Digital Technology Adoption and Supply Chain Resilience as Serial Mediators Between Firm Intellectual Capability and Performance in Shanxi Manufacturing SMEs: A Conceptual Framework

Wu Liang[1], Alex Hou Hong Ng[2]

[1,2] School of Business, Malaysia University of Science and Technology, Petaling Jaya, Selangor, Malaysia

ABSTRACT: This research examines the mediating effects of digital technology adoption and supply chain resilience on the relationship between firm intellectual capability and firm performance in small and medium-sized manufacturing enterprises in Shanxi, China. Grounded in Resource-Based Theory, this conceptual paper addresses significant gaps in understanding how manufacturing SMEs can utilise intellectual assets to improve performance via digital transformation and efficient supply chain strategies. The proposed framework integrates four key constructs—firm intellectual capability, digital technology adoption, supply chain resilience, and firm performance—and examines both direct and serial mediation effects. The research employs a quantitative, cross-sectional design, utilising structured data collection from 385 manufacturing SMEs in Shanxi Province. Measurement instruments draw on validated scales from prior studies, with data analysis conducted through SPSS version 29 and SmartPLS version 4 for structural equation modelling. The framework is grounded in a thorough review of over 35 empirical studies and employs Resource-Based Theory to clarify how valuable, rare, inimitable, and non-substitutable resources enable sustained performance improvements. The study contributes to strategic management literature by elucidating mechanisms through which intellectual resources provide competitive advantage in emerging economies, and offers practical guidance for SME managers and policymakers seeking to foster digital transformation and supply chain resilience as strategies for sustained competitive advantage.

KEY WORDS: Digital technology adoption, supply chain resilience, firm intellectual capability, firm performance, manufacturing SMEs, Resource-Based Theory, serial mediation, Shanxi Province.

1. INTRODUCTION

Maritime transport facilitates global trade, and so too does the manufacturing sector serve as a key driver of economic growth in emerging economies. Small and medium-sized enterprises are the backbone of China's economy, accounting for approximately 60% of gross domestic product, 80% of employment, and more than half of all tax revenues (Shi & Iqbal, 2020; Gu, 2024). In Shanxi Province, small and medium-sized manufacturing businesses face two significant challenges: keeping pace with the digital transformation while maintaining strength in a supply chain environment that is becoming increasingly unstable globally. The COVID-19 pandemic further revealed the vulnerability of traditional supply chain systems, compelling numerous SMEs to re-evaluate their technological integration and operational resilience strategies (Basit et al., 2024).

Despite substantial research investigating intellectual capital, digital technology, and supply chain management as distinct themes, there exists a paucity of studies examining the interplay of these factors in influencing SME performance, especially in China's

Digital Technology Adoption and Supply Chain Resilience as Serial Mediators Between Firm Intellectual Capability and Performance in Shanxi Manufacturing SMEs: A Conceptual Framework

inland regions such as Shanxi. Inland manufacturing hubs face different challenges from coastal provinces, including limited access to infrastructure, skilled workers, and stable supply chain networks (Sun, 2024). These regional differences underscore the importance of context-specific frameworks that reflect local realities.

Firm intellectual capability—comprising human, structural, and relational capital—constitutes a vital yet frequently underutilised resource for SMEs (Aljuboori et al., 2021). However, intellectual resources alone seldom ensure enhanced performance unless they are efficiently activated through complementary organisational mechanisms. Digital technology adoption can help by converting knowledge and skills into improved processes and innovative practices. At the same time, supply chain resilience enables a company to handle shocks, manage disruptions, and sustain its performance under adverse conditions (Chen et al., 2025).

The objective of this study is threefold: to examine the direct relationship between firm intellectual capability and firm performance; to investigate the individual mediating roles of digital technology adoption and supply chain resilience; and to propose and test a serial mediation framework in which digital technology adoption and supply chain resilience sequentially mediate the intellectual capability–performance relationship. The study focuses on manufacturing SMEs operating in Shanxi Province, China, drawing on validated measurement scales, a systematic literature review, and a quantitative research design with a planned sample of 385 respondents.

2. LITERATURE REVIEW

Resource-Based Theory as Theoretical Foundation

The Resource-Based Theory asserts that companies obtain enduring competitive advantage by acquiring and strategically utilising resources that are valuable, rare, inimitable, and non-substitutable (Barney, 1991). In this context, intellectual capabilities—comprising tacit knowledge, organisational routines, and relational networks—are regarded as strategic assets that are challenging for competitors to imitate (Martín-De-Castro et al., 2011). However, merely possessing these resources is insufficient. Companies also need to build dynamic capabilities that allow them to reconfigure their resources as the environment changes (Teece, 2007). Digital technology adoption and supply chain resilience are two important organisational capabilities that can convert intellectual resources into improved performance outcomes. Digital technologies help businesses identify new market opportunities faster, streamline internal processes, and transform business models (Helfat et al., 2023). Supply chain resilience reflects how well a company can anticipate, manage, and recover from disruptions, ensuring operational continuity and learning from past challenges (Ding et al., 2024).

