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Exploring the Nexus: IT Capabilities, Digital Transformation, and Innovation in Traditional Manufacturing

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Abstract

This research investigates the interplay between information technology capabilities, digital transformation strategies, and digital innovation performance in traditional manufacturing enterprises. Utilizing a multi-case exploratory research approach, incorporating dynamic capability theory and institutional theory, hypotheses were formulated and validated through empirical analysis of questionnaire survey data. Findings reveal that IT capabilities positively influence both digital product and process innovation performance. Additionally, digital transformation strategies mediate the relationship between IT capabilities and innovation performance. Organizational legitimacy moderates the impact of digital transformation strategies on innovation performance, while environmental dynamism influences the relationship between IT capabilities, transformation strategies, and innovation performance. The study underscores the importance of aligning internal resources with strategic needs to navigate digitalization successfully in traditional manufacturing contexts.

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1. Introduction

1.1 Background of Study

The digital transformation of the manufacturing industry is a crucial step in advancing the new industrial revolution and enhancing industrial modernization. In 2023, China's industrial growth was notable, with the added value of industries above a designated size increasing by 4.6% year-on-year, up from 3.6% in 2022. Manufacturing saw a 5.0% year-on-year increase, demonstrating a stable and upward trend, supported by the significant roles of key industries and provinces. For 14 consecutive years, China has led the world in manufacturing scale. This progress is marked by a shift towards intelligent manufacturing, as evidenced by the establishment of 62 "lighthouse factories" and the cultivation of numerous intelligent manufacturing demonstration factories (Yang & Lei, 2021; Lv, 2019). The emphasis on green and low-carbon transformation has also improved the utilization efficiency of industrial resources, surpassing 2.2 billion tons of bulk industrial solid waste annually. Digital transformation is now a critical strategy for traditional manufacturing enterprises to survive and thrive. It is not only a response to traditional technological innovation and market-driven transformations but also a means to leverage digital technologies like big data, cloud computing, and the Internet of Things. These technologies offer new opportunities for traditional enterprises, reshaping competition in various industries (Li, 2016; Li & Huang, 2018). The COVID-19 pandemic further accelerated the need for digital transformation due to its impact on workforce mobility and traditional manufacturing processes (Jia & Zhu, 2022). Failure to adapt has caused significant setbacks for some established firms, such as Kodak and Fuji Film, which did not transition quickly enough to digital formats.

1.2 Problem Statement

Research on digital transformation and its role in enhancing enterprise innovation is expanding. Scholars have explored the concepts (Vial, 2019), theoretical frameworks (Matt & Hess, 2015; Xiao & Qi, 2019), and influencing factors (Westerman & Bonnet, 2014) of digital transformation. However, studies focusing on manufacturing typically use theoretical and case study methods, examining the internal and external factors affecting digital transformation (Chi & Ye, 2020; Veldhoven & Vanthienen, 2021). There is a lack of comprehensive research on the interplay of these factors and how they collectively influence digital innovation performance. Traditional manufacturing enterprises face two main challenges in digital transformation: a lack of IT resources and integration issues, and difficulties in market entry for digital products/services (Luo & Jiang, 2020). Effective IT capabilities are crucial for localizing IT resource development and improving business process digitization (Krimpmann, 2015). Furthermore, the non-technical aspects of digital transformation, such as social and institutional factors, also play a significant role (Vial, 2019; Bharadwaj et al., 2013). Successful digital transformation involves applying technology within a broader social and institutional context, requiring a balance between technological and non-technological factors (Tilson & Lyytinen, 2010). From an institutional theory perspective, digital transformation in traditional manufacturing enterprises changes the operational norms within organizations and industries (Sarker & Chatterjee, 2019). This transformation faces legal and institutional challenges, impacting the ability of digital products/services to gain market entry and acceptance. Few studies have examined how these enterprises can overcome these barriers to achieve digital innovation performance. The implementation of digital transformation strategies also depends on environmental factors. The dynamic external environment influences resource acquisition and allocation, necessitating an exploration of how environmental dynamics affect digital transformation and innovation in traditional manufacturing enterprises (Lazonick & Prencipe, 2008). Combining internal IT capabilities and organizational legitimacy with external

environmental factors can help enterprises navigate these challenges and successfully implement digital transformation strategies (Burns & Stalker, 1994; Thompson & Kopelman, 2015). The study of digital transformation in traditional Chinese manufacturing enterprises is both practically significant and theoretically enriching. Understanding the mechanisms by which these enterprises leverage IT capabilities, navigate institutional challenges, and adapt to dynamic environments is crucial for enhancing their digital innovation performance and maintaining their competitive edge in the global market.

1.3 Research Questions and Objectives

This study addresses specific issues related to the digital innovation performance of traditional manufacturing enterprises. The main questions investigated are: (1) the impact of IT capabilities on digital innovation performance, (2) the effect of digital transformation strategy on digital innovation performance, and (3) the mediating role of digital transformation strategy. Specifically, it asks whether IT capability positively impacts digital transformation strategies and whether digital transformation strategy mediates between IT capabilities and digital innovation performance. Additionally, the study examines the regulatory role of organizational legitimacy and environmental dynamics in these relationships. The study aims to achieve several objectives based on the research questions. It seeks to: (1) test the impact of IT capabilities on the digital innovation performance of traditional manufacturing enterprises, (2) examine the impact of digital transformation strategies on digital innovation performance, (3) investigate the mediating role of digital transformation strategies, including their impact on IT capabilities and digital innovation performance, (4) test the moderating effects of organizational legitimacy and environmental dynamics on these relationships, and (5) verify the moderating role of these factors on the mediating effects of IT capabilities, digital transformation strategies, and digital innovation performance.

1.4 Research Significance

This study constructs a research framework based on dynamic capability theory, contingency theory, and institutional theory, focusing on traditional manufacturing enterprises. It explores the interactions between IT capabilities, digital transformation strategies, and digital innovation performance. The research reveals that IT capabilities provide the technical support necessary for digital transformation, but these alone do not guarantee high digital innovation dividends. Effective digital innovation requires the integration of IT capabilities with digital transformation strategies that span different functional departments within an organization. Moreover, the study highlights the moderating roles of environmental dynamism and organizational legitimacy, emphasizing the contingency nature of these factors in digital transformation (Sarker & Chatterjee et al., 2019; Chalmers & Matthews et al., 2021; Xu & Li, 2021; Wang & Feng, 2022; Henfridsson & Bygstad, 2013; Warner & Wager, 2019).

Practically, the study offers guidance for traditional manufacturing enterprises on leveraging IT capabilities to achieve localized applications of digital technology and successfully implement digital transformation strategies. It underlines that merely investing in IT is insufficient; enterprises must align IT capabilities with strategic needs to gain competitive advantages. The findings provide insights into addressing legitimacy challenges within the institutional environment and responding to dynamic market conditions. This guidance is crucial for traditional manufacturing enterprises aiming to enhance their digital innovation performance, which in turn can stimulate economic vitality and promote sustainable national economic development. In summary, this study provides a comprehensive analysis of how IT capabilities, digital transformation strategies, organizational legitimacy, and environmental dynamics interact to influence digital innovation performance in traditional manufacturing

enterprises. It contributes both theoretically and practically by revealing critical mechanisms and offering actionable insights for enterprises navigating digital transformation.

2. Literature Review

2.1 IT Capability

Research on organizational capability, influenced by resource-based theory and dynamic capability theory, highlights the importance of rare and immutable resources for competitive advantage and organizational performance (Eisenhardt & Martin, 2000; Bharadwaj, 2000). IT capabilities, which encompass IT investment, infrastructure quality, and human capital, have been central to this discussion (Weill & Broadbent, 1998; Bharadwaj, 2000). Bharadwaj (2000) categorizes IT capabilities into infrastructure, human resources, and intangible assets, emphasizing their role in supporting strategic goals and digital innovation (Lu & Ramamurthy, 2011). Research suggests IT capabilities are crucial for executing corporate strategies and enhancing competitive positions in the information age (De Haes & Van Grembergen, 2009). Effective IT governance and the integration of IT with business strategy, organizational structure, and capabilities are vital for achieving sustainable business value (Yeh et al., 2002; Drnevich & Croson, 2013). Despite significant investments in IT systems, many manufacturing industries struggle to improve business operations due to a lack of integration between technical resources and business strategy (Park & Mithas, 2020).

2.2 Digital Transformation Strategy

Patel and McCarthy (2000) first applied the concept of digital transformation in enterprise management research, but significant academic and industry attention emerged only after 2014. Digital transformation has since been examined across various disciplines, including information systems and management studies. Information system researchers focus on how enterprises adopt and use digital technologies (Skog & Wimelius, 2018), while management scholars explore the changes digital technology brings to business operations, organizational structures, and management concepts (Kaufman & Horton, 2015; Hess et al., 2016). Digital transformation strategy involves comprehensive and systematic changes in organizational elements constituting enterprise strategy. This transformation affects not only strategic content but also the processes, products, and overall structure of the organization (Xue & Wang, 2012). Digital transformation is seen as an organizational strategic change driven by digital technologies (Sambamurthy & Bharadwaj, 2003). Existing literature lacks consensus on the definition of "digital transformation strategy." Some scholars view it as the integration of digital technology to reshape business models and create new value (Kane et al., 2017). Others define it as significant business improvements driven by new digital technologies (Fitzgerald et al., 2014; Graesch et al., 2021). Research indicates that digital transformation involves transforming enterprise goals, governance structures, and business models to drive high-quality development (Liu et al., 2020; Jia & Zhu, 2022). From a strategic management perspective, digital transformation reshapes major business operations through continuous strategy, organizational structure, and business model changes (Matt et al., 2015; Hess et al., 2016). It is a comprehensive strategic decision involving digital technology integration (Sanchez, 2017). Digital transformation research spans multiple disciplines, exploring its impact from macro and micro perspectives. At the macro level, studies investigate the broad societal and economic changes driven by digital technologies (Sebastian et al., 2017). At the micro level, research examines digital transformation's effects on enterprises, such as performance improvements and innovation (He & Liu, 2019). Process-oriented studies detail stages in implementing digital transformation, from initial digital technology development to comprehensive organizational reform (Venkataraman, 1994; Berman, 2012). These stages

help understand the complexities and unique requirements of digital transformation within enterprises.

2.3 Digital Innovation Performance

Research on digital innovation stems from studies on digital technology in Information Systems (IS), highlighting its heterogeneity, editability, self-referential, and distributive characteristics, which influence corporate strategy, innovation, and business models (Bharadwaj et al., 2013; Hess et al., 2016; Sambamurthy et al., 2003; Yoo et al., 2010). Digital innovation spans multiple disciplines, including IT, management, and sociology. Digital technology's unique properties, such as reprogrammability, data homogenization, and self-referential nature, allow digital products to have infinite iteration and organizational boundaries to blur. These attributes facilitate the integration of digital capabilities into previously purely physical objects, forming digital innovations with characteristics like renewability and convergence (Yoo & Henfridsson, 2010). Digital innovation can decouple and disintermediate processes, enabling enterprises to innovate without relying on proprietary resources (Otio et al., 2018). It includes embedding digital technology into traditional physical products and reshaping their design, production, and usage patterns (Nambisan et al., 2016). Yoo et al. (2012) categorize digital innovation into distributed and combinatorial types, while Nambisan et al. (2016) describe it as developing new products or enhancing existing ones through digital technology. Digital innovation focuses on creating new user value through hierarchical modular construction of digital components (Lusch & Nambisan, 2015). Digital innovation performance measures the beneficial outcomes of implementing digital innovation, including enhanced organizational performance and competitive advantage (Thomas, 2015). This performance encompasses digital product innovation, digital service innovation, digital process innovation, and digital business model innovation (Khin & Ho, 2019; Zhang & Edgar, 2016). Boeker and Howard (2019) use patents to quantify digital innovation performance. Digital innovation reshapes resources and business models, affecting performance. Internal and external factors drive digital innovation activities. Externally, competition and the integration of IT and industry pressure enterprises to invest in digital innovation (Feng et al., 2021). Internally, digital resources such as infrastructure and platforms form the foundation for innovation (Nwankpa & Datta, 2017). Effective use of IT resources and organizational capabilities is essential for obtaining digital innovation performance. Strategic management highlights the need for integrating digital solutions and business concepts into organizational structures and IT governance (Hess et al., 2016). Successful digital innovation requires synergy between resources, capabilities, strategies, and the external environment (Svahn et al., 2017).

2.4 Organizational Legitimacy

Organizational legitimacy, a key concept in institutional theory, has evolved from political science to social psychology and organizational management (Matheson, 1987; Meyer & Rowan, 1977). It refers to the extent to which organizational actions align with societal norms, rules, and beliefs, and the degree of acceptance by stakeholders (Suchman, 1995; Singh et al., 1986). Legitimacy can be classified into regulatory, normative, and cognitive types (Scott, 1995). Regulatory legitimacy is maintained through compliance with laws and regulations, normative legitimacy is based on adherence to societal moral norms, and cognitive legitimacy arises when organizational goals align with public expectations (Aldrich & Fiol, 1994). From an institutional perspective, legitimacy involves imitating other organizations, complying with legal standards, and adhering to professional norms (Oliver, 1991). Strategic management researchers suggest that organizations can enhance legitimacy through activities like social welfare participation (He & Su, 2016). Managers play a crucial role in this process by managing stakeholder perceptions and ensuring alignment with social expectations (Huy & Corley, 2014;

Xu & Li, 2021). Empirical research highlights the positive impact of organizational legitimacy on performance metrics such as financial outcomes, IPO value, and stock prices (Deephouse, 1999; Cohen & Dean, 2005; Lamin & Zaheer, 2012). However, the benefits of legitimacy can diminish as the costs of maintaining it rise, particularly in dynamic environments (Grimpe & Sofka, 2009). Effective legitimacy management is thus vital for long-term success, especially during organizational changes like digital transformation (Gawer & Phillips, 2013; Heilig & Lalla Ruiz, 2017). Therefore, maintaining a balanced level of legitimacy is essential for organizations to navigate complex institutional environments and achieve sustainable development (Aisaiti & Liang, 2021).

