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Bridging Technological Competence and Innovation Performance: The Mediating Role of Collaborative Innovation in Chinese Manufacturing SMEs

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Abstract
Purpose: This study investigates the interplay between technological competence, collaborative innovation, and innovation performance within the context of Chinese manufacturing Small and Medium-sized Enterprises (SMEs). Utilizing a theoretical framework that integrates the Resource-Based View and Dynamic Capabilities perspective, the research posits that technological competence is a critical antecedent to collaborative innovation, which in turn enhances innovation performance. **Design/methodology/approach:** Data was collected from 163 SMEs representatives in China. PLS-SEM analysis was conducted to verify the proposed hypotheses. **Findings:** The current study demonstrated that technological competence significantly influences collaborative innovation, which subsequently drives innovation performance. Furthermore, collaborative innovation is identified as a vital mediating mechanism that amplifies the impact of technological competence on innovation outcomes. **Research limitations/implications:** The findings underscore the importance of fostering technological capabilities and collaborative networks to navigate the challenges of a volatile market environment, providing actionable insights for SMEs aiming to enhance their innovation capabilities through strategic partnerships. **Originality/value:** This research contributes to the understanding of how internal resources can be leveraged through external collaborations to achieve superior innovation performance in the manufacturing sector.
Keywords: SMEs, Technological Competence, Innovation, Collaboration, Firms Performance, Pls-Sem, China

Introduction

Manufacturing Small and Medium-sized Enterprises (SMEs) operate within a national policy environment that strongly prioritizes and subsidizes innovation (X. Wang et al., 2023). Despite this strategic impetus, a significant implementation gap persists. Industry analyses, such as that by McKinsey, (2023), indicate that the adoption of advanced technologies like AI and big data remains below 20% among these firms. As illustrated in Figure VI, this technological deficit is further evidenced by low rates of investment in automation, cloud computing, and Industry 4.0 solutions. This limited technological competence critically constrains absorptive capacity—the organizational ability to identify, assimilate, and apply external knowledge, which is a prerequisite for leveraging advanced technologies (Wang, Li, Ding, & Guo, 2025). Foundational IT competencies are a necessary antecedent for the integration of emergent digital tools (Yang, Peng, Du, Xie, & Cheng, 2023). When present, such competence enables practical applications, including AI-driven predictive maintenance (Zhou, Zhou, Nie, & Zheng, 2024), and facilitates entry into Industry 4.0 ecosystems through partnerships with technology providers and academic institutions (Nithyanandam, Munguia, & Marimuthu, 2022).

A parallel deficiency exists in the domain of collaborative innovation. Chinese SMEs demonstrate markedly lower engagement with higher education institutions—approximately 10%—compared to European counterparts (Du, Wang, & Yin, 2024). This collaborative deficit restricts access to external R&D funding (constituting less than 10% of total funding) and is compounded by significant perceived barriers, including intellectual property concerns (cited by 35% of firms), high partnership costs (25%), and perceived inadequacies in supportive government policy. Consequently, Chinese SMEs often lack the institutional frameworks and capabilities to pursue effective collaborative innovation, even as they increasingly recognize its necessity for enhancing innovation capabilities through alliances with universities and other enterprises (Zeng et al., 2010).

To address these challenges, an integrative theoretical framework is proposed, synthesizing the critical internal capabilities i.e., technological capability. This capability is fundamental for reducing time-to-market and achieving breakthrough innovations, particularly in contexts historically reliant on imported technology. From a theoretical standpoint, this framework bridges the Resource-Based View (RBV)—which emphasizes internal assets like technological competence—with the Dynamic Capabilities perspective, where collaborative innovation acts as the strategic mechanism to reconfigure these assets in response to external change. Collaborative innovation thus serves as a critical mediating conduit, linking a firm's internal resource base to its ultimate market performance. This study is designed to address these identified gaps by investigating the extent to which technological competence enhance innovation performance through the mediating mechanism of collaborative innovation. This inquiry provides a valuable framework for manufacturing SMEs in volatile environments, guiding the alignment of their internal capabilities with external collaborative strategies to achieve superior innovation outcomes.

Although previous research has recognized the individual significance of technological competence and collaborative innovation, a critical gap persists in understanding the specific mechanism that links these factors to superior innovation performance—particularly within Chinese manufacturing SMEs. Existing studies often examine these elements in isolation or overlook how firms transform internal technological capabilities into commercially viable innovations. This issue is especially salient for SMEs operating in volatile environments characterized by limited internal resources and complex innovation pathways. To address this gap, our study develops and empirically validates an integrative model in which collaborative innovation serves as a key mediating mechanism. The findings reveal that technological competence enhances innovation performance not only directly, but more importantly, by fostering and strengthening external collaborative partnerships. This provides a clear and actionable framework for SMEs to effectively leverage their internal technological resources to achieve a sustainable competitive advantage.