Firm Intellectual Capability and Performance

Firm intellectual capability is generally understood as a multidimensional construct comprising human capital, structural capital, and relational capital. Human capital refers to employees' skills, creativity, and attitudes; structural capital encompasses an organisation's processes, databases, and intellectual property; and relational capital reflects the quality of relationships with customers, suppliers, and other external stakeholders (Chen et al., 2004). A large body of empirical evidence supports a positive association between intellectual capital and firm performance across various industries (Jikhan et al., 2023). In particular, human and structural capital have been found to exert strong effects in manufacturing contexts, where knowledge sharing, process efficiency, and innovation play critical roles (Liu et al., 2022). However, the strength of this relationship can differ depending on contextual factors. For instance, in Chinese agricultural enterprises, financial efficiency and capital utilisation tend to have a stronger influence on performance than human capital (Gao et al., 2024), whereas research on Indonesian manufacturing firms reveals that all three dimensions of intellectual capital significantly enhance firm outcomes (Cahyono & Ardianto, 2024).

Digital Technology Adoption as First Mediator

Digital technology adoption refers to the integration of advanced digital tools and systems—such as artificial intelligence, the Internet of Things, big data analytics, and cloud computing—into organisational processes (Yang et al., 2021). For manufacturing SMEs, adopting these technologies enables conversion of intellectual capabilities into tangible operational and strategic benefits through several mechanisms: enhancing human decision-making via data-driven insights; formalising tacit knowledge into structured systems and processes; and strengthening relational capital through digital platforms that improve collaboration and communication (Bhatti et al., 2024). Studies in European manufacturing contexts show that digitalisation can lead to major innovations in products, services, and processes, particularly within traditionally low-tech industries (Blichfeldt & Faullant, 2021). Similarly, Chinese firms report that digital tools improve both operational efficiency and sustainability outcomes (Li et al., 2022). Within the Resource-Based Theory framework, digital technology acts as a capability-enhancing bridge between intellectual resources and firm performance, serving as a critical first mediator.

Supply Chain Resilience as Second Mediator

Supply chain resilience refers to an organisation's capacity to anticipate, adapt to, respond to, recover from, and learn from disruptions that threaten operational continuity (Ding et al., 2024). A resilient supply chain not only mitigates the impact of unexpected events but also transforms vulnerabilities into strategic strengths (Tufan et al., 2024). In Ghanaian manufacturing firms,

resilience significantly improves operational and financial outcomes, with agility emerging as the most influential factor (Hamidu et al., 2023). Studies of Chinese automotive enterprises show that resilience mediates the relationship between digital innovation and business performance (Chen et al., 2025). Evidence from Swiss manufacturing firms further highlights the value of proactive resilience strategies in enhancing long-term organisational effectiveness (Meier, 2024). From a Resource-Based Theory perspective, supply chain resilience represents a dynamic capability that complements and extends the value of intellectual and digital resources, functioning as the second mediator linking intellectual capability to firm performance.

Serial Mediation Framework and Research Gaps

Although previous research has considered the independent mediating effects of digital technology adoption and supply chain resilience, relatively few studies have examined their serial mediation. Empirical evidence from the Chinese automotive industry shows that digital technologies enhance firm performance by reinforcing supply chain resilience (Chen et al., 2025). Meta-analyses indicate the positive influence of big data on organisational success through innovation capability and logistic operations (Kumar & Raj, 2024). Research on Pakistani manufacturing firms also confirms that digital technologies enhance resilience in times of crisis while enabling greater supply chain integration and coordination (Basit et al., 2024). Despite growing research, three important gaps remain: the majority of studies focus on direct relationships without thoroughly investigating mediation mechanisms; research disproportionately emphasises coastal Chinese regions or developed economies, overlooking inland manufacturing centres such as Shanxi; and serial mediation frameworks combining intellectual capability, digital adoption, and supply chain resilience remain theoretically underdeveloped.