2.5 Environmental Dynamism

Environmental dynamism, crucial for organizational strategy, involves the pace and predictability of changes in industry conditions (Miller, 1983). It encompasses technological advancements, market fluctuations, and stakeholder behaviors (Baum & Wally, 2003). In highly dynamic environments, firms face intense, fleeting competition, necessitating continuous adaptation (Ilinitch & D'Aveni, 1996). This digital era amplifies such dynamism, challenging firms to innovate persistently to maintain competitiveness (Schumpeter, 1934). Environmental dynamism moderates corporate performance and drives strategic change (Lumpkin & Dess, 2001). Firms adept at navigating dynamic environments achieve superior financial performance through innovation (Liu & Liu, 2013). Such firms recognize the imperative of constant innovation to seize emerging market opportunities (Ilinitch & D'Aveni, 1996). However, inertia can lead traditional firms to neglect market shifts, risking obsolescence (Porter, 1996). Embracing strategic transformation aligned with digital trends enables firms to thrive amidst environmental complexity (Deng & Liu, 2021). In summary, understanding and adapting to environmental dynamism are essential for firms to sustain competitiveness in the digital age.

2.6 Theoretical Basis

Dynamic Capability Theory (DCT) emerges from the resource-based view theory, emphasizing how enterprises harness internal and external resources to create competitive advantages (Barney, 1991). However, in today's digital era, the traditional emphasis on static, immobile resources becomes insufficient (Cai & Zhang, 2021). Teece et al. (1994) proposed DCT, highlighting the importance of enterprises' ability to adapt to changing environments through resource integration and business model evolution. DCT complements the resource-based view by focusing on dynamic resource restructuring to maintain competitiveness (Grant, 1995). In practice, dynamic capabilities enable firms to swiftly respond to technological and market shifts (Zahra & Sapienza, 2006). Particularly, in the face of digital disruptions, dynamic capabilities are essential for firms to innovate, transform business models, and sustain competitiveness (Achtenhagen & Melin, 2013; Karimi & Walter, 2015). This underscores the need for traditional manufacturing firms to cultivate dynamic capabilities to navigate digital transformation successfully (Teece, 2018). However, while some firms excel in integrating resources for digital innovation (Garbellano & Da Veig, 2019), others struggle to align IT capabilities with organizational needs (Nadeem & Abedin, 2018). Thus, understanding how firms leverage dynamic capabilities for digital innovation, especially in traditional manufacturing, remains a critical research gap. Institutional Theory examines how institutional factors shape organizational behavior and development (Meyer & Rowan, 1977). Originating from two main schools of thought—economic and organizational sociology—it elucidates the influence of norms and legitimacy on organizational actions (North, 1990; Scott, 1995). Organizational behaviors conform to established norms, yet innovations also emerge within institutional constraints (DiMaggio & Powell, 1983). Traditional manufacturing

enterprises undergoing digital transformation encounter institutional hurdles such as market competition and stakeholder resistance (Greenwood & Raynard, 2011). Overcoming these obstacles requires aligning internal perceptions and industry legitimacy, facilitating digital innovation (Chalmers & Matthews, 2021). However, the precise mechanism linking organizational legitimacy to digital transformation in traditional manufacturing remains underexplored (Pfeffer & Salancik, 2003). Future research aims to address this gap, shedding light on how firms navigate institutional constraints to achieve digital innovation success. Contingency Theory, initially focusing on organizational leadership effectiveness, emphasizes the impact of leader, follower, and environmental variables (Otley, 2016). Models like Federer's, House's, and Carmen's typify its application. External environment, crucial for strategy execution, necessitates organizational adjustments (Venkataraman, 1989). Environmental dynamism, characterized by unpredictability, challenges firms to adapt strategies (Schilke, 2014). Digital economies face heightened dynamism, urging organizations towards digital transformation for competitive edge (Ivanov & Sokolov, 2013). Coping with evolving customer expectations and global competition mandates digital innovation (Cenamor & Parida, 2019). Contingency theory offers insights into firms' adaptive behaviors amidst environmental shifts, facilitating strategic resource integration (Chen & Song, 2019).

2.7 Hypotheses and Framework

The study aims to investigate how IT capabilities, environmental dynamics, and organizational legitimacy influence digital transformation strategies and digital innovation performance in traditional manufacturing enterprises. Based on existing literature and industry context, sixteen theoretical hypotheses are proposed. Firstly, IT capabilities positively affect digital product and process innovation performance (H1a, H1b). Secondly, digital transformation strategies positively impact digital innovation performance (H2a, H2b). Thirdly, IT capabilities positively influence digital transformation strategies (H3). Fourthly, digital transformation strategies mediate the relationship between IT capabilities and digital innovation performance (H4a, H4b). Fifthly, organizational legitimacy positively moderates the relationship between digital transformation strategies and innovation performance (H5a, H5b). Sixthly, organizational legitimacy moderates the mediating effect between IT capabilities, digital transformation strategies, and innovation performance (H6a, H6b). Lastly, environmental dynamism positively moderates the relationship between IT capabilities and digital transformation strategies (H7).

Hypotheses Description:

(1) H1a: IT capabilities positively impact digital product innovation performance.
(2) H1b: IT capabilities positively impact digital process innovation performance.
(3) H2a: Digital transformation strategy positively impacts digital product innovation performance.
(4) H2b: Digital transformation strategy positively impacts digital process innovation performance.
(5) H3: IT capabilities positively impact digital transformation strategies.
(6) H4a: Digital transformation strategy mediates between IT capabilities and digital product innovation performance.
(7) H4b: Digital transformation strategy mediates between IT capabilities and digital process innovation performance.
(8) H5a: Organizational legitimacy positively moderates the relationship between digital transformation strategies and digital product innovation performance.
(9) H5b: Organizational legitimacy positively moderates the relationship between digital transformation strategies and digital process innovation performance.

(10) H6a: Organizational legitimacy positively moderates the mediating effect between IT capabilities, digital transformation strategies, and digital product innovation performance.
(11) H6b: Organizational legitimacy positively moderates the mediating effect between IT capabilities, digital transformation strategies, and digital process innovation performance.
(12) H7: Environmental dynamism positively moderates the relationship between IT capabilities and digital transformation strategies.

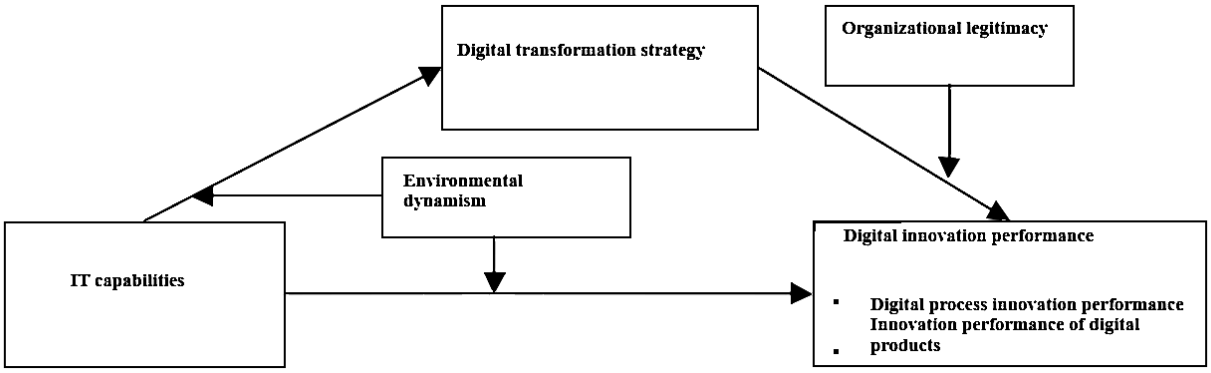

Figure 2-1: Research Framework

These hypotheses provide a framework for understanding the complex interplay between IT capabilities, organizational dynamics, and digital innovation performance in traditional manufacturing enterprises.

3. Methodology

3.1 Research Design

To address the research inquiries effectively and enhance the rigor of findings, this study employs a mixed-methods approach integrating qualitative and quantitative methodologies. Firstly, a comprehensive literature review was conducted, synthesizing seminal theories like dynamic capability theory, institutional theory, and contingency theory alongside variables such as IT capability, digital transformation strategy, organizational legitimacy, environmental dynamism, and digital innovation performance. Through systematic analysis, research questions were formulated, and a theoretical framework was developed, yielding hypotheses for investigation (Sun & Zuo, 2024). Secondly, exploratory case studies were undertaken in three traditional manufacturing enterprises across Changzhou, Cixi, and Changchun, gathering primary data through interviews and secondary data from various sources. The collected data were analyzed to derive constructs for each variable, facilitating the construction of a research model (Sun & Zuo, 2024). Lastly, a questionnaire survey involving 462 traditional manufacturing enterprises was conducted to validate the research hypotheses. The survey instrument was designed based on existing literature and refined through pre-research and expert discussions. Statistical analyses using SPSS 26.0 and AMOS 21.0 were employed to assess the hypotheses' validity (Sun & Zuo, 2024). This methodological approach ensures robustness and reliability in exploring the impact mechanism of enterprise digitalization in traditional manufacturing settings.

3.2 Questionnaire Design

In crafting the questionnaire, this study upholds several principles to ensure its scientific rigor. Firstly, the questionnaire design adheres to the principles of scientificity, ensuring that key variables are measured accurately (Sun & Zuo, 2024). Secondly, mature scales validated by authoritative literature are utilized to enhance operability and reliability (Sun & Zuo, 2024).

Thirdly, the questionnaire items are kept within a reasonable range to prevent respondent fatigue and maintain data quality (Sun & Zuo, 2024). The questionnaire design process involves multiple stages. Initially, scales for key constructs are selected based on extensive literature review and expert consultation. Subsequently, the scale content is translated, reviewed by bilingual experts, and refined based on pre-survey feedback (Sun & Zuo, 2024). The survey structure is meticulously designed to collect comprehensive data efficiently, incorporating both personal information and Likert scale measurements for key variables (Sun & Zuo, 2024). Prior to formal administration, the questionnaire undergoes rigorous testing through pre-research to refine its quality (Sun & Zuo, 2024). Finally, formal research is conducted both on-site and online, with survey participants receiving training to ensure data integrity (Sun & Zuo, 2024).

3.3 Variable Measurement

IT capabilities are assessed through three dimensions: IT infrastructure, IT business expansion, and IT forward-looking capabilities (Lu & Ramamurthy, 2011). These dimensions encompass aspects such as hardware deployment, data management, and innovation pursuit. The measurement scale, validated in the Chinese context (Chu & Chi, 2020), consists of nine observation variables. Digital innovation performance, encompassing product and process innovation, is gauged through subjective indicators (Ardito & Raby, 2021). Digital product innovation and digital process innovation are measured using seven and three items respectively, drawing from established research (Leonhardt et al., 2018; Pesch & Endres, 2020; Ardito & Raby, 2021; Zhen & Yousaf, 2021). The digital transformation strategy focuses on leveraging digital technologies to innovate business processes and models (Hess et al., 2016). An 11-item scale, validated by prior studies (Wang & Feng, 2020; Zhu & Lin, 2022), assesses the integration of digital technology into strategic goals and operational activities. Organizational legitimacy, reflecting social acceptance, is measured through perceptions of stakeholders (Certo & Hodge, 2007; Du & Li, 2012). Six items evaluate aspects such as supplier relationships and government evaluations. Environmental dynamism, capturing market changes and technological advancements, is assessed using subjective perceptions (Lumpkin & Dess, 2001). Three items gauge market demand fluctuations and technological innovation speed. Control variables, including the presence of a Chief Digital Officer (CDO), company age, company size, and industry type, are incorporated to mitigate potential endogeneity (Bernerth & Aguinis, 2016). These variables control for enterprise and industry-level influences on digital transformation and innovation activities.

3.4 Pre-Survey and Questionnaire Revision

Pre-survey plays a pivotal role in refining questionnaire surveys, especially when adapting scales from diverse cultural contexts. Considering the study's focus on Chinese organizations, it conducted pre-surveys to gauge the comprehension and relevance of selected scales. Targeting senior, middle, and grassroots managers in manufacturing industries around Changchun, the pre-survey gathered 80 valid responses out of 100 distributed questionnaires. Analysis of reliability and validity indicated satisfactory results, warranting no deletion of the questionnaire. Feedback from participants prompted revisions in questionnaire wording, culminating in the final study survey instrument (Sun & Zuo, 2024). This iterative process ensured the questionnaire's appropriateness and effectiveness in capturing the intended constructs accurately.

