used partial least square structural equations modeling through PLS-SEM statistics. Results indicated that open innovation has a direct, positive and significant connection with innovation performance. Similarly, the current research serves as a pioneering exploration into mediation analysis, highlighting the mediating role of knowledge management capability that influences the relationship between open innovation and innovation performance. Empirical studies offer valuable insights for leaders of high-tech firms, guiding them to identify effective knowledge management practices and determine the ideal extent of open innovation to boost innovation performance. The current study reveals novel insights into the benefits of knowledge management capability in enhancing open innovation efforts within firms. This research provides valuable implications and future research directions.

Keywords: open innovation; knowledge management capability; innovation performance; high-tech companies

1. Introduction

Within the dynamic and competitive global arena, innovation is the lifeblood of high-tech companies. Open innovation presents an intriguing approach, but its efficacy remains a subject of ongoing debate. As globalization progresses, the complexities of technology, intensifying competition, and limited resources are driving firms toward collaboration, aiming to hone their competitive edge (Seidler et al., 2008). This transition broadens the innovation landscape, blending diverse knowledge sources and pushing the scale of innovative initiatives within corporations to peak performance (Wang and Wang, 2022).

Unlike the confines of closed innovation, open innovation empowers firms to harness external expertise and integrate it seamlessly with their internal assets, thereby bolstering their competitive positioning (Lee and wong, 2009). However, the interplay between open innovation and innovation prowess is intricate and multifaceted. While open innovation can undoubtedly enhance innovative capabilities, its effects are not straightforward (Zhao and Xu, 2016). Alongside its potential benefits, open innovation also introduces additional risks and financial burdens (González-Mohíno et al., 2023).

This complex relationship manifests a connection between open innovation and innovation performance. Excessive openness can inadvertently hinder a firm's decision-making agility (Seidler et al., 2021). Thus, the current study explored open innovation including inbound open innovation and outbound open innovation in the context of high-tech firms, with other variables such as knowledge management capabilities.

Knowledge management capabilities play a pivotal role in augmenting the diversity of knowledge within firms, a factor that can directly contribute to enhanced firm performance (Tiwari, 2022). In line with the tenets of Dynamic Capability Theory (Owiyo et al., 2023), technology companies, in particular, require specialized knowledge management capabilities to effectively identify and harness existing and emerging knowledge, ultimately transforming it into opportunities for innovation (Ferreira et al., 2020). The Knowledge Management Process Cycle Model provides a pragmatic framework for organizational knowledge management, fostering the acquisition, utilization, and sharing of knowledge. This cyclical model encompasses the key stages of knowledge creation, capture, dissemination, application, and evaluation, ensuring that knowledge is continuously generated, updated, and utilized effectively (Wang et al., 2022; Gold et al., 2001). Our study also explored the components of knowledge management capabilities such as acquisition, translation, application, and protection with other constructs such as innovation performance. With open innovation and knowledge management capabilities, the current study explored innovation performance, and it includes the effects of innovation exclusion (Ma et al., 2016), environmental impact (Hung et al., 2013), network dynamics (Ovuakporie et al., 2021), risk and cost-sharing, and a spectrum of knowledge-related capabilities, such as knowledge learning (Wang and Wang, 2022), absorption (Tong and Han, 2021), knowledge integration capabilities (Guo et al., 2020), and sharing. Additionally, the role of business models in shaping the relationship between open innovation and innovation performance has also garnered significant attention (Zhao and Xu, 2016).

High-tech firms are particularly well-suited for exploring the relationship between open innovation and innovation performance through the mediating role of knowledge management capability due to several factors (Wang and Xu, 2018). High-tech firms operate in dynamic and rapidly evolving environments, where the ability to effectively manage and integrate external knowledge is crucial for maintaining a competitive edge. Open innovation provides a mechanism for high-tech firms to access external knowledge from a wide range of sources, including universities, research institutions, and other companies (Kakabadse et al., 2003). However, effectively managing and integrating this external knowledge can be challenging. knowledge management capability plays a critical role in helping high-tech firms to capture, organize, and utilize external knowledge, enabling them to leverage it for innovation (Van and Rubalcaba, 2016). Similarly, high-tech firms often generate a vast amount of internal knowledge, which can be difficult to manage and utilize effectively. Knowledge management capability provides a framework for high-tech firms to effectively manage their internal knowledge assets, enabling them to identify, capture, and share knowledge across organizational boundaries (Cohen and Levinthal, 1990). This can lead to increased innovation and improved innovation performance

(Anand et al., 2002). Moreover, high-tech firms are typically characterized by a strong culture of innovation, which is conducive to the adoption of open innovation practices (Chen and Taylor, 2009). Open innovation requires a willingness to collaborate with external partners, which can be challenging for some firms. However, high-tech firms are often more open to collaboration due to their innovation-driven culture.

Our research is grounded in the resource-based view of the firm, which suggests that firms achieve sustained competitive advantage through the development and exploitation of their unique resources and capabilities (Zakaria and Wilemon, 2004). We argue that knowledge management capability is a key resource and capability that can enable high-tech firms to leverage open innovation for innovation and improve innovation performance (Santoro et al., 2018). Knowledge management capability is a critical factor in enabling high-tech firms to effectively leverage open innovation for enhanced innovation performance (Díaz-Díaz and de Saá Pérez, 2014). Knowledge management capability provides the framework for effectively capturing, organizing, and utilizing both internal and external knowledge, which are essential for innovation success. Empirical studies have demonstrated a positive relationship between knowledge management capability and improved innovation performance, highlighting the role of knowledge management capability in facilitating the acquisition, integration, and utilization of knowledge for innovation (Iqbal et al., 2021). Our research focuses on the mechanisms through which open innovation, knowledge management capability, and improved innovation performance are interrelated in high-tech firms, exploring how knowledge management capability mediates the relationship between open innovation and improved innovation performance. Our findings aim to provide practical insights for high-tech firms seeking to optimize their innovation strategies by effectively managing knowledge management capability and leveraging open innovation for enhanced and improved innovation performance.