Based on Resource-Based Theory and systematic literature review, this study proposes a conceptual framework (Figure 1) hypothesising the serial mediation pathway.
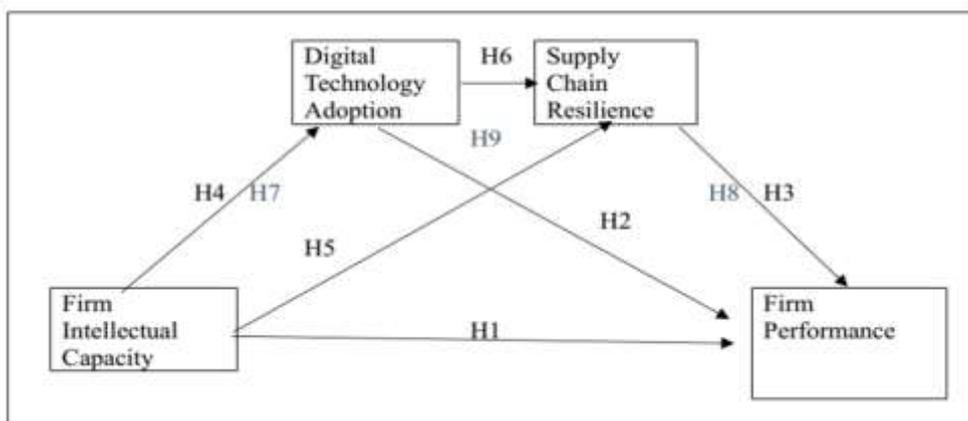

Figure 1: Proposed Conceptual Framework
Source: Authors

3. METHODOLOGY

A quantitative, cross-sectional research design was adopted for this study. Online surveys were directed at manufacturing SMEs in Shanxi Province, China. The population comprises 72,427 registered manufacturing companies (Dnb.com, 2025). The sample size was calculated using Krejcie and Morgan's (1970) formula, which indicated that 382 to 385 respondents were needed. Convenience sampling via online platforms facilitates efficient data collection while ensuring representativeness across industry sub-sectors.

Measurement instruments employ scales that have been validated in prior studies. Firm intellectual capability is measured using Chen et al.'s (2004) three-dimensional scale, encompassing employee competence, attitude, and creativity. Digital technology adoption employs Özşahin et al.'s (2022) organisational innovativeness scale, encompassing behavioural, product, process, market, and strategic dimensions. Supply chain resilience utilises Ding et al.'s (2024) five-capability framework: anticipate, adapt, respond, recover, and learn. Firm performance is measured using the competitive performance indicators developed by Vandenbosch (1999) and Garengo et al. (2005).

Data analysis proceeds in two stages. SPSS version 29 performs initial analyses including descriptive statistics, reliability testing (Cronbach's alpha), and correlation analysis. SmartPLS version 4 conducts structural equation modelling (SEM) to test direct effects, individual mediation, and serial mediation paths. SmartPLS is selected for its suitability with complex models, small to medium-sized samples, and exploratory research designs (Sarker et al., 2024). A pilot study (n = 40) confirms the reliability and clarity of the instrument, with Cronbach's alpha coefficients exceeding the 0.70 threshold for all constructs. Ethical considerations encompass informed consent, data anonymity, voluntary participation, and secure data storage in accordance with institutional research ethics standards.

Digital Technology Adoption and Supply Chain Resilience as Serial Mediators Between Firm Intellectual Capability and Performance in Shanxi Manufacturing SMEs: A Conceptual Framework

4. RESULTS AND ANALYSIS

As a conceptual paper, this study does not present primary empirical data. The proposed serial mediation framework—firm intellectual capability → digital technology adoption → supply chain resilience → firm performance—is derived from a systematic review of over 35 empirical studies. The framework yields the following propositions grounded in the reviewed literature.

First, firm intellectual capability is expected to have a direct positive effect on firm performance, consistent with findings across multiple industries and national contexts (Jikhan et al., 2023; Liu et al., 2022; Cahyono & Ardianto, 2024). Second, digital technology adoption is expected to mediate the relationship between firm intellectual capability and firm performance, as supported by evidence from European and Chinese manufacturing contexts (Blichfeldt & Faullant, 2021; Li et al., 2022). Third, supply chain resilience is expected to mediate the relationship between digital technology adoption and firm performance, consistent with findings from Ghanaian, Chinese, and Swiss manufacturing studies (Hamidu et al., 2023; Chen et al., 2025; Meier, 2024). Fourth, the serial mediation pathway—through digital technology adoption and then supply chain resilience—is expected to represent a significant indirect effect linking firm intellectual capability to firm performance (Chen et al., 2025; Kumar & Raj, 2024; Basit et al., 2024).

Table 1: Summary of Hypothesised Relationships

H	Hypothesised Relationship	Supporting Evidence
H1	FIC → FP (Direct positive effect)	Jikhan et al. (2023); Liu et al. (2022)
H2	FIC → DTA → FP (DTA mediates)	Blichfeldt & Faullant (2021); Li et al. (2022)
H3	DTA → SCR → FP (SCR mediates)	Hamidu et al. (2023); Chen et al. (2025)
H4	FIC → DTA → SCR → FP (Serial mediation)	Chen et al. (2025); Kumar & Raