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A Significant Structured Review of Technological Innovation Capability and Firm Performance

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ABSTRACT

This systematic review explores the complex relationship between technological innovation capability and firm performance in the context of modern business dynamics. Organizations struggle to leverage innovation to preserve competitive advantage as technology continues to advance at an unparalleled rate. This review endeavours to provide a holistic understanding of the subject by employing a comprehensive methodology that includes a systematic literature review, meta-analysis (PRISMA), and synthesis of empirical findings. The advanced searching employed two powerful databases which are Scopus and Web of Science (WoS). Based on the advanced searching, the final quantitative main data (n=30) were analysed. Three main themes were developed; (1) effect of technological innovation capability on firm performance, (2) factors influencing technological innovation capability, and (3) evaluation of technological innovation capability. The review suggests that understanding the interplay between technical innovation capability and firm performance is essential for businesses aiming to thrive in the ever-changing technological landscape. In summary, this review contributes to the evolving discourse on innovation management by offering a structured synthesis of current knowledge, potentially guiding strategic decisions for firms navigating the complexities of technological innovation in the modern era.

Keywords:

Technological innovation capability; Firm; SMEs; Performance

1. Introduction

In today's fast-paced and ever-evolving business landscape, technological innovation has emerged as a cornerstone for achieving sustained competitive advantage and enhanced firm performance [1-3]. The ability to develop and leverage technological innovations has been found to significantly influence a firm's performance, growth, and sustainability [4,5]. The relentless march of

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technology, coupled with the globalization of markets, has compelled organizations across industries to invest substantially in their technological innovation capabilities. This has given rise to the body of research dedicated to understanding the intricate relationship between technological innovation capability and firm performance.

As the global economy becomes increasingly knowledge-based and technology-driven, firms are under immense pressure to adopt and adapt to technological advancements. Organizations that possess the capability to effectively manage and exploit these innovations are more likely to achieve success in terms of market share, profitability, and long-term survival [6-8]. Companies that can harness and leverage technology effectively stand to thrive, while those that lag behind face the risk of obsolescence. The ability to innovate technologically is often considered a strategic imperative for firms aiming to maintain relevance and competitiveness. However, the relationship between technological innovation capability and firm performance is far from straightforward. It involves a web of intricate variables, including organizational culture, resource allocation, managerial acumen, and the competitive landscape. Moreover, the nature of technological innovation itself has evolved significantly, encompassing not only product innovation but also process innovation, business model innovation, and digital transformation.

Through an in-depth examination of empirical studies, theoretical frameworks, and methodological approaches, this article seeks to explicate the technological innovation capability's impact on performance of the firms. Numerous studies have suggested a positive relationship between these two variables, indicating that firms with stronger technological innovation capabilities tend to outperform their competitors [9-12]. However, the precise mechanisms and contingencies that underlie this relationship remain unclear. This article endeavours to identify the effect of technological innovation capability on firm performance, factors enhancing it, and technological innovation capability evaluation providing valuable insights for both scholars and practitioners seeking to enhance their organizations' technological innovation capabilities in an era where adaptability and agility are paramount. By understanding the intricacies of this relationship, firms can better strategize their innovation efforts, allocate resources effectively, and ultimately enhance their overall performance in the dynamic business landscape characterized by rapid technological advancements.

1.1 Literature Review

A considerable amount of literature has been published on the relationship between technological innovation capability and firm performance in rapidly developing economies. Technological innovation capability is crucial for firms to enhance their core competencies and competitive capabilities. [13] developed a conceptual model to examine the moderating role of environmental turbulence in the relationship between a firm's technological innovation capabilities and firm performance in the Malaysian automotive industry. The model facilitates future research and contributes to the development of the automotive industry in Malaysia. Additionally, [14] conduct an empirical study examining the relationship between technological innovation capabilities and competitive advantage and firm performance in the Malaysian automotive industry. It was found that enhanced technological innovation capabilities would intensify the Malaysian automotive industry. Similarly, a study of 144 Spanish industrial firms examines the impact of organizational innovation and technological innovation capabilities on firm performance. It is concluded that organizational innovation favours the development of technological innovation capabilities. Both organizational innovation and technological innovation capabilities for products and processes can enhance firm performance [3].

Technological innovation capability is a set of characteristics a firm possesses that supports its technological innovation strategies. The dimensions that constitute the technological innovation capabilities can be a source to improve business performance. This study examines seven technological innovation capability dimensions: learning, research and development (R&D), resource allocation, manufacturing, marketing, organization, and strategic planning capabilities. Empirical data from a survey study of 200 manufacturing firms in the Hong Kong/Pearl River Delta region revealed that different technological innovation capability dimensions have different impacts on different performance measures, with organization capability being the most influential [15]. As highlighted by a study that examines the importance of seven technological innovation capabilities for Chinese firms' competitiveness of 213 firms in Beijing, it was revealed that R&D and resource allocation capabilities are the most crucial technological innovation capabilities. The findings suggest that Chinese firms should balance their technological innovation capabilities harmonizing enhancement to maintain sustainable development and effectively plan and implement innovation strategies [16]. Furthermore, [17] examine the impact of technological innovation capabilities on the electronics industry in Hong Kong/Pearl River Delta region. Empirical data from a survey was used to examine the relationship between technological innovation capabilities and innovation performance. Results showed that R&D, resource allocation, learning, and strategy planning capabilities significantly improve innovation sales of electronic firms. R&D and resource allocation capabilities can also significantly improve new product introduction. In a study involving 215 Chinese electronics companies, [18] found that technological innovation capabilities positively impact product innovation, starting with linkage, progressing to production and investment, and that product innovation mediates the relationship between these capabilities and firm performance.

2. Methodology

2.1 Identification

The systematic review process consists of three basic phases that were used to choose many relevant papers for this study [19]. The first phase entails the identification of keywords and the search for associated, related terms using thesaurus, dictionaries, encyclopaedias, and prior research [20,21]. Following the selection of all pertinent terms, search strings for the databases Scopus and Web of Science (WOS) (refer Table 1) have been developed [22]. The current research endeavours effectively obtain 186 papers from both databases during the first stage of the systematic review process.

Table 1
The search string

Scopus	TITLE-ABS-KEY (("technological innovation capability" OR "technological innovation capabilities") AND (firm OR business OR company OR sme*) AND performance) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2023)) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (LANGUAGE , "English")) Access date on 18 Sept 2023
WoS	("technological innovation capability" OR "technological innovation capabilities") AND (firm OR business OR company OR SME*) AND performance (Topic) and 2020 or 2021 or 2022 or 2023 (Publication Years) and English (Languages) and Article (Document Types) Access date on 18 Sept 2023

2.2 Screening

Based on various inclusion-and-exclusion criteria determined by the researchers, 123 papers were excluded in the second phase. Therefore, 63 articles were reviewed in this phase (Table 2). Duplicate papers were also eliminated in this screening phase where 15 articles were removed. Literature from research articles is the main source of useful knowledge, hence it was the first criterion used in the screening process [23]. Additionally, publications in the form of systematic reviews, reviews, meta-analyses, meta-synthesis, book series, books, chapters, and conference proceedings were excluded from the current study [19]. The review was limited to studies published in English-language only. The review was established for a four-year period of 2020 to 2023.

Table 2
The selection criterion in searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Time line / Years	2020 – 2023	< 2020
Literature type	Journal (Article)	Conference, Book, Review
Publication Stage	Final	In Press

2.3 Eligibility

For the third step, a total of 48 articles were prepared for eligibility. All articles' titles and key content were thoroughly reviewed at this stage to ensure that the inclusion requirements were fulfilled and fit into the present study with the current research aims [24]. Therefore, 18 full text articles were omitted due to the out of field, titles were not significant and abstracts were not related to the objective of the study. Finally, 30 articles were available for further review (see Figure 1).

2.4 Data Abstraction and Analysis

In this study, a number of research designs (quantitative, qualitative, and mixed techniques) were examined and synthesized using an integrative analysis as one of the assessment strategies. This important study sought to identify pertinent topics and subtopics regarding technological innovation capability and business performance. Data collection was the initial phase of the theme's development. Figure 1 demonstrates how the authors carefully scrutinized a collection of 30 publications for claims or information pertinent to the subjects of the current investigation. The authors then assessed the recent significant research on technological innovation capability. Investigations are being conducted into both the research findings and methodology employed in all studies. The author then worked with additional co-authors to create themes based on the evidence in this study's context. Throughout the data analysis process, a log was kept to note any analyses, opinions, puzzles, or other ideas that might be pertinent to the data interpretation. The authors then compared the findings to look for any discrepancies in the theme design procedure. It is important to note that the authors discuss any conceptual disagreements to resolve them. Final refinements were made to the themes created to ensure consistency. Two experts in the field of entrepreneurship, one from a public university and the other from the industry were involved in the analysis selection process. The expert review phase was implemented to ensure each subtheme within the research domain is clear, significant, and appropriate.

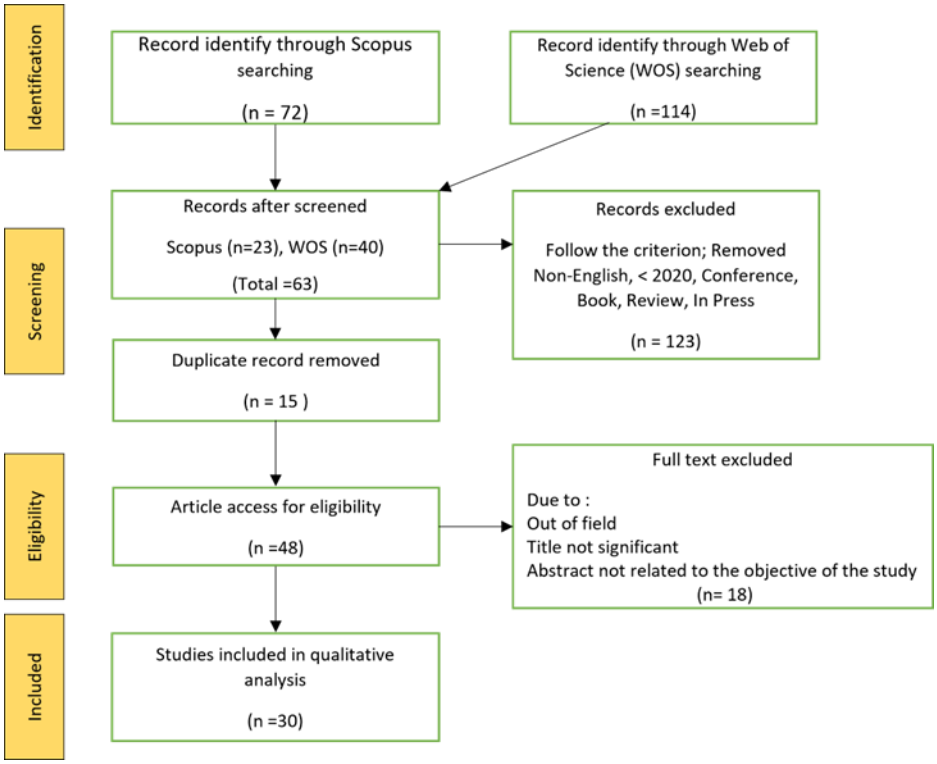

Fig. 1. Flow diagram of the proposed search study

3. Results

This section presents the results and findings of a systematic review conducted to investigate three key themes related to technological innovation capability and firm performance:

i. effect of technological innovation capability on firm performance
ii. factors influencing technological innovation capability
iii. evaluation of technological innovation capability.

Through a comprehensive analysis of existing scholarly works, this chapter aims to provide a comprehensive understanding of the current state of knowledge in these areas and offer insights for future research and practical implications. Thirty (30) articles were extracted and analysed using the search technique.

3.1 Effect of Technological Innovation Capability on Firm Performance

Technological innovation capability has been consistently identified as a key driver of firm success. Numerous studies have indicated that firms possessing a robust technological innovation capability tend to outperform their competitors in various dimensions of firm performance. Table 3 describes the findings of the effect of technological innovation capability on firm performance.

Table 3
The findings of the effect of technological innovation capability on firm performance

Author, Year	Title	Source title	Effect of technological innovation capability
[25] (2023)	How enterprise interactions in innovation networks affect technological innovation performance: The role of technological innovation capacity and absorptive capacity	PLoS ONE	From the viewpoint of an innovation network, this study examines the mechanism of enterprise interaction on innovation. The results reveal that the performance of technological innovation is greatly influenced by the three enterprise interaction dimensions that are management interaction, resource interaction, and affective interaction. Technological innovation capabilities, including technological R&D and technological commercialization capabilities, must play a partially mediating role to realize this effect.
[26] (2023)	Green supply chain management, risk-taking, and corporate value-Dual regulation effect based on technological innovation capability and supply chain concentration	Frontiers in Environmental Science	This study assess how firm value is affected by green supply chain management. It delves into the moderating impact of risk-taking level and the dual moderating influence of supply chain concentration and technological innovation capability. The results provide insights into how implementing green supply chain management can enhance enterprise value. The degree of enterprise risk-taking controls the green supply chain management process to increase enterprise value. Ultimately, capacity for technological innovation and supply chain concentration control the amount of risk an organization takes, hence increasing the value of the company.
[27] (2022)	Research on the Relationship between Construction 4.0 and Construction Firm's Performance: Based on the Mediating Role of Technological Innovation Capability	Mathematical Problems in Engineering	In the context of China's construction industry, this study conducts an empirical investigation into the relationship between Construction 4.0, technological innovation capabilities, and listed construction firms' performance. The findings show that technological innovation capabilities mediate the relationship between Construction 4.0 and firm performance. Additionally, Construction 4.0 itself has a significant positive promotional effect on the latter. The study suggests that construction firms should use Construction 4.0 technologies, improve research and development, advance technological innovation capabilities, and establish innovation networks to enable digital transformation.
[28] (2021)	The impact of entrepreneurial leadership on SMEs' performance: the mediating effects of organizational factors	Heliyon	A study was conducted investigating the effect of entrepreneurial leadership, entrepreneurial orientation, and technological innovation capability on firm performance. It was determined that the entrepreneurial leadership enhances the performance of Vietnam IT SMEs through the full mediator role of team creativity, dynamic capabilities, and competitive advantages. While technological innovation capabilities provide some advantages on performance, entrepreneurial orientation does not.

[29]	Big data analytics capabilities for reinforcing green production and sustainable firm performance: the moderating role of corporate reputation and supply chain innovativeness	Environmental Science and Pollution Research	The role of big data analysis (BDA) technology capability, green technological innovation capabilities (GTIC), and environmental orientation toward green production and sustainable firm performance were examined among Pakistani manufacturing firms. Findings indicate that BDA technology capability, GTIC, and environmental orientation positively impact green production. Green production enhances a green competitive advantage, which in turn positively impacts sustainable firm performance. The research suggests that Pakistani manufacturing firms can improve green production and sustainable firm performance by implementing BDA technology capability and GTIC.
[30] (2020)	Strategic fit implication of technological innovation capabilities for SMEs with new product development	Management Science Letters	This research investigates the influence of technological innovation capabilities dimensions on the performance of new product development (NPD) in small and medium-sized enterprises (SMEs). TIC has 7 capability dimensions namely learning, R&D, resource allocation, manufacturing, marketing, organizing and strategic planning. Capability dimensions of marketing, R&D and strategic planning were found to significantly impact the NPD performance.
[31] (2020)	Effects of organizational innovation and technological innovation capabilities on firm performance: evidence from firms in China's Pearl River Delta	Asia Pacific Business Review	This research delves into the association between technological innovation capabilities (TICs) and organizational innovation (OI), as well as the influence these factors have on the performance of manufacturing firms located in China's Pearl River Delta. The mediating effect of TICs on the relationship between OI and firm performance was analysed. Furthermore, this study examines the moderating effect of OI on the relationship between TICs and firm performance. Results confirmed that the relationship between OI and firm performance was partially mediated by TICs. In a similar vein, OI partially moderated the impact of TICs on firm performance.
[32] (2022)	Practicing circular economy performance in Malaysia: managing supply chain disruption and technological innovation capability under industry 4.0	International Journal of Logistics-Research and Applications	This research examining how business handles the disruption caused by IR 4.0 technology and how it affects Malaysian manufacturing companies' circular economy performance (CEP), has demonstrated the positive significant impact of CEP on the management of supply chain disruption and technological innovation capability (TIC). TIC shows a complimentary mediation effect to support managing supply chain disruption and supply chain disruption recovery as well as CEP.

[33] (2023)	Management Innovation in an Emerging Economy: An Analysis of Its Moderating Effect on the Technological Innovation-Performance Relationship	IEEE Transactions on Engineering Management	Based on the dynamic capability theory, this research examines the relationship among management innovation, technological innovation, and performance. Other than that, this article tested the moderating effect of management innovation among Colombian manufacturing firms. The companies do not gain from adopting technological and management innovations simultaneously. This is due to management innovation weakens the association between technological innovation and performance. When used separately, management and technological innovations have a positive impact on the performance of the company. Hence, it is pivotal to understand the impact of new administrative practices, organizational structures, and management techniques on technological innovation capabilities and firm performance
[34] (2021)	The role of value appropriation capability of Chinese multinationals in operating cross-border business models	Sustainability (Switzerland)	In order to maintain a balance with stakeholders and generate profits in a highly competitive and uncertain global market, multinational corporations (MNCs) must possess a distinctive capability that allows them to more successfully synergize with these widely acknowledged capabilities (such as technological innovation capabilities (TIC) and marketing capabilities (MC) alongside the global value chain (GVC).This study investigated how value appropriation capability (VAC) efficiently moderates MNCs' capabilities to operate cross-border business models (CBMs) in the Chinese manufacturing industry. The study indicates that VAC, TIC, and MC significantly enhance MNC performance, with VAC-TIC interaction leading to significant improvement and VAC-MC interaction enhancing performance.
[35] (2020)	The government R&D funding and management performance: The mediating effect of technology innovation	Journal of Open Innovation: Technology, Market, and Complexity	This study examines whether the government financial support for R&D in Korea's small- and medium-sized enterprises (SMEs) has enhanced companies' management performance by focusing on 105 KOSDAQ-listed enterprises with technology development experience. The study indicates that technological innovation capabilities in companies positively impact management performance, with most companies enhancing their management performance when government financial support is provided for R&D.

3.2 Factors Influencing Technological Innovation Capability

In today's rapidly evolving technological landscape, the ability of organizations to innovate and adapt is paramount for their survival and competitiveness. Technological innovation capability, a multifaceted construct, plays a central role in this context. Understanding the factors that influence this capability is essential for companies. This article explores the intricate web of factors that impact technological innovation capability as presented in Table 4.

Table 4
The findings of the factors influencing technological innovation capability

Authors, Year	Title	Source title	Factors Influencing Technological Innovation Capabilities
[36] (2022)	Impact of Open Innovation in Peruvian food firms	Cuadernos De Administracion	This research empirically confirmed how inbound open innovation and absorptive capacity positively influence technological innovation capability of food firms in Peru. It has been verified how the implementation of inbound open innovation and absorptive capacity increase the technological innovation capability of the low-tech Peruvian food firms.
[37] (2023)	Role of knowledge management processes within different stages of technological innovation: evidence from biotechnology SMEs	Knowledge Management Research and Practice	This paper examines knowledge management's role in the biotechnology sector in the Netherlands, highlighting its potential to enhance technological innovation capabilities and provide a sustainable competitive advantage. The study identifies three key roles of knowledge management processes in biotechnology innovation, highlighting their importance in different phases, and providing insights for effective performance improvement.
[38] (2023)	Gamification as an innovation: a tool to improve organizational marketing performance and sustainability of international firms	International Marketing Review	This study explores the impact of organizational culture (OC), including gamification and non-gamification, on innovation capability, environmental and marketing performance, using theories of organizational creativity and administrative behaviour (AB). Hypotheses on the role of AB in driving technological creativity and climate-consciousness in firms were tested. The findings identified that OC has a positive influence on technological innovation capabilities and environmental innovation capabilities.
[39] (2020)	Knowledge sharing and technological innovation capabilities of Chinese software SMEs	Journal of Knowledge Management	This study investigates the factors affecting knowledge sharing and technological innovation capability (TIC) of the software small- and medium-sized enterprises (SSMEs) in China. The knowledge sharing culture, organizational structure, middle-level leadership and management system have significantly positive effects on tacit knowledge sharing. Additionally, management system and IT support have significantly positive effects on explicit knowledge sharing. Finally, both explicit and tacit knowledge sharing affects TIC significantly and positively.
[40] (2022)	Impact of organizational dynamic capability on international expansion and the moderating role of environmental dynamism	International Journal of Organizational Analysis	This study explores how dynamic capability (DC) affects international expansion. In addition, the environmental dynamism role as a moderator in the same context for Indian organizations is analysed. According to the study, an organization's capacity for sensing, seizing, and transformation has a positive and significant impact on technological innovation capability and international marketing capability, consequently having a favourable and notable impact on an organization's capacity for international expansion.

[41] (2022)	Sophisticated Technology Innovation Capability: Entrepreneurial Resilience on Disaster-Resilient MSMEs	Serbian Journal of Management	This research explores the connection between entrepreneurial resilience, disaster-resilient, and new ideas on complex technical innovations to modulate entrepreneurship among micro, small and medium enterprises MSMEs in Central Java, Indonesia. Entrepreneurial resilience enhances technological innovation capability and disaster-resilience in MSMEs, highlighting the importance of understanding entrepreneurs' survival strategies during uncertainty, thereby strengthening technological inventive capacities.
[42] (2022)	Assessment of the effect of IT infrastructure on the relationship between knowledge sharing and technological innovation capability: survey in multinational companies	Technology Analysis and Strategic Management	This research analyses the contribution of Information Technology (IT) infrastructure responsiveness in the initiative of using knowledge sharing to enhance the technological innovation capability of industrial multinational companies. The research indicates that knowledge sharing initiatives enhance technological innovation capability, and the responsiveness of IT infrastructure can also facilitate this process.
[43] (2022)	The Impact of Firm Heterogeneity and External Factor Change on Innovation: Evidence from the Vehicle Industry Sector	Sustainability (Switzerland)	The study explores the connection between firms' technological innovation capabilities and their internal and external factors for new energy vehicle (NEV) firms and traditional fuel vehicle firms in China. The study confirmed that public subsidies positively affect firms' technology innovation capability for both NEV and traditional fuel vehicle firms. Firms' innovative ability is positively influenced by high profitability, low leverage, high equity concentration, and highly educated employees. The study analyses internal and external factors of NEV firms to improve technological innovation capability and reduce greenhouse gas emissions.
[44] (2020)	Interactive control capability, effective organizational learning and firm performance: An empirical study of milling and metal industry in Tegal	Management Science Letters	This study examines the role of effective organizational learning on technological innovation capabilities and company performance in the smelting and metalwork industry in Tegal. The research findings verify the correlation between effective organizational learning and technological innovation capabilities and company performance by mediating role of interactive control capabilities. The interactive control capabilities are crucial in improving technological innovation capabilities and business performance.

[45] (2022)	How do Chinese SMEs enhance technological innovation capability? From the perspective of innovation ecosystem	European Journal of Innovation Management	This study analyses the influence mechanisms of multi-level ecological participants on technological innovation capabilities within innovative SMEs in Shenzhen, Shanghai and Jiangsu, China. The author examines the moderating role of the innovation ecological environment. Findings revealed that SMEs' collaboration with universities and research institutions enhances their independent and collaborative technological innovation capabilities, with the innovation ecological environment positively moderating between the focal SME's ecological participants and these two technological innovation capabilities. In conclusion, Chinese SMEs can enhance their technological innovation capabilities by constructing and coordinating innovation ecosystems, allowing them to cultivate world-class enterprises quality.
[46] (2023)	Assessing the impacts of government environmental policies on the small and medium-sized firm's performances in Korea and China	Benchmarking	This paper explores the role governments play in enhancing the environmental capabilities of Korean and Chinese SMEs in the global market and explores the impact of government intervention on firm performance based on country-specific policies. The study found that government intervention positively impacted MNF's environmental and technological innovation capabilities, with SMEs' reactions mediating the relationship between government intervention and SME performance. This study is unique in its cross-cultural analysis of two distinct nations with contrasting government structures, capitalistic and socialistic.
[47] (2021)	Open innovation with relational capital, technological innovation capital, and international performance in SMEs	Sustainability (Switzerland)	This study investigates the impact of relational capital and technological innovation capability on the international performance of SMEs, focusing on the moderating effect of alliance proactiveness. The study confirmed that relational capital significantly influenced technological innovation capability which consequently influences international performance, mediates the relationship between relational capital and international performance. On the other hand, alliance proactiveness was found to moderate the relationship between technological innovation capability and international performance. Hence, companies need to focus strengthening relational capital and alliance proactiveness to improve international performance as they enhance the technological innovation capability.

[48] (2021)	An exploratory study of how latecomers transform strategic path in catch-up cycle	Sustainability (Switzerland)	This paper proposes a firm-level framework for latecomers to transform their strategic path in catch-up cycles, identifying the impetus and trigger factors for this transformation. The mismatch between technological innovation capability and strategic mode serves as the catalyst. The progressive industrial policy is the catalyst. The study is based on the China Railway Rolling Stock Corporation (CRRC), a Chinese supplier of rail transit equipment. The paper reveals that strategic path transformation is an evolutionary process involving mismatches and rematches between strategic mode and technological innovation capability, leading to performance pressure. The implementation of industrial policy exerts changes in the company's technological innovation capability.
[49] (2021)	The Business and Accounting Technology Innovation for Better Firm Performance: A Case of Malaysian Firms	Academic Journal of Interdisciplinary Studies	The study assessed the influence of business innovation, technology orientation, and accounting technological innovation capabilities on the performance of Malaysian firms involved in technology and innovation. The study indicates that business innovation and technology orientation have a significant positive effect on technology innovation capability while accounting technology innovation capability has a significant positive effect on firm performance. Managers should be aware of OI and technological innovation capabilities (TICs), their impact on firm performance, and utilize OI to develop skills, methods, and innovation, fostering creativity and openness among employees.

3.3 Evaluation of Technological Innovation Capability

Evaluating technological innovation capability is imperative for understanding an organization's innovation potential and competitiveness. Table 5 presents the findings of technological innovation capability assessment in contemporary business strategies.

Table 5
The findings of evaluation of technological innovation capability

Authors, Year	Title	Source Title	Evaluation of technological innovation capability
[50] (2021)	Measurement technological innovation capabilities in agriculture knowledge and innovation systems	Ciencia Tecnologia Agropecuaria	Technological innovation capabilities (TICs) are crucial for agricultural knowledge and innovation systems (AKISs), but current methods lack a dynamic understanding of TICs and innovation systems. The research presents a method based on an organizational behaviour model to assess the TIC level in a survey of 256 coffee and 74 avocado AKIS firms in Antioquia, Colombia. The results confirm that the measurement of TIC levels and their dynamics over time provides a better understanding of innovation processes. It enables the evaluation and identification of existing gaps between TICs and these systems' innovation functions.

[51] (2020)	Technological innovation capability evaluation of high-tech firms using conjunctive and disjunctive belief rule-based expert system: A comparative study	Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Application	This article presents two web-based Belief Rule-Based Expert Systems (BRBES) for evaluating Technological Innovation Capability (TIC), conjunctive and disjunctive BRBES. A comparison has been performed between them to determine the reliability of TIC evaluation. Conjunctive BRBES performs better than disjunctive BRBES, and a new learning mechanism, Belief Rule-Based Adaptive Particle Swarm Optimization (BRBAPSO), supports learning in BRBES. A comparison between trained conjunctive and trained disjunctive BRBES has also been carried out to evaluate TIC, where trained conjunctive BRBES is found effective than trained disjunctive BRBES.
[52] (2023)	Managing Technological Innovation Capabilities to Align Exploration and Exploitation with Technological Changes	International Journal of Innovation and Technology Management	This paper explores a high-tech firm's technological innovation capabilities (TICs) configuration, focusing on R&D, manufacturing, and marketing capabilities to develop technology and market exploiting activities based on customer value shifts. The study examines the strategic configuration of micro, electrical, mechanical systems (MEMS) accelerometers by innovators, highlighting the importance of customer value trajectory stability in market transition. The study provides a managerial decision-making framework for strategic management of TICs in high-velocity markets, considering customer value trajectory.
[53] (2023)	Evaluating high-tech industries' technological innovation capability and spatial pattern evolution characteristics: Evidence from China	Journal of Innovation and Knowledge	The study measured China's high-tech industries' technological innovation capability from 2010-2019 using factor analysis and Moran index, focusing on spatial pattern and evolution characteristics. This study provides managerial insights to enhance high-tech industries' technological innovation capabilities, accelerating industrial development in the middle and high end of the global value chain.
[54] (2022)	Evaluating technology innovation capabilities of companies based on entropy- TOPSIS: the case of solar cell companies	Information Technology & Management	Current methods to evaluate TIC have limitations in accuracy and efficiency. The paper introduces a novel method for assessing enterprises' TIC, combining the entropy weight method and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) based on patent information. Entropy enhances indicator weighting rationality and TOPSIS can rank results fairly, addressing poor results in fuzzy comprehensive evaluations. The Entropy-TOPSIS method, used to evaluate solar cell technology in seven enterprises, is found to be effective and suitable for small samples.

4. Discussion and Conclusions

4.1 Effect of Technological Innovation Capability on Firm Performance

This comprehensive set of studies delves into the intricate relationship between technological innovation capability (TIC) and firm performance across various industries and contexts. The findings consistently emphasize the positive impact of TIC dimensions, such as technological research and development capabilities, on firm performance. The studies also highlight the mediating role of TIC

in linking various factors, including enterprise interaction, green supply chain management, entrepreneurial leadership, big data analysis technology capability, and organizational innovation, to improved firm performance. Additionally, the research underscores the significance of environmental orientation, learning capability, R&D capability, and marketing capability within TIC dimensions in driving performance, particularly in new product development and sustainable practices. Moreover, the moderating effects of factors like management innovation and value appropriation capability further elucidate the complex interplay between capabilities and performance in the rapidly changing landscape of technology and business. These studies collectively offer valuable insights for organizations aiming to harness TIC to enhance their competitive advantage and overall performance in diverse settings and industries.

4.2 Factors Influencing Technological Innovation Capabilities

This comprehensive collection of studies investigates various factors influencing technological innovation capabilities (TICs) across different industries and regions. It encompasses research on inbound open innovation, absorptive capacity, knowledge management, organizational culture, dynamic capability, and more. The findings consistently highlight the positive impact of these factors on enhancing TIC, underscoring their crucial role in promoting innovation within organizations. Additionally, the studies emphasize the importance of collaboration with external entities, such as universities and research institutions, and the moderating influence of innovation ecosystems and government interventions on TIC. Furthermore, the role of relational capital, alliance proactiveness, and accounting technological innovation capabilities in shaping firm performance is explored, emphasizing their significance in achieving international success. Overall, these studies provide valuable insights for businesses and policymakers looking to foster technological innovation capabilities and drive sustainable growth in various sectors and contexts.

4.3 Evaluation of Technological Innovation Capability

The paper underscores the vital role of technological innovation capabilities (TICs) in agricultural knowledge and innovation systems (AKISs) and the need for more dynamic evaluation methods. It introduces an organizational behaviour model-based approach to measure TIC levels within AKIS firms, highlighting the importance of monitoring TIC levels over time to enhance understanding of innovation processes and identify gaps within these systems. The complexity of TIC is acknowledged, involving both quantitative and qualitative criteria, with inherent measurement uncertainties. The article presents two web-based Belief Rule-Based Expert Systems (BRBES) for TIC assessment, with conjunctive BRBES outperforming disjunctive BRBES. Additionally, it emphasizes the significance of diverse TICs for high-velocity market firms, offering a decision-making framework that considers customer value trajectory. Furthermore, the study extends its focus to the evaluation of China's high-tech industries' technological innovation capabilities, proposing a novel Entropy-TOPSIS method for assessing enterprises' TIC, which proves effective in addressing the limitations of existing evaluation methods. These studies shed light on the critical role of TICs in innovation systems, both in agriculture and high-tech industries, and advocate for more dynamic and effective evaluation approaches. By introducing innovative methods such as BRBES and Entropy-TOPSIS, it provides valuable tools for assessing and enhancing TIC in different contexts, ultimately contributing to improved strategic management and innovation within organizations and industries.

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