The existing literature on open innovation and knowledge management capability has primarily focused on the direct relationship between these two constructs (Lopes et al., 2017; Parida et al., 2012; Santoro et al., 2018; Díaz-Díaz and de Saá Pérez, 2014). However, there is a lack of understanding of the mediating role of knowledge management capability in the relationship between open innovation and innovation performance (Chesbrough and Bogers, 2014). The existing body of literature recognizes open innovation as a significant factor influencing innovation performance in high-tech firms. This acknowledgment is widespread, extending to both the broader business landscape as demonstrated by Zhao et al. (2021), and the general domain of ordinary business firms (Kuo, 2023). Notably, open innovation is identified as a potential resource that impacts organizational knowledge management capability. Similarly, in high-tech firms, knowledge management capability is identified as a potential factor that can enhance innovation performance (Huang et al., 2015). However, despite this extensive recognition, critical questions in this domain remain unanswered. Therefore, our study addresses this gap by investigating the mediating role of knowledge management capability in the relationship between open innovation and innovation performance in high-tech firms.

This study makes several significant contributions to the literature on open innovation, knowledge management capability, and innovation performance. First, it provides empirical evidence to support the mediating role of knowledge management

capability in the relationship between open innovation and innovation performance. Second, it demonstrates that open innovation and knowledge management capability are both important factors for achieving high levels of innovation performance in high-tech firms. Third, it provides insights into the specific mechanisms through which open innovation and knowledge management capability influence innovation performance. Fourth, this study extends the existing theoretical framework on open innovation, knowledge management capability, and innovation performance by incorporating the mediating role of knowledge management capability. This theoretical extension provides a more nuanced understanding of the complex relationship between these three constructs. This study employs a partial least squares structural equation modeling (PLS-SEM) approach to analyze the data. PLS-SEM is a robust and flexible method that is well-suited for analyzing complex relationships with multiple mediating variables. This study focuses on high-tech firms because they are characterized by a high degree of innovation and are therefore highly reliant on open innovation and knowledge management capability to achieve success. Overall, this study makes a significant contribution to the understanding of the relationship between open innovation, knowledge management capability, and innovation performance. The findings have important implications for managers and practitioners in high-tech firms. Drawing from these theoretical and methodological perspectives, we formulated the following research objectives:

- To assess the impact of open innovation and knowledge management capability on innovation performance.
- To explore the mediating role of knowledge management capability in the relationship between open innovation and innovation performance.

Research questions:

- Do open innovation and knowledge management capability have a positive impact on innovation performance?
- Does knowledge management capability mediate the relationship between open innovation and innovation performance?

2. Literature review and hypothesis formulation

2.1. Open innovation

The open innovation concept was introduced by Henry Chesbrough in the early 2000s (Bogers et al. 2019). This is a strategic approach that highlights the usage of external knowledge and collaborative partnerships to augment innovation processes within organizations (Ehls et al., 2020). This concept is grounded in the belief that firms stand to gain significant advantages by implementing both internal and external ideas, thus propelling their technological advancements and facilitating the successful introduction of products to the market (Simba et al., 2024). By breaking down traditional boundaries and fostering collaboration with external partners, open innovation seeks to create a dynamic ecosystem where the exchange of ideas, expertise, and resources accelerates the pace of innovation (Zhou and Yang, 2024), ultimately contributing to a firm’s competitive edge and enhance innovation performance in the ever-evolving business landscape.

2.2. Innovation performance

Innovation performance is an integral aspect of innovation management and can be defined as the tangible and measurable outcomes stemming from a firm's engagement in innovative activities (Mo et al., 2024). These outcomes encompass a spectrum of achievements, including the successful introduction of novel products, expansion of market share, and enhancements in operational efficiency (Zhang et al., 2024). Evolving from the broader domain of innovation management, the concept of innovation performance serves as a critical metric for evaluating the effectiveness of an organization's innovation endeavors (Zhang and Jiang, 2024). At its core, this concept is grounded in the fundamental belief that achieving success in innovation is intrinsically linked to the enhancement of overall performance and competitiveness (Lu et al., 2023). By gauging the real-world impact of innovation efforts, firms can not only optimize their strategies but also position themselves favorably in the competitive landscape, fostering sustained growth and relevance in their respective industries (Zhao and Fang, 2023). In addition, the current study also explored knowledge management capability as an antecedent of innovation management.

2.3. Knowledge management capability

Knowledge management capability has a pivotal role in organizational dynamics and can be defined as the proficiency of an organization in efficiently capturing, storing, disseminating, and applying knowledge across its operational landscape (Yan et al., 2023). Originating from the field of knowledge management, this concept garnered prominence in the late 20th century as organizations recognized the strategic importance of harnessing their intellectual capital (Tamirat and Amentie, 2023). Grounded in the fundamental idea that effective knowledge management is crucial for innovation and overall performance improvement, this capability empowers organizations to leverage their internal expertise and experiences (Munawar et al., 2022). By establishing streamlined processes for knowledge creation, storage, and dissemination, organizations can not only enhance their decision-making processes but also foster an environment conducive to continuous learning and innovation, ultimately contributing to sustained competitive advantage and operational excellence (Zámborský et al., 2023). Moreover, knowledge management capability is referred to as knowledge acquisition capability, knowledge translation capability, knowledge application capability, and knowledge protection capability (Ma et al., 2023; Murunga et al., 2020; Idrees et al., 2022). In the realm of knowledge management, distinct capabilities contribute to the comprehensive optimization of organizational knowledge throughout its lifecycle. Collectively, these capabilities acknowledge the holistic nature of knowledge management, providing a well-rounded approach to enhance and safeguard organizational knowledge. These perspectives need to be explored. Therefore, the current research explores the connection between open innovation and innovation performance through knowledge management capability.

2.4. Open innovation and innovation performance

This research argues that in open innovation activities, firms commercialize valuable knowledge resources to improve their knowledge management capabilities

and help them achieve their goals (Chesbrough, 2003), which shows that open innovation has a significant role to play in improving knowledge management capabilities (Díaz-Díaz and de Saá Pérez, 2014; Wang et al., 2023). In particular, technological innovation is in dynamic change (Teece, 2010), driven by the knowledge economy, knowledge occupies an essential position in the technological innovation activities of enterprises, and at the same time, technological innovation also helps to support the development of the knowledge economy (Carrasco-Carvajal et al., 2023). Applying enterprise knowledge management capability in the context of open innovation to technological innovation activities can improve the enterprise's technological innovation performance (Parida et al., 2012). To this end, the following hypothesis was proposed:

- H1. Open innovation has a positive and significant influence on innovation performance.

2.5. Open innovation and knowledge management capability

Open innovation has emerged as a prominent paradigm in the field of innovation management, emphasizing the utilization of external knowledge sources to enhance a firm's innovative capabilities (González-Mohíno et al., 2023; Lopes et al., 2017; Parida et al., 2012). Open innovation has been associated with numerous benefits, including increased innovation speed, reduced innovation costs, and access to a broader range of knowledge capacities (Santoro et al., 2018; Díaz-Díaz and de Saá Pérez, 2014). Empirical studies have demonstrated a positive relationship between open innovation and innovation performance, with open innovation acting as a catalyst for innovation success (Che et al., 2023). Knowledge management capability plays a crucial role in facilitating the effective implementation of open innovation strategies. Knowledge management capability encompasses the firm's ability to create, capture, share, and utilize knowledge effectively (Gold et al., 2001). A firm with strong knowledge management capability can effectively integrate external knowledge into its existing knowledge base, enabling it to derive greater value from open innovation activities (Andreeva and Kianto, 2011). Empirical studies have supported the mediating role of knowledge management capability in the relationship between open innovation and innovation performance (Bock et al., 2012; Carrasco-Carvajal et al., 2023). Overall, open innovation has emerged as a powerful tool for enhancing knowledge management capability. Therefore, our study explored the connection between open innovation and knowledge management capability by formulating the following hypothesis:

- H2: Open innovation has a positive and significant relationship with knowledge management capability.

2.6. Knowledge management capability and innovation performance

The research explores the positive correlation between knowledge management capabilities and innovation performance (Chesbrough and Bogers, 2014). Knowledge management capability is comprised of knowledge acquisition, knowledge sharing, and knowledge application (Kuo, 2023). Knowledge management capabilities play complementary roles at varying levels (Tanriverdi, 2005). Our research theorizes that

the capacity to acquire, share, apply, and safeguard knowledge bolsters innovation performance (Hurmelinna-Laukkanen, 2011). Knowledge management capabilities are a prerequisite for improving firms' innovation performance (Mokhtar and Don, 2014). Firstly, knowledge management capability ensures that enterprises effectively capture, organize, store, and share knowledge, providing the basis for enhancing innovation performance (Lin, 2007). Secondly, knowledge management capability is conducive to transforming knowledge into real innovation results (Zhao et al., 2021). Employees are encouraged to share their ideas, insights, and expertise through effective knowledge-sharing platforms and collaborative tools (Paroutis and Al Saleh, 2009). High-performing firms incorporate all significant sources of information into the product innovation process and actively contribute to the overall knowledge creation and management process (McCann and Buckner, 2004). These factors promote a culture of innovation and increase the organization's ability to generate new and creative ideas (Abbas and Khan, 2023). Knowledge management capabilities have a crucial impact on firms' innovation performance (Kuo, 2023). By effectively integrating and applying internal and external knowledge resources, enterprises can turn innovative ideas into actual products, services, or business processes (Huang et al., 2015). To this end, the connection between knowledge management capability and innovation performance was assumed and measured this relationship through formulating the following hypothesis:

- H3. Knowledge management capability has a positive impact on innovation perfomance.

2.7. Knowledge management capability as a mediator in the relationship between open innovation and innovation performance

Knowledge management capability plays a key intermediary role in the relationship between open innovation and innovation performance (Zhao et al., 2021). It facilitates the integration of external knowledge into the internal innovation process, enabling firms to effectively utilize both internal and external knowledge resources to enhance innovation performance (Bagherzadeh et al., 2019). Open innovation often involves collaboration and partnerships with external stakeholders, and knowledge management capabilities are crucial for efficiently managing these relationships (Abbas and Khan, 2023). By providing platforms, tools, and processes for effective knowledge sharing and diffusion, knowledge management capabilities enhance knowledge flows within and outside the organization, driving innovation activities and ultimately positively impacting innovation performance (Mura et al., 2013).

Knowledge management capabilities also support internal and external knowledge sharing and diffusion, enabling firms to effectively capture and integrate emerging knowledge using specialized exploration processes (Abbas and Khan, 2023). This facilitates the utilization of external knowledge sources, including customers, suppliers, and other partners, to bolster innovation processes and contribute to innovation performance (Zack et al., 2009). However, as open innovation activities intensify, there may also be challenges and constraints that have an impact on innovation performance (Lichtenthaler and Lichtenthaler, 2009). These challenges include enhancing coordination, managing intellectual property issues, aligning

external knowledge with internal capabilities, and ensuring effective collaboration with external partners (Zhou et al., 2018).

Over-reliance on external resources for innovation can constrain opportunities for organizational growth and internal capacity development (Francis and Bessant, 2005). Additionally, open innovation can introduce risks about intellectual property protection, especially when sharing knowledge and information with external partners (Chesbrough, 2003). Therefore, it is crucial for firms to strike a balance between internal and external innovation endeavors and to regularly evaluate the influence of open innovation initiatives on innovation performance (Rajapathirana and Hui, 2018). This strategic approach allows companies to determine the optimal degree of open innovation, thus maximizing its advantages and mitigating potential drawbacks (Tamirat and Amentie 2023). All these perspectives indicated that knowledge management capability has a mediating role in the relationship between open innovation and innovation performance, and measured through the following hypothesis:

- H4: Knowledge management capability mediates the relationship between open innovation and innovation performance.

2.8. Conceptual framework

The resource-based view (RBV) of the firm provides a robust theoretical foundation for examining the relationship between open innovation, knowledge management capability, and innovation performance (Wernerfelt, 1984). The RBV posits that firms achieve sustained competitive advantage by developing and exploiting their unique resources and capabilities (Wernerfelt, 1984). In this context, open innovation and knowledge management capability can be considered valuable resources that firms can leverage to enhance innovation performance (Hsu and Wang, 2009). Open innovation refers to the process of firms actively engaging with external sources to acquire and utilize knowledge and technologies for innovation (West et al., 2014). This approach contrasts with traditional closed innovation, which relies solely on internal sources of knowledge (West et al., 2014). Open innovation offers several potential benefits for firms, including access to a broader knowledge base, risk reduction, cost-sharing, and increased speed to market (Laursen and Salter, 2006).

Knowledge management capability refers to a firm's ability to effectively capture, organize, disseminate, and utilize knowledge for innovation (Alavi and Leidner, 2001). This capability is essential for firms to leverage open innovation effectively (Alavi and Leidner, 2001; Tamirat and Amentie, 2023). Knowledge management capability encompasses several key dimensions, including knowledge acquisition, knowledge organization, knowledge dissemination, and knowledge utilization (Zack, 1999). Knowledge management capability plays a critical mediating role in the relationship between open innovation and innovation performance (Hsu et al., 2014). Innovation performance refers to a firm's ability to develop and market new or improved products or services (Laursen and Salter, 2006). It is a key measure of a firm's success in the innovation process (Laursen and Salter, 2006).

In summary, the conceptual framework of this paper is shown in **Figure 1**.

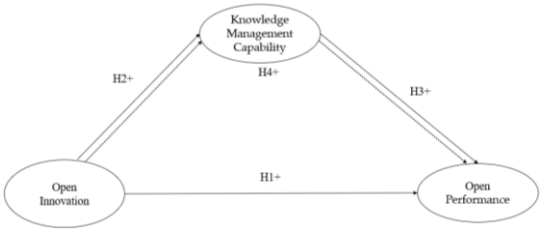

Figure 1. The conceptual model: Solid lines represent the direct relation while the dashed lines indicate an indirect relationship between variables used in the conceptual model.

3. Methodology

3.1. Sampling and data collection

To gain in-depth insights into the relationship between open innovation and innovation performance among high-tech small and medium-sized enterprises (SMMEs), our research focused on three exemplary companies located in the Zhengzhou High-Tech Industrial Park. These companies are recognized for their robust innovation efforts and extensive adoption of open innovation practices. They actively engage with external partners, including suppliers, competitors, universities, research institutes, and clients, to acquire and leverage knowledge, technologies, and resources for innovation. This collaborative approach provides a rich context for examining the intricacies of open innovation behavior and its impact on innovation performance. To assess the perceptions and experiences of employees regarding open innovation and innovation performance, we employed a structured questionnaire utilizing a 7-point Likert scale. The questionnaire encompassed questions related to open innovation practices, knowledge management capability, and innovation performance.

Before commencing data collection, we rigorously validated and ensured the reliability of the scales employed in our research. This process involved a pilot test with 50 participants mirroring the characteristics of the final sample. These participants were specifically instructed to offer feedback on any challenges and comprehension issues related to the questionnaire items. Additionally, we sought validation from five experts in the relevant fields, further enhancing the robustness of our measures. Subsequent to the valuable input from participants and experts, necessary modifications were made to the questionnaire items prior to initiating the final data collection phase.

We distributed the questionnaire electronically through WeChat QR codes and links to employees of the three selected high-tech companies. Prior to participation, all respondents were informed about the purpose of the study, their right to confidentiality, and the voluntary nature of their participation. Out of the 500 questionnaires distributed, 462 were returned with valid and usable responses, resulting in a response rate of 92.4% (see **Figure 2**). This high response rate indicates the strong interest and engagement of employees in the study, enhancing the credibility of the findings. Obtaining informed consent from participants is paramount in any research endeavor. Before data collection, we obtained explicit consent from all participants, ensuring that they were aware of the study's objectives, their right to

anonymity, and the voluntary nature of their involvement. Furthermore, the study received ethical approval from the Research Committee of Innovation College, North-Chiang Mai University, Chiang Mai, Thailand, adhering to strict ethical guidelines and ensuring the protection of participants' rights and privacy.

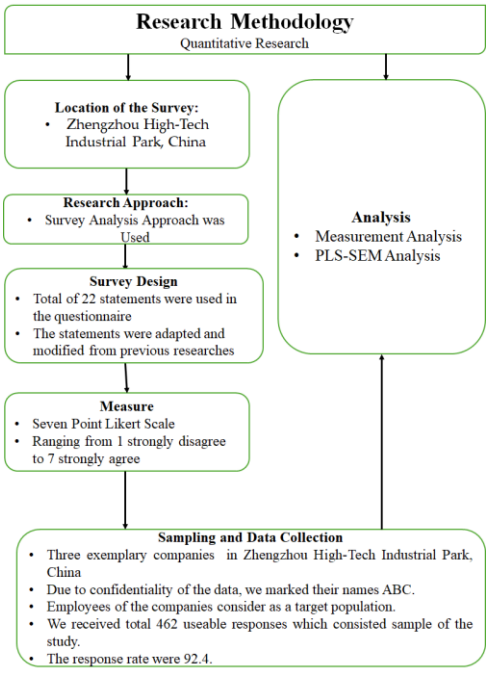

Figure 2. Methodology flow chart.

3.2. Instrument development

The choice of research methods was guided by the specific objectives of the study. The focus on case studies allowed for an in-depth examination of open innovation practices and their relationship with innovation performance within the context of high-tech SMMEs. This approach provided rich insights into the nuances of open innovation implementation and its impact on innovation outcomes. The use of a structured questionnaire facilitated consistent and quantifiable data collection across the three case study companies. The 7-point Likert scale enabled respondents to express their perceptions and experiences with greater precision.

Our measurement tools were adapted from literature. These were seven-point Likert scale, starting at 1, signifying "strongly disagree," and culminating at 7, representing "strongly agree." The metrics utilized are detailed in Appendix, **Table A1**. We employed a questionnaire developed by Cheng and Huizingh (2014). In total, six items were wielded to gauge open innovation (see Appendix, **Table A1**). Knowledge management capability was taken from the work of Akram et al., (2018); knowledge management capability consists of four dimensions, knowledge acquisition, knowledge transformation, knowledge application, and knowledge preservation, which describe the flow and change of knowledge within and outside of the organization, each of the dimension is measured with three items and all the knowledge management capability items (see Appendix, **Table A1**). Innovation Performance Scale items were adapted and developed based on the work of Bashir et al. (2022). Moreover, the scales' reliability and validity were ensured through pilot

testing incorporating 50 participants of the sample with the same characteristics and 5 experts' opinions. A few modifications and changed were made to the items of the scales according to the feedback of the participants and expert opinion before the start of the final data collection (see Appendix A, **Table A**).

3.3. Data analysis procedures

In this study, we employed statistical methods encompassing both descriptive and inferential analyses to extract results from the collected data. Descriptive statistics were utilized to determine response rates, while inferential statistics were employed to analyze direct and indirect relationships through Partial Least Squares Structural Equation Modeling (PLS-SEM). Additionally, the data were analyzed using a combination of Structural Equation Modeling (SEM). PLS-SEM was employed to assess the overall fit of the proposed theoretical model and to test the mediating role of knowledge management capability in the relationship between open innovation and innovation performance. In the first stage, we analyzed the measurement modeling (Factor Loading, Cronbach Alpha, composite reliability roh_A, roh_C) and Average variance extraction (AVE) to measure the reliability and validity of our scales used in the research model. We also checked the model robustness by applying goodness-of-fit, and later on, we applied structural equation modeling to assess the relationship between variables. Due to the complexity of the research framework, we used PLS-SEM to analyze the hypothesized relationships. PLS-SEM can handle complex model structures and extensive metrics even with small sample sizes, and it doesn't require data to be normally distributed. In PLS-SEM, the sample size should be at least 10 times the maximum number of paths impacting an endogenous variable (Hair et al. 2019). Therefore, we applied partial least square structural equation modeling to analysis the direct and indirect relationship between the variables used in this research.

3.4. Common method bias

To mitigate common method variance (CMV) bias in our study, we employed Harman's one-factor test, a statistical remedy suggested by Podsakoff et al. (2012). Through exploratory factor analysis (EFA) conducted in SPSS, we loaded all variables' items of the model. The results of the analysis revealed that the first factor of the model explained only 23.7% of the total variance, falling below the recommended threshold of 50%. This outcome from this statistical measure assures that there is no significant concern regarding CMV bias in the employees' responses.

4. Data analysis

4.1. Measurement modeling

The test of the PLS model was generally divided into two parts. First, the measurement model was analyzed for validity and reliability. Convergent validity is tested through factor loadings and average extracted variance values (AVE).

Table 1 displays factor loadings and AVE values exceeding 0.50, indicative of good convergent validity. To assess discriminant validity, the square root of the AVE is compared to correlation values; when the AVE square root exceeds the correlation

value, it confirms discriminant validity. **Table 2** illustrates that each dimension's AVE exceeds 0.5 and the composite reliability (CR) surpasses 0.7, suggesting both strong convergent validity and composite reliability.

Table 1. Reliability and convergent validity.

Construct	Indicator	Indicator loadings	Bartlett's test of sphericity		KMO	VIF	CR	AVE
Inbound open innovation	OI1	0.618	Chi-square	316.732	0.756	3.229	0.849	0.574
	OI2	0.745	df	3		3.222		
	OI3	0.839	sig.	0.000		2.852		
Outbound open innovation	OI4	0.801	Chi-square	243.430	0.765	2.837		
	OI5	0.822	df	3		3.060		
	OI6	0.697	sig.	0.000		3.420		
Knowledge acquisition capability	KMC1	0.762	Chi-square	333.328	0.753	4.977	0.926	0.551
	KMC2	0.703	df	3		4.052		
	KMC3	0.814	sig.	0.000		3.475		
Knowledge translation capability	KMC4	0.748	Chi-square	267.801	0.768	3.534		
	KMC5	0.733	df	3		3.592		
	KMC6	0.779	sig.	0.000		3.672		
Knowledge application capability	KMC7	0.731	Chi-square	273.022	0.770	3.540		
	KMC8	0.703	df	3		3.886		
	KMC9	0.783	sig.	0.000		3.344		
Knowledge protection capability	KMC10	0.714	Chi-square	247.639	0.750	3.438		
	KMC11	0.726	df	3		3.575		
	KMC12	0.698	sig.	0.000		3.631		
Innovation performance	IP1	0.879	Chi-square	487.184	0.834	3.976	0.912	0.791
	IP2	0.906	df	6		2.882		
	IP3	0.898	sig.	0.000		3.154		
	IP4	0.874				2.835		

Abbreviations: KMO: Kaiser-Meyer-Olkin; VIF: Variance Inflation Factor; CR: Composite Reliability; AVE: Average Variance Extracted.

Table 2. Discriminant validity (HTMT).

Constructs	1	2	3
1. Innovation performance	-	-	-
2. Knowledge management capability	0.742	-	-
3. Open innovation	0.736	0.848	-

Note: Heterotrait-Monotrait Ratio (HTMT) discriminate at (HTMT < 0.9).

For reliability, both the CR and Cronbach's alpha should exceed 0.70. **Table 1** confirms these metrics are above the threshold. Addressing multicollinearity is pivotal. We evaluated multicollinearity through the variance inflation factor (VIF). **Table 1** demonstrates that the full covariance VIF values remain within acceptable bounds, negating concerns of multicollinearity. Hair et al. (2019) argue that covariance VIF offers a traditional, perhaps superior, approach to detecting multicollinearity.

Discriminant validity was further assessed using the heterogeneous-to-

unidimensional trait ratio, which compares the correlation between different constructs (inter-trait) to the correlation within the same construct (intra-trait). The threshold for this ratio is set at 0.9. As evidenced in **Table 2**, the HTMT value between constructs remains below this threshold. Therefore, our scale was considered valid (see **Table 2**).

Table 3 of model fit statistics indicates that the saturated model is a good fit for the data. The SRMR value is low, which means that the model does a good job of reproducing the observed data. The d_ULS and d_G values are close to 0, which means that the model is not significantly different from the unconstrained model or the saturated model, respectively. The NFI value is close to 1, which means that the model does a good job of accounting for the variability in the data. The Chi-square value is high, but this may be due to the large sample size (Hair et al., 2019). Overall, **Table 3** of model fit statistics suggests that the saturated model is a good fit for the data.

Table 3. Model fit statistics.

Model fites	Saturated model	Estimated model
SRMR	0.059	0.059
d_ULS	0.874	0.874
d_G	0.394	0.394
Chi-square	1013.685	1013.685
NFI	0.848	0.848

Abbreviations: SRMR: Standardized Root Mean Square Residual; d_ULS: Unweighted Least Squares discrepancy; d_G: Geomin discrepancy; Chi-square: Chi-square statistic, NFI: Normed Fit Index.

4.2. Model estimation and results

The use of both Structural Equation Modeling (SEM) in this study served complementary purposes. SEM was employed to assess the overall fit of the proposed theoretical model and to test the mediating role of knowledge management capability in the relationship between open innovation and innovation performance. SEM is a powerful tool for analyzing complex relationships among multiple variables, particularly when a mediating role is hypothesized. It allows for simultaneous examination of direct and indirect effects, providing a more comprehensive picture of the causal dynamics at play. In this study, SEM enabled us to rigorously assess the mediating role of knowledge management capability, accounting for its influence on both open innovation and innovation performance. Moreover, we also run bootstrapping (5000) (Iqbal, Asghar, Asghar, et al., 2022).

Our hypothesis assessment was conducted using partial least squares structural equation modeling (PLS-SEM). As illustrated in **Table 4**, open innovation substantially and positively influences innovation performance (β = 0. 309; $p < 0.05$), which endorsed H1. Similarly, **Table 4** demonstrates the results that open innovation has a positive and significant influence on knowledge management capability. The coefficient for open innovation indicates a substantial positive relationship ($B = 0.756$; $p < 0.05$), suggesting that open innovation has a direct and favorable influence on a firm's knowledge management capability which supported H2. Similarly, **Table 4** demonstrates the results that knowledge management capability has a positive influence on innovation performance. The coefficient indicates a substantial positive

relationship ($B = 0.450$; $p < 0.05$), suggesting that knowledge management capability has a positive and significant relationship with innovation performance which approved H3 (See **Figure 3**).

Table 4. Structural relationships between variables.

Direct relations	Coefficients	Mean	SD	*T* values	*P* values	Decisions
Open Innovation →Innovation Performance	0.309	0.308	0.065	4.781	0.000	Accepted
Open Innovation →Knowledge Management Capability	0.756	0.757	0.027	28.359	0.000	Accepted
Knowledge Management Capability → Innovation Performance	0.450	0.450	0.075	6.025	0.000	Accepted
Open Innovation →Knowledge Management Capability→ Innovation Performance	0.340	0.341	0.059	5.801	0.000	Accepted

Abbreviations: SD, standard deviation.

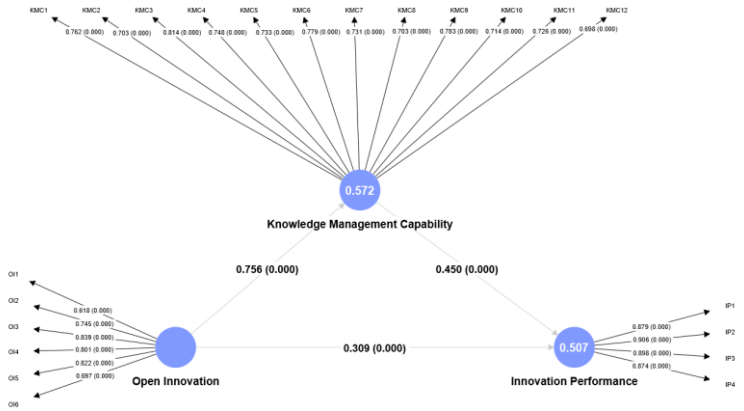

Figure 3. Structural relationship between variables including open innovation, knowledge management capability, and innovation performance.

Knowledge management capabilities act as a bridge between open innovation and firm innovation performance. Building on the framework, we initially assessed the impact of the independent variable (open innovation) on the mediator (knowledge management capabilities. Lastly, we showcased that the mediator (knowledge management capabilities) impacts the dependent variable (firm innovation performance) while accounting for the independent variable (open innovation). Results reveal that knowledge management capability's coefficient ($B = 0.340$, $p < 0.05$), suggests that knowledge management capability favorably impacts the relationship between open innovation and innovation performance.

Results indicated that open innovation has a positive, significant, direct and indirect impact on innovation performance, which indicated that knowledge management capability partially mediated the connection between open innovation and innovation performance.

5. Discussions

5.1. Discussion of results

Over time, open innovation has evolved from being just an approach to innovation to becoming a central element in strategic innovation management research (Chiaroni et al., 2011). Numerous analyses have proffered theoretical frameworks to

explore the influence of corporate adoption of open innovation on innovation outcomes. Within the scope of this manuscript, our attention is centered on the mediating role of knowledge management capability in the relationship between open innovation and innovation performance. Specifically, we endorse the mediation model, establishing a theoretical framework that encompasses the empirical relationships among open innovation, knowledge management capabilities, and innovation performance.

Our results indicated that open innovation has a positive and significant relationship with innovation performance, which approved H1. The relationship between open innovation and innovation performance, as observed in previous research (Schäper et al. 2023), implies that the strategic integration of external sources enhances the value chain. Our results align with this perspective, emphasizing the positive impact on innovation outcomes. The study further supports the notion that openness to cross-sector collaboration positively influences innovation performance (Inauen and Schenker-Wicki, 2011). This implies that companies benefit from diversifying their innovation approach by engaging with a broad spectrum of industries. Our findings echo the assessment of open innovation implementation across managerial and organizational dimensions (Srisathan et al., 2023). This emphasizes the importance of organizational adaptability and effective management in leveraging open innovation for improved innovation performance.

Results also indicated that open innovation increased knowledge management capability, which supported hypothesis H2. Open innovation, as explored in various studies (Cheng et al., 2016), is a strategic approach that involves collaboration and idea exchange with external entities. This collaborative process seems to enhance an organization's ability to manage knowledge effectively. Similarly, the study's results align with the growing recognition of the interplay between open innovation and knowledge management capabilities. Organizations embracing open innovation practices tend to foster an environment conducive to knowledge sharing, ultimately bolstering their ability to harness and utilize information efficiently. This positive relationship contributes to organizational agility (Idrees et al., 2022). Moreover, this suggests that firms that engage in open innovation are more likely to develop and commercialize new products and services than firms that do not. This is likely because open innovation allows firms to access a wider range of knowledge and resources, which can lead to more innovative ideas (Díaz-Díaz and de Saá Pérez, 2014).

Knowledge management capabilities act as a mediator between open innovation and innovation performance, which approved H4. The study emphasizes the significance of the design of the knowledge management process in implementing open innovation. It suggests that the mediation effect of knowledge management design enhances the impact of open innovation on innovation performance (Wu and Hu, 2018). The research findings demonstrate a strong correlation between knowledge management and innovation capability, highlighting the pivotal role of knowledge management in fostering an environment conducive to innovation (Lam et al., 2021). This study explores the mediating role of internal knowledge integration in the relationship between internal IT capability and open innovation performance, contributing insights into the broader dynamics of open innovation (Wu and Gao, 2022). Investigating the impact of knowledge management capabilities on new

product development performance, this study emphasizes the integral role of KM in enhancing innovation outcomes (Idrees et al., 2022). The study from Borodako et al. (2023) supports the idea that knowledge management acts as a mediator between strategic (entrepreneurial) orientation and innovation performance, further underlining the mediating function of knowledge management. The current research provides robust support for the notion that knowledge management capabilities play a crucial mediating role, channeling the benefits of open innovation to enhance innovation performance in various organizational contexts.