Hypotheses Development

Technological Competence and Collaborative Innovation

The Resource-Based View (RBV) posits that a firm's sustained competitive advantage is derived from its endowment of strategic resources that are valuable, rare, inimitable, and non-substitutable (VRIN) (Barney, 1991). Technological competence constitutes precisely such a strategic asset, encompassing not only advanced technical capabilities and R&D infrastructure but also a pronounced absorptive capacity (Bhatia, 2021). This composite resource base empowers firms to spearhead innovation and navigate dynamic technological and market landscapes.

In contemporary innovation ecosystems, where collaboration is paramount, technological competence serves as a fundamental antecedent to effective collaborative innovation (Teece, 2007). It actively cultivates collaborative ventures by enabling sophisticated knowledge exchange, promoting joint problem-solving, and facilitating the integration of disparate expertise. For instance, digital competence within manufacturing SMEs significantly underpins collaborative innovation by streamlining communication and fostering knowledge symbiosis among stakeholders (Mubarak & Petraite, 2020). Technologically proficient employees act as critical liaisons, bridging functional siloes and thereby enabling open innovation paradigms (Bogers et al., 2019). Furthermore, the deployment of advanced capabilities such as artificial intelligence (AI) and data analytics enriches collaborative innovation through predictive insights and real-time decision-making (Nambisan et al., 2020). The utilization of digital collaboration tools—including cloud platforms and virtual reality—further amplifies innovation outcomes within multidisciplinary teams (Dell'Era et al., 2025). Crucially, a firm's technological competence is intrinsically linked to its absorptive capacity, allowing it to efficiently assimilate external knowledge and contribute meaningfully to collaborative knowledge flows (Vivona, Demircioglu, & Audretsch, 2023). This enhanced capacity for relational learning and co-creation directly translates to superior innovation performance (Ebersberger et al., 2021).

Firms distinguished by advanced technological capabilities are perceived as more credible and reliable partners, fostering the trust and relational capital essential for enduring and productive collaborations (Dong et al., 2022). This perception not only facilitates partnership formation but also positions these firms to selectively engage with partners possessing complementary capabilities, thereby driving the co-creation of novel solutions (Ebersberger et al., 2021; Xuecheng & Iqbal, 2022). Consequently, such firms are at the vanguard of open innovation initiatives, leveraging external partnerships to accelerate the development of pioneering technologies and products (Pedersen et al., 2022). Accorindlgy, following hyptohesis is proposed.

H1: Technological competence significantly and positively influences collaborative innovation

Collaborative Innovation and Innovation Performance

Drawing on Dynamic Capability Theory, organizations leverage robust dynamic capabilities to make and reconfigure their resource bases, thereby sustaining competitive advantage in turbulent environments (Bell et al., 2010). Within this framework, collaborative innovation serves as a critical strategic mechanism, enabling firms to augment their internal capabilities by accessing and integrating external, complementary knowledge (Xie et al., 2023). This is particularly salient for Small and Medium-sized Enterprises (SMEs) in China's manufacturing sector, for whom collaboration is not merely advantageous but often essential for survival and growth.

For these SMEs, collaborative innovation—through partnerships with universities, suppliers, and customers—facilitates critical knowledge exchange and resource sharing (Gao et al., 2023; Kumar et al., 2020). This process directly enhances their dynamic capabilities by providing access to complementary technologies and fostering joint problem-solving within innovation ecosystems (L. E. N. Silva et al., 2024). The acquisition and assimilation of external knowledge are fundamental to transcending organizational boundaries and generating novel innovations (Harel et al., 2020; C. Wang & Hu, 2020). Consequently, firms can accelerate development cycles and enhance the efficiency of their innovation outputs (Ju et al., 2018).

Furthermore, collaboration mitigates the profound risks and uncertainties inherent in innovation. By distributing R&D costs and technical risks across partners (Silva et al., 2022; Panda et al., 2020), it reduces the resource burden on individual SMEs. This shared approach not only lowers barriers to innovation but also diminishes ambiguity, enhancing organizational responsiveness to volatile market and technological shifts (Bagherzadeh et al., 2020). The resultant improvement in innovation performance—characterized by offerings that more closely align with market demands—subsequently bolsters market image and cultivates customer confidence, leading to higher adoption rates for new products (Wang et al., 2018). Therefore, the following hypothesis is proposed:

H2: Collaborative innovation significantly and positively influences innovation performance

Mediating role of Collaborative Innovation

Technological competence exerts a significant and pivotal indirect effect on a firm’s innovation performance, primarily mediated through the mechanism of collaborative innovation. While foundational to innovation, a firm's internal technological prowess achieves its fullest potential when leveraged to initiate and sustain external partnerships. Such collaboration acts as a force multiplier, enabling firms to transcend the limitations of internal R&D by accessing complementary knowledge, sharing risks, and accelerating development cycles.

The efficacy of this relationship is grounded in the principle of absorptive capacity (Cohen & Levinthal, 1990). A robust technological base equips firms with the essential expertise to identify, assimilate, and apply valuable external knowledge (Musa & Enggarsyah, 2025). This capability is critical within open innovation paradigms (Nambisan et al., 2019; West & Bogers, 2014), where collaborative ventures—including alliances, joint R&D, and university partnerships—provide access to novel ideas and technologies. Consequently, technologically competent firms are not only more adept at engaging in knowledge co-creation but are also more attractive to high-quality partners, creating a virtuous cycle of resource enrichment (Ebersberger et al., 2021).

Technological competence, when coupled with collaboration, facilitates the rapid translation of technological advancements into commercial products, significantly reducing time-to-market (Ancillai et al., 2023, building on Teece, 2007). Collaborative innovation distributes the costs and uncertainties inherent in R&D across partners. Firms with strong technological foundations are more inclined to enter such alliances, effectively pooling technological development risks (Billewar et al., 2022). Collaboration fosters mutual learning processes. Technologically advanced firms are superior at internalizing knowledge from these interactions, generating novel capabilities that sustain long-term innovation performance (Ghorbani et al., 2023). By leveraging unique technological competencies through collaboration, firms can create differentiated, high-value products and services, erecting barriers to imitation and securing market position (Costa et al., 2024, extending Barney, 1991).

In conclusion, the influence of technological competence on innovation performance is not merely direct but is profoundly channeled through collaborative innovation. It is this mediating function—encompassing enhanced knowledge absorption, strategic co-creation, risk distribution, and accelerated commercialization—that allows firms to fully actualize the value of their technological capabilities, ultimately driving superior and sustainable innovation outcomes. Accordingly, following hpyothesis is proposed.
H3: Collaborative innovation significantly mediates the relationship between Technological competence and innovation performance.
Based on above hypothesis development and research gap, following research framework is proposed as shown in figure 1.

Figure 1: *Research Framework*

Methods

Sampling and Data Collection

The study population comprised 2,817 manufacturing Small and Medium-sized Enterprises (SMEs) listed on the Shanghai and Shenzhen stock exchanges. A purposive sampling approach was adopted to target senior and mid-level managers (e.g., CEOs, R&D managers, operations directors) who possess a comprehensive understanding of their firms' technological capabilities and innovation strategies. This sampling technique was considered appropriate, as it ensures that respondents hold the requisite expertise to provide valid and reliable information on the complex organizational constructs under examination (Saunders, Lewis, & Thornhill, 2019).

A total of 250 online questionnaires were distributed via email to representatives of these firms, with data collection spanning three months beginning in January 2025. In total, 163 valid responses were received, yielding a response rate of 65.2%. This high rate can be attributed to the use of professional networks for survey dissemination, a strategy known to enhance respondent engagement and trust, thereby improving data quality (Iqbal et al., 2020). The final sample size of 163 exceeded the minimum requirement of 98, as determined through an a priori power analysis conducted using G*Power software.

To further ensure data quality and minimize potential biases, several procedural and statistical measures were implemented. First, the questionnaire design incorporated procedural controls to reduce common method bias (CMB), including assurances of respondent anonymity and the use of clear, unambiguous measurement items. Second, a post-hoc statistical test—Harman's single-factor analysis—was conducted, revealing that the first factor accounted for 28.7% of the total variance. This value falls well below the critical 50% threshold, indicating that CMB is not a major concern in the dataset (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

Measures

All constructs were measured using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

Technological Competence was assessed using the established 12-item scale developed by Ritter and Gemünden (2004). Collaborative Innovation was conceptualized as a second-order formative construct, reflected by two first-order dimensions: (1) partnership networks and (2) relational collaboration. The measurement items were adapted from Pundziene and Geryba (2023), whose original scales demonstrated high reliability (Cronbach's $\alpha = 0.846$ for partnership networks; $\alpha = 0.816$ for relational collaboration). Innovation Performance was measured using a five-item scale adapted from Wang et al. (2024), which has shown strong internal consistency in the context of Chinese firms (Cronbach's $\alpha = 0.941$).

Measurement Analysis

The measurement model, also referred to as the outer model in Partial Least Squares Structural Equation Modeling (PLS-SEM), specifies the relationships between latent constructs and their manifest indicators (Hair & Lukas, 2014). Evaluation of this model involves verifying the reliability and validity of the constructs through the PLS algorithm.

Construct Reliability

While Cronbach's Alpha is commonly used, Composite Reliability (CR) is more appropriate within the PLS-SEM framework (Hair & Lukas, 2014). Unlike Cronbach's Alpha, which assumes equal indicator loadings and can be sensitive to the number of items, CR accounts for the varying contributions of each indicator as estimated by the model, providing a more accurate gauge of internal consistency.

Construct Validity

Construct validity confirms that a set of indicators accurately measures the theoretical construct it is intended to represent (Westen & Rosenthal, 2003). This study assessed construct validity along two dimensions: convergent and discriminant validity (Sekaran & Bougie, 2016).

Convergent Validity

Convergent validity is established when indicators of a specific construct share a high proportion of variance, demonstrating measurement consistency (Hair, Ringle, & Sarstedt, 2013). It is assessed using indicator loadings, Average Variance Extracted (AVE), and

Composite Reliability (CR). Following established thresholds (Hair & Lukas, 2014), indicator loadings should ideally exceed 0.70. Loadings between 0.50 and 0.70 are acceptable if the removal of the indicator does not improve the construct's CR or AVE (Chin, 1998; Hulland, 1999). Convergent validity is further supported when the AVE for a construct exceeds 0.50 and its CR surpasses 0.70.

In this study, all indicator loadings ranged from 0.634 to 0.882, confirming their reliability. All constructs demonstrated CR values above 0.70 and AVE values exceeding the 0.50 threshold (ranging from 0.504 to 0.868), thus establishing adequate convergent validity.

Discriminant Validity
Discriminant validity confirms that a construct is empirically distinct from others in the model (Hair & Lukas, 2014). This study employed multiple criteria to rigorously assess it. First, the analysis of cross-loadings confirmed that each indicator loaded highest on its assigned construct. Second, the Fornell-Larcker Criterion was met, as the square root of each construct's AVE was greater than its correlations with all other constructs (Chen, Peng, & Hung, 2015). The Heterotrait-Monotrait (HTMT) ratio of correlations was also computed as a more modern test, with all values falling below the conservative threshold of 0.85, further reinforcing discriminant validity (Henseler, Ringle, & Sarstedt, 2015).

Findings
The analysis was conducted using SmartPLS, which employs a variance-based structural equation modeling (SEM) approach. A key advantage of this method is that it does not assume the data are normally distributed. To assess the statistical significance of the model's coefficients—including path coefficients, outer weights, and outer loadings—a non-parametric bootstrapping procedure with 5,000 subsamples was applied, following the recommendations of Henseler et al. (2009) and Hair et al. (2016). The bootstrapping was configured for 363 cases and utilized the individual sign change option.

The results of the hypothesis testing are summarized in Table 1. The analysis confirms that technological competence exerts a significant positive effect on collaborative innovation ($\beta = 0.274$, $p < 0.05$), thus providing support for Hypothesis H1. Furthermore, collaborative innovation demonstrates a significant positive impact on innovation performance ($\beta = 0.314$, $p < 0.05$), supporting Hypothesis H2.

The significance of the proposed mediation effect (H3) was evaluated by examining the bootstrapped t-values and bias-corrected confidence intervals. Mediation is established when the indirect effect is statistically significant, indicated by a t-value exceeding the critical threshold and a confidence interval that does not include zero. The results confirm that technological competence has a significant positive indirect effect on innovation performance through collaborative innovation ($\beta = 0.086$, $p < 0.05$). Therefore, Hypothesis H3 is supported.

Table 4-1
Hypotheses Testing

Relationship	β	S. E	T-values	P-Value	LLCI	ULCI
TC → CI	0.274	0.065	4.215	0.000	0.147	0.401
CI → IP	0.314	0.046	6.826	0.000	0.224	0.404
TC → CI → IP	0.086	0.029	2.966	0.003	0.029	0.143

Note: CI=collaborative innovation, TC=technological competence, IP= innovation performance.