3.5 Data Collection and Sample Characteristics

The study's research questions center on digital activities within traditional manufacturing enterprises. Consequently, the sample selection focused on industries such as

biological/chemical/pharmaceutical manufacturing and textile/clothing manufacturing, which have been actively engaged in digital transformation to meet evolving consumer demands amidst the digital economy and the COVID-19 pandemic (Sun et al., 2024). Data was collected through a questionnaire survey conducted in regions with a significant concentration of traditional manufacturing enterprises, including the Northeast, Central, and Eastern regions of China. The questionnaire comprised sections on the importance and purpose of the survey, demographic information, enterprise details, variable measurements, and respondent feedback. Given the familiarity of management with pertinent concepts, the questionnaire was primarily administered to middle and senior management personnel. The data collection process spanned two stages: from August to September 2023 and from January to December 2023. In the first stage, 600 questionnaires were distributed, resulting in 544 valid responses. The second stage targeted 544 companies for follow-up, yielding 462 valid responses, indicating a recovery rate of 97.07% (Sun et al., 2024). Descriptive analysis of the 462 valid samples revealed insights into respondent and enterprise characteristics. Regarding respondent profiles, 62.67% were mid-level managers, and 37.33% were senior managers, with 54.84% male and 45.16% female participants. In terms of enterprise age, 29% were less than 10 years old, 51.15% were between 11-20 years old, and 35.02% were between 21-50 years old. Notably, 36.41% of the surveyed enterprises operated in the electronic equipment manufacturing sector, reflecting the ongoing relevance of traditional manufacturing industries amidst digitalization efforts (Sun et al., 2024). Furthermore, the distribution of surveyed companies across various industries highlighted the diverse representation: food/tobacco/alcohol manufacturing (10.14%), biological/chemical/pharmaceutical manufacturing (11.52%), electronic equipment manufacturing (36.41%), transportation equipment manufacturing (10.6%), textile/clothing manufacturing (9.22%), and construction/real estate sales (9.22%), among others (Sun et al., 2024).

3.6 Nonresponse Bias and Common Method Bias Analysis

Nonresponse bias, or refusal bias, arises when respondents decline to participate in a survey, potentially skewing the results. This bias can stem from uncooperative respondents or an unrepresentative sample due to selective surveying. To address nonresponse bias, the study conducted a t-test on key variables, including firm size and age, between early and late recovery samples (Zhang & Edgar, 2016; Luo, 2020). The results, with $p>0.1$, indicated no significant nonresponse bias in the study. F-tests and T-tests were employed on both online and offline population samples, yielding p-values > 0.05, suggesting no significant differences between the data types. Furthermore, the Harman single factor method was applied, revealing four factors without rotation, with the first factor explaining 36.287% of the variance. This absence of a single factor dominating variance indicates no substantial common method bias in the sample data.

3.7 Reliability and Validity Testing

The reliability of the scale was assessed through corrected item total correlation (CITC) and Cronbach's Alpha coefficient analysis. A CITC value above 0.3 indicates high consistency between items, while a Cronbach's Alpha coefficient exceeding 0.7 suggests good reliability (Wu, 2010). Results show CITC values and Cronbach's Alpha coefficients for variables like IT capability and digital transformation strategy surpassing critical values, indicating high internal consistency and reliability. Validity testing includes content, convergent, and discriminant validity assessments. Content validity was ensured by using established scales applicable to the Chinese context. Convergent validity was confirmed through confirmatory factor analysis (CFA) using AMOS21.0, while discriminant validity was assessed by comparing the square root of Average Variance Extracted (AVE) values with correlation coefficients

(Fornell & Larcker, 1981). For instance, validity testing of IT capabilities demonstrates factor loadings exceeding 0.5, indicative of good reflection of the variable. Convergent validity was established with favorable goodness of fit indices and AVE values surpassing correlation coefficients, signifying good discriminant validity. Validity testing of digital transformation strategy also shows satisfactory factor loadings and goodness of fit indices, affirming high intrinsic quality and overall validity. Similar validity testing was conducted for organizational legitimacy, environmental dynamism, and digital innovation performance, all demonstrating robust reliability and validity. The discriminant validity of the overall path model was examined using AMOS21.0, with the five-factor model exhibiting optimal fit indices. The results indicate superior fit compared to alternative models, affirming the model's validity and appropriateness.

3.8 Descriptive Statistical Analysis and Correlation Analysis

The study undertook descriptive statistics and correlation analysis on all variables, revealing significant insights. Correlation coefficients between variables remained below 0.7. Key variables such as IT capability, digital transformation strategy, organizational legitimacy, and environmental dynamism exhibited significantly positive correlations with digital product innovation performance and digital process innovation performance. Moreover, the square root of the Average Variance Extracted (AVE) value for these variables surpassed others, indicating robust validity. For instance, the correlation coefficient between IT capability and digital transformation strategy stood at 0.585, between digital transformation strategy and organizational legitimacy at 0.553, and between organizational legitimacy and digital product innovation performance at 0.500. These coefficients signify moderate to strong positive correlations ($p < 0.05$). Furthermore, environmental dynamism displayed a noteworthy correlation with digital product innovation performance (0.577) and digital process innovation performance (0.954), suggesting its influential role in innovation endeavors. Additionally, the correlation between firm size and digital transformation strategy (0.223) underscores the strategic importance larger firms may place on digital transformation initiatives. In summary, the correlation analysis underscores the interrelation among variables crucial for digital innovation performance, highlighting the significance of factors like IT capability, digital transformation strategy, and environmental dynamism.

4. Results and Discussion

4.1 The Relationship between Enterprise IT Capability and Digital Product Innovation Performance

The study utilized SPSS 26.0 for hierarchical regression analysis to verify the direct effects posited in theoretical hypotheses, controlling for variables such as company age, size, industry, and the presence of a Chief Digital Officer (CDO). The analysis revealed a significant positive relationship between enterprise IT capability and digital product innovation performance ($\beta = 0.619$, $p < 0.001$), supporting hypothesis H1a. Similarly, IT capability was positively correlated with digital process innovation performance ($\beta = 0.567$, $p < 0.001$), validating hypothesis H1b. The results also indicated a significant positive relationship between digital transformation strategy and both digital product innovation performance ($\beta = 0.443$, $p < 0.001$) and digital process innovation performance ($\beta = 0.669$, $p < 0.001$), confirming hypotheses H2a and H2b. Additionally, enterprise IT capabilities positively impacted digital transformation strategies ($\beta = 0.464$, $p < 0.001$), supporting hypothesis H3.

The analysis further revealed that the age and size of traditional manufacturing enterprises negatively impact their digital innovation performance. Larger and older enterprises may face increased organizational inertia, making it difficult to implement effective changes in response

to a dynamic external environment. This organizational rigidity can hinder digital innovation efforts. The presence of a CDO did not significantly affect the implementation of digital transformation strategies, despite existing literature suggesting that digital-savvy leaders are crucial for successful transformation (Singh & Hess, 2017; Singh, Klarner, & Hess, 2020). The study found that while most traditional manufacturing companies engage in some degree of digital transformation, only a few have appointed CDOs, which may explain the negligible impact observed.

Table 4-1: Direct Effect Analysis Results

Variable	Digital innovation performance			
	Innovation performance of digital products		Digital process innovation performance	
	Model1-1	Model2-1	Model1-2	Model2-2
Enterprise age	-0.064	-0.059	-0.014	-0.007
Enterprise scale	-0.011	-0.007	-0.048	-0.043
CDO settings	-0.325***	-0.207**	-0.144	0.034
industry	-0.015	-0.098	-0.016	0.155
IT capabilities	0.619***	0.414***	0.567***	0.257***
Digital transformation strategy	0.443***		0.669***	
R^2	0.665	0.720	0.569	0.719
F	35.753	40.194	21.551	39.886

The study focuses on traditional manufacturing enterprises in the digital economy, exploring how IT capabilities can enhance digital innovation performance through the lens of dynamic capability theory. IT capability, defined as the organizational ability to manage and utilize IT resources, is crucial for integrating these resources with other organizational resources for value creation (Lu & Ramamurthy, 2011). Strong IT capabilities enable firms to quickly leverage IT resources, integrate IT with business needs, and support digital innovation activities. In the digital age, technological strengths alone are insufficient; the ability to acquire and develop IT capabilities is vital for competitive advantage. The research demonstrates that enterprises with robust IT capabilities are better positioned to incorporate emerging technologies into their operations, supporting digital product and process innovations. These capabilities help address the inherent challenges of integrating technology resources within traditional manufacturing contexts (Luo & Jiang, 2020). Consequently, IT capabilities are a critical antecedent for achieving digital innovation performance in traditional manufacturing enterprises.

4.2 The Mediating Effect of Digital Transformation Strategy

This study employed Hayes' Process analysis program (Hayes, 2017) to verify the mediating effect of digital transformation strategy, using Model 4 with 5000 iterations. The results indicated a significant mediating effect of digital transformation strategies on the relationship between IT capabilities and digital innovation performance. Specifically, for digital process innovation performance, the 95% confidence interval was between 0.214 and 0.423, indicating a significant mediating effect ($\beta = 0.310$, $p < 0.001$). This confirms that digital transformation strategy partially mediates the relationship between IT capability and digital process innovation performance, supporting hypothesis H4b.

For digital product innovation performance, the confidence interval ranged from 0.120 to 0.301, also indicating a significant mediating effect ($\beta = 0.206$, $p < 0.001$), thus validating hypothesis H4a. The mediating effect coefficient was less than the total effect coefficient of 0.620, indicating that digital transformation strategy partially mediates the relationship between IT capability and digital product innovation performance. The study focuses on how digital transformation strategies mediate the relationship between IT capabilities and digital innovation performance in traditional manufacturing enterprises within the digital economy

context. High-level IT capabilities facilitate the implementation of digital transformation strategies, which in turn enhance both digital product and process innovation performance. Digital transformation strategies act as a crucial intermediary, leveraging IT capabilities to drive digital innovation.

Table 4-2: Mediation Effect Analysis Results

Variable	Digital transformation strategy	Digital process innovation performance (dip)	Innovation performance of digital products (did)
	Model3	Model4-1	Model4-2
Enterprise age	-0.011	-0.007	-0.059
Enterprise scale	-0.009	-0.043	-0.007
Cdo settings	-0.266	0.034	-0.207
Industry	-0.256	0.155	-0.098
It capability (itc)	0.464***	0.257***	0.414***
Digital transformation strategy (dts)		0.669***	0.443***
R^2	0.437	0.517	0.518
F	34.868	39.886	40.194
The total effect of itc		0.619***	0.620***
Mediating effect	Effect	Llci	Ulci
Itc→dts→dip	0.310***	0.214	0.423
Itc→dts→did	0.206***	0.120	0.301

According to dynamic capability theory, the value of a company's resources or capabilities is realized through the effective construction, integration, and reallocation of these resources to align with strategic development and environmental changes (Teece et al., 1997). Digital innovation is complex and requires more than just investment in IT; it necessitates strategic direction and support. For traditional manufacturing enterprises, digital transformation involves digitizing traditional businesses and integrating emerging technologies such as the Internet of Things, big data, and artificial intelligence into various operational processes. This promotes the networked and intelligent development of enterprises. IT capability enhances the efficiency with which enterprises utilize information technology resources. However, the integration of digital technologies into business processes depends on strategic changes within the organization. Enterprise strategy sets the direction for digital activities, guiding the coordination of resources and capabilities to support digital innovation. Thus, the empowerment of enterprise innovation through IT capabilities is inseparable from the strategic support provided by digital transformation strategies.

4.3 The Moderating Effect of Organizational Legitimacy

The study employed Hayes' Process analysis program to examine the moderating mediating effects of organizational legitimacy on IT capabilities, digital transformation strategies, and digital innovation performance, using Model 14 with 5000 iterations. The results indicated that organizational legitimacy significantly moderates the relationship between digital transformation strategies and both digital process innovation performance ($\beta = 0.228$, $p < 0.05$) and digital product innovation performance ($\beta = 0.280$, $p < 0.01$), confirming hypotheses H5a and H5b.

The mediating effect analysis showed that at different levels of organizational legitimacy, the confidence interval for the effect on digital process innovation performance was between 0.029 and 0.201, with a mediating effect coefficient of 0.105. Similarly, for digital product innovation performance, the interval was between 0.025 and 0.244, with a coefficient of 0.139. This indicates that organizational legitimacy partially mediates the relationship between IT capability, digital transformation strategy, and both types of innovation performance, validating hypotheses H6a and H6b.

Table 4-3: Organizational Legitimacy Role Analysis Results

Variable	Digital process innovation performance		Innovation performance of digital products
Model	Model5-1		Model5-2
Enterprise age	-0.015		-0.069
Enterprise scale	-0.041		-0.010
Cdo settings	0.012		-0.245**
Industry	0.145		0.071
It capability (itc)	0.211***		0.326***
Digital transformation strategy (dts)	0.602***		0.316***
Organizational legitimacy (ol)	0.172*		0.316***
Dts*ol	0.228*		0.280**
R^2	0.538		0.568
F	32.246		36.527
	Index of moderated Mediation Effect	LLCI-OL	ULCI-OL
ITC →DTS→DIP	0.105	0.029	0.201
ITC→DTS→DID	0.139	0.025	0.244

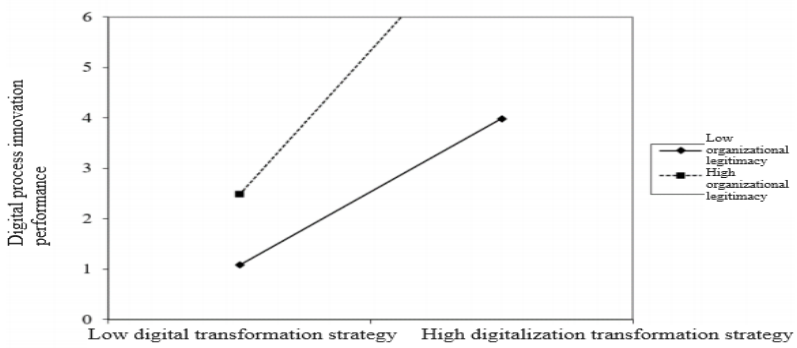

Figure 4-1: Moderating Effect of Organizational Legitimacy on Digital Transformation Strategies and Digital Process Innovation Performance

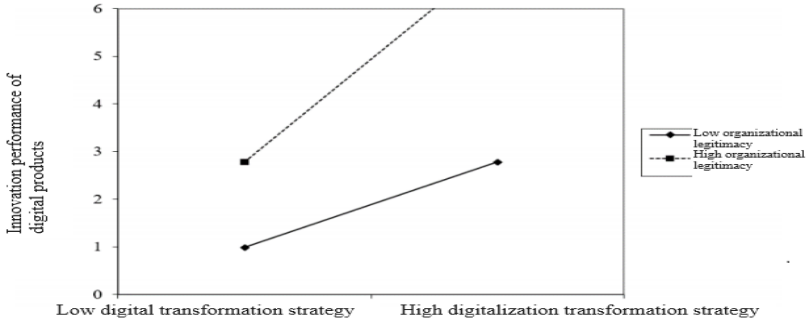

Figure 4-2: Moderating Effect of Organizational Legitimacy on Digital Transformation Strategies and Innovation Performance of Digital Products

The study explores the regulatory mechanism of organizational legitimacy through the lenses of dynamic capability theory and institutional theory. The findings reveal that organizational legitimacy positively influences the relationship between digital transformation strategy and innovation performance in both digital products and processes. It also moderates the relationship between IT capability, digital transformation strategy, and digital innovation performance. Organizational legitimacy refers to the general evaluation of an organization's behavior by its stakeholders within its operational context. This social attribute is a critical resource for internalizing external contextual factors. Traditional manufacturing enterprises face challenges in implementing digital transformation strategies, including limited digital resources, insufficient technological application capabilities, and legal recognition barriers.

Unlike digital-native Internet enterprises, traditional manufacturers rely on acquired technology investments to enhance their IT resources. Amid the impacts of the COVID-19 pandemic and the rise of the Internet economy, many manufacturing enterprises have increased digital investments to enhance competitiveness. The ability to integrate IT resources into operational processes is crucial for these enterprises to derive value from information technology. Institutional theory suggests that digital transformation extends beyond traditional organizational boundaries and involves challenges related to competitive logic, institutional complexity, and legitimacy (Greenwood & Raynard, 2011). For traditional manufacturing enterprises, digital transformation and innovation represent radical organizational changes that disrupt existing operational logics. These enterprises face significant legitimacy barriers from stakeholders, including internal employees, suppliers, and customers. Overcoming these barriers is essential for successfully reaping the benefits of digital transformation. Unlike Internet enterprises, traditional manufacturers must navigate a process of technological socialization, altering existing organizational and industry "rules of the game." Enhancing organizational legitimacy helps mitigate resistance from the institutional environment, facilitating successful digital innovation and market entry.

4.4 The Regulatory Effect of Environmental Dynamism

This section examines the impact of environmental dynamism on IT capabilities, digital transformation strategies, and digital innovation performance, testing five theoretical hypotheses. The results reveal that environmental dynamism significantly moderates these relationships. Firstly, the regression analysis indicates that environmental dynamism positively moderates the impact of IT capabilities on digital transformation strategies ($\beta = 0.168$, $p < 0.05$), confirming hypothesis H7. Higher levels of environmental dynamism strengthen the positive relationship between IT capability and digital transformation strategy.

Table 4-4: Environmental Dynamics Effect Analysis Results

Variable	Digital process innovation performance (dip)	Innovation performance of digital products (did)
Model	Model7-1	Model7-2
Enterprise age	-0.012	-0.058
Enterprise scale	-0.046	-0.011
Cdo settings	-0.093	-0.296
Industry	0.027	0.040
It capability (itc)	0.463***	0.537***
Environmental dynamism (ed)	0.215***	0.155**
Itc*ed	0.227*	0.056
R^2	0.376	0.462
F	19.180	27.387

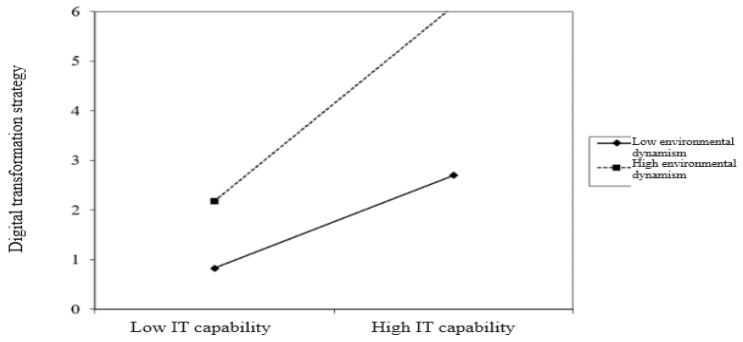

Figure 4-3: Moderating Effect of Environmental Dynamism on IT Capabilities and Digital Transformation Strategies

Secondly, environmental dynamism positively moderates the impact of IT capability on digital process innovation performance (β = 0.227, p < 0.05), validating hypothesis H8b. However, the moderating effect on digital product innovation performance is positive but not significant (β = 0.056, p > 0.05), rejecting hypothesis H8a.

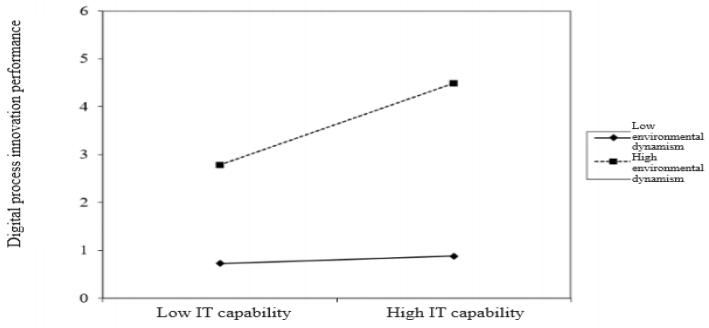

Figure 4-4: Moderating Effect of Environmental Dynamism on IT Capabilities and Digital Process Innovation Performance

Further analysis using Hayes' Process analysis program confirms the mediating effect of IT capability and digital transformation strategy on digital innovation performance, moderated by environmental dynamism. For digital process innovation performance, the mediating effect is significant (95% confidence interval: 0.010 to 0.220, β = 0.112). Similarly, for digital product innovation performance, the mediating effect is also significant (95% confidence interval: 0.003 to 0.156, β = 0.075), supporting hypotheses H9a and H9b.

Table 4-5: Environmental Dynamics Effect Analysis Results

variable	DTS	Digital process innovation Performance (DIP)	Innovation performance of digital products (DID)
model	Model6	Model8-1	Model8-2
Enterprise age	-0.007	-0.007	-0.059
Enterprise scale	-0.070	-0.043	-0.007
CDO settings	-0.220	0.034	-0.207
industry	-0.202	0.155	0.098
IT Capability (ITC)	0.366***	0.257***	0.414***
Environmental dynamism (ED)	0.217***		
Digital transformation strategy	0.669***		0.443***
ITC*ED	0.168*		
R^2	0.704	0.719	0.72
F	31.218	39.886	40.193
	Index of moderated Mediation		
	Effect	LLCI-ED	ULCI-ED
ITC→DTS→DIP	0.112	0.010	0.220
ITC→DTS→DID	0.075	0.003	0.156

This study explores the moderating effect of environmental dynamism through the lenses of contingency theory and dynamic capability theory. The findings suggest that environmental dynamism enhances the relationship between IT capability and digital transformation strategy, as well as between IT capability and digital process innovation performance. However, its moderating effect on the relationship between IT capability and digital product innovation performance is not significant. Environmental dynamism, reflecting the rapid pace of technological changes, product updates, and evolving consumer demands, drives traditional manufacturing enterprises to adopt digital transformation strategies and innovation actions. The rapid development of digital technologies not only propels Internet enterprises but also

transforms the industry and market environments of traditional manufacturers. This increased dynamism demands higher competencies in acquiring, managing, and applying information.
In highly dynamic environments, traditional enterprises face greater risks if they cling to existing product strengths and organizational strategies, potentially leading to market elimination. Consequently, environmental dynamism compels these enterprises to leverage their IT capabilities for digital transformation and innovation. Unlike the relatively stable market conditions of the industrial era, the digital age presents a constantly evolving environment. The fast-paced iteration of digital technologies complicates the prediction of technological and consumer trends, thereby increasing the urgency for traditional manufacturers to innovate digitally. This heightened dynamism also makes achieving digital product innovation performance more challenging within short timeframes.

4.5 Summary of Hypothesis Test Results

The results confirm that IT capability positively impacts both the innovation performance of digital products (H1a) and digital process innovation performance (H1b). Similarly, digital transformation strategy has a positive effect on both the innovation performance of digital products (H2a) and digital process innovation performance (H2b). IT capability is also found to positively influence digital transformation strategies (H3). The mediating role of digital transformation strategy between IT capability and both innovation performance of digital products (H4a) and digital process innovation performance (H4b) is supported. Furthermore, organizational legitimacy positively moderates the relationship between digital transformation strategies and the innovation performance of digital products (H5a) as well as digital process innovation performance (H5b). It also positively moderates the mediating effect of IT capability and digital transformation strategy on innovation performance of digital products (H6a) and digital process innovation performance (H6b). Environmental dynamism positively regulates the direct effect of IT capability on digital transformation strategy (H7). However, it does not significantly regulate the relationship between IT capability and the innovation performance of digital products (H8a). It does positively moderate the relationship between IT capability and digital process innovation performance (H8b). Additionally, environmental dynamism positively moderates the mediating effect of IT capability and digital transformation strategy on both the innovation performance of digital products (H9a) and digital process innovation performance (H9b).

5. Conclusions

5.1 Research Conclusion

This study, grounded in dynamic capability theory, institutional theory, and contingency theory, establishes a comprehensive research model exploring the nexus between digital transformation strategy, IT capability, digital innovation performance, organizational legitimacy, and environmental dynamism in traditional manufacturing enterprises. Utilizing a multi-case exploratory research approach, hypotheses were formulated and validated with data from 462 traditional manufacturing enterprises via questionnaire surveys, employing linear regression analysis and Bootstrap analysis.

The findings reveal that IT capabilities positively influence digital innovation performance in traditional manufacturing enterprises, both in terms of digital product innovation and digital process innovation. Notably, digital transformation strategies act as a mediator between IT capabilities and digital innovation performance, facilitating organizational adaptation to digitalization. Moreover, organizational legitimacy moderates the relationship between digital transformation strategies and digital innovation performance, mitigating resistance and enhancing stakeholder support. Additionally, organizational legitimacy moderates the

mediation effect between IT capabilities, digital transformation strategies, and digital innovation performance, emphasizing the importance of aligning technological resources with strategic goals. Environmental dynamism exerts a significant moderating effect on the relationship between IT capabilities and digital process innovation performance but does not significantly affect the relationship between IT capabilities and digital product innovation performance. The COVID-19 outbreak has further heightened market uncertainty, influencing innovation performance. Finally, environmental dynamism impacts IT capabilities, digital transformation strategies, and digital innovation performance, underscoring the need for strategic flexibility and adaptation in the face of dynamic environments.

5.2 Management Insights

The advent of concepts like "Industry 4.0" and "smart factories" has catalyzed significant changes in the traditional manufacturing sector, including the integration of digital technologies and the emergence of service-oriented products. However, the transition to digitalization poses multifaceted challenges and opportunities for traditional manufacturing enterprises. Firstly, fostering robust IT capabilities is paramount for successful digital transformation and innovation. IT investments empower enterprises to navigate the digital landscape, driving efficiency gains and facilitating product and process innovation. Companies like Haier and Midea exemplify how strategic IT utilization can fuel leapfrog development. Secondly, effective IT governance is essential to align IT resources with strategic goals, ensuring optimal digital transformation outcomes. Traditional manufacturers must proactively manage digital resources, recognizing that competitive advantage now hinges on adeptly managing information technology. Thirdly, leveraging organizational legitimacy is vital to overcoming institutional hurdles and fostering stakeholder buy-in during digital transformation. Legitimacy not only bolsters internal morale but also assuages consumer skepticism, paving the way for successful innovation. Furthermore, environmental monitoring and agility are imperative for seizing digital opportunities and responding to dynamic market forces. COVID-19 underscored the importance of digital resilience, prompting firms to harness digital tools for remote operations and customer engagement. Lastly, while digital transformation is imperative, a phased approach is prudent. Given the complexity and risks involved, enterprises should prioritize process innovation before venturing into product innovation. Gradual adaptation ensures sustainable transformation aligned with organizational capacities and market demands.

5.3 Future Perspectives

This study delves into the intricate dynamics between information technology capabilities, digital transformation strategies, and digital innovation performance in traditional manufacturing enterprises, amalgamating internal and external factors. While significant strides have been made in digitalization research, numerous research avenues remain unexplored. Firstly, future research could unravel the role of organizational practices, corporate culture, and digital flexibility in shaping digital transformation strategies. Understanding how these factors influence organizational dynamics within a digital context is paramount for strategic management. Secondly, investigating how enterprises can optimize resource allocation across different stages of digital transformation is crucial. Tailoring resource orchestration to meet evolving digital needs could enhance organizational agility and competitiveness. Lastly, exploring the synergy between digital transformation and other organizational strategies is essential. Integrating digital initiatives with overarching organizational goals can foster holistic growth and sustained competitive advantage in traditional manufacturing enterprises.

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