5.2. Conclusions

Based on the results and discussion, we made the following conclusions; open innovation has become a central element in strategic innovation management research. Similarly, knowledge management capability mediates the relationship between open innovation and innovation performance. Additionally, innovation performance increases knowledge management capability. Furthermore, knowledge management capability is more important for innovation performance in high-tech firms than in other types of firms. Lastly, open innovation leads to increased innovation performance, but this effect is partly mediated by knowledge management capability. In other words, firms that are better at managing their knowledge are more likely to benefit from open innovation. This is because open innovation allows firms to access a wider range of knowledge and resources, which can lead to more innovative ideas. However, firms need to be able to capture, store, and share this knowledge to fully benefit from open innovation. Knowledge management capability is therefore an essential element for firms that want to succeed in the open innovation era.

5.3. Theoretical contribution

This research contributes to the existing literature by providing a deeper understanding of the interplay between open innovation, knowledge management capability, and innovation performance. The study investigates the sequential influence of open innovation on innovation performance, using a mediating model to demonstrate that open innovation acts as a catalyst, enhancing knowledge management capability, which in turn boosts innovation performance. This finding reinforces the critical role of knowledge management capability in enabling firms to effectively leverage the benefits of open innovation to enhance innovation outcomes. The study also identifies the contextual factors that influence this relationship, including firm size, industry characteristics, and innovation culture. Larger firms may have greater resources to invest in open innovation and knowledge management capability initiatives, while firms operating in industries with rapid technological advancements may have an intensified need for these capabilities. Moreover, a robust innovation culture fosters a supportive environment for open innovation and knowledge management capability practices to thrive.

5.4. Practical implications

The study highlights the pivotal role of knowledge management capability in mediating the relationship between open innovation and innovation performance.

Management in high-tech industries needs to invest in designing and implementing effective knowledge management processes. This includes creating an environment conducive to knowledge sharing, capturing, storing, and efficiently utilizing information. The findings suggest that a robust knowledge management capability contributes to organizational agility, ultimately enhancing the ability to develop and commercialize new products and services. Management in high-tech industries should strategically embrace open innovation practices as a central element in their innovation strategy. The positive and significant relationship between open innovation and innovation performance suggests that integrating external sources can enhance the value chain. Management should actively seek opportunities for cross-sector collaboration, diversifying their innovation approach by engaging with a broad spectrum of industries. This strategic openness is crucial for fostering innovation outcomes and gaining a competitive edge. The research indicates that knowledge management capability is more critical for innovation performance in high-tech firms compared to other types of firms. Therefore, management in high-tech industries should place a heightened emphasis on developing and refining their knowledge management practices. This may involve specialized training, technology infrastructure investments, and fostering a culture that encourages knowledge sharing and collaboration. Recognizing the specific importance of knowledge management in the high-tech context is essential for optimizing innovation outcomes in these sectors.

5.5. Limitations and future research

The study highlights the crucial role of knowledge management capability in driving innovation performance across various industries. However, it acknowledges limitations in its scope and methodology, suggesting the need for further research to validate and expand its findings. Additionally, to mitigate the potential bias introduced by Common Method Variance (CMV), upcoming research endeavors should shift away from surveys. Instead, a more effective strategy involves adopting a time-lagged and cross-lagged research design. This methodology facilitates a comprehensive exploration of the causal relationships among the variables in question, as advocated by Kasl and Jones (2003), and adopts more objective measures to enhance the generalizability of the results. Additionally, research should explore the granular impact of open innovation and knowledge management on specific innovation projects or processes.

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Appendix

Table A1. Measurement of the variables.

Variables	Items	Reference
Open innovation entry		
Inbound open innovation	(IOI1) The firm often receives technical and intellectual support from external sources. (IOI2) The firm often collaborates with external organizations to develop new technologies. (IOI3) The firm often brings in externally developed knowledge and technology to supplement our in-house R&D.	Huang (2011)
Outbound open innovation	(OOI1) The firm often sells or licenses its own patents and technologies. (OOI2) The firm often discloses new knowledge and technology to increase its presence in the industry. (OOI3) The firm is in a better position to benefit from our innovation efforts by creating spin-off organizations.	Cheng and Huizingh (2014)
Knowledge management capability		
Knowledge acquisition capability	(KA1) The firm has a knowledge acquisition process for customer or supplier data. (KA2) The firm has processes in place for gaining knowledge about new products/services in our industry. (KA3) The firm has a knowledge exchange process with our trading partners.	Akram et al. (2018)
Knowledge translation capability	(KTC1) The firm has a process for translating knowledge into new product/service models. (KTC2) The firm has a knowledge filtering process. (KTC3) The firm has processes in place to replace out-of-date knowledge.	
Knowledge application capability	(KAC1) The firm has a process/service for the use of knowledge in developing new products (KAC2) The firm has a process of using knowledge to solve novel Akram et al., 2018problems. (KAC3) The firm will use the knowledge to adjust its strategic orientation.	
Knowledge protection capability	(KPC1) The company has processes in place to protect the knowledge from being misused within the organization. (KPC2) The firm has incentives to encourage knowledge protection. (KPC3) The firm has measures in place to restrict access to some sources of information.	
Innovation performance	(IP1) Corporations reduce the risk of innovation. (IP2) The firm lowers the development costs of new products/services. (IP3) The firm has reduced the time required to market innovative products and services. (IP4) The firm has introduced new or substantially improved products and services.	-