Discussion and Conclusion

This study affirms the foundational role of technological competence as a critical value-driver for products and processes. The empirical results demonstrate a significant positive effect of technological competence on collaborative innovation (H1), corroborating prior research. For instance, studies across diverse contexts—from German industrial firms (Ritter & Gemünden, 2004) to Taiwanese ICT companies (Huang, 2011)—consistently identify technological competence as a key determinant of innovation success, albeit its relative importance may vary across competitive environments (Seram et al., 2019). Furthermore, the findings align with contemporary research underscoring the necessity of advanced digital capabilities, such as AI and digital platforms, for enhancing innovation efficiency (Wang & Yang, 2024).

Concurrently, the results confirm that collaborative innovation exerts a significant and positive influence on the innovation performance of Chinese manufacturing SMEs (H2). This finding is consistent with a body of empirical work conducted in various Chinese industrial and supply chain contexts, which has established a strong link between collaborative activities and capabilities and superior innovation outcomes (Daradkeh, 2022; Shi et al., 2022; Wang & Hu, 2020).

Most critically, this research provides empirical evidence for the mediating role of collaborative innovation in the relationship between technological competence and innovation performance. This aligns with the theoretical proposition that internal capabilities are often actualized through external strategic mechanisms. Our findings are consistent with studies identifying similar mediation pathways, such as talent competence mediating the talent-innovation relationship (Zhang & Liu, 2022) or business model innovation mediating the effect of collaborative networks (Lu et al., 2025). However, it is important to contextualize these findings within the broader scholarly discourse, which also documents complexities such as inverted U-shaped relationships (Schulze & Brojerdi, 2012; Xie et al., 2022) and contingent effects based on collaboration breadth, depth, and absorptive capacity (Jang et al., 2023; Najafi-Tavani et al., 2018). This suggests that the efficacy of collaborative innovation is not universal but is subject to important contextual and operational moderators.

Theoretical Implications

This study reveals that for Chinese manufacturing SMEs, achieving superior innovation performance requires more than developing strong internal technological capabilities—it depends on strategically leveraging those capabilities to engage in and sustain collaborative innovation networks. The findings integrate insights from the Resource-Based View and Dynamic Capabilities theory, demonstrating that internal resources (technological competence) are effectively mobilized through dynamic processes (collaboration) to create and sustain competitive advantage.

Prior to pursuing complex collaborative partnerships, SMEs should prioritize strengthening their core technological infrastructure. This entails investing in foundational elements such as cloud computing tools, data management systems, and the digital skills of employees. Establishing a robust technological base enhances a firm’s credibility and attractiveness as a collaborative partner, facilitates more efficient joint activities, and ensures that externally acquired knowledge can be effectively absorbed and applied. To address the challenges associated with R&D costs and capability constraints, managers are encouraged to form strategic alliances with local universities and technical institutions. Such partnerships provide access to advanced research, specialized facilities, and a pool of emerging talent, thereby accelerating product development while reducing associated time and financial burdens. Moreover, these collaborations create ongoing opportunities for innovation and talent acquisition. However, successful collaboration requires more than participation—it demands formalized management structures. SMEs should institutionalize partnership management by assigning dedicated relationship roles, establishing clear intellectual property (IP) agreements at the outset, and implementing systematic processes for knowledge sharing and joint problem-solving. Adopting a structured approach minimizes risks related to IP disputes and resource inefficiencies, while maximizing the strategic and operational returns from collaborative innovation initiatives.

Limitations and Suggestions for Future Research

Notwithstanding its contributions, this study is subject to several limitations that warrant acknowledgment and present avenues for future inquiry. First, the cross-sectional research design, while appropriate for the stated objectives, inherently limits the ability to infer causal relationships or capture the longitudinal evolution of the proposed mediation effect. A longitudinal study would offer more robust insights into the dynamic interplay between technological competence, collaborative innovation, and performance over time. Second, the reliance on self-reported data from single respondents within each firm introduces the potential for common method bias. Although statistical tests (e.g., Harman's single-factor test) indicated that this bias is not a pervasive issue, it remains a methodological constraint. Future research would benefit from multi-source data collection to mitigate this concern. Third, the contextual focus on Chinese manufacturing SMEs constrains the generalizability of the findings. The unique institutional, cultural, and market characteristics of this context may limit the direct application of the results to other industries or geographic regions. Future studies should seek to validate and extend this model across diverse national and sectoral settings to enhance its external validity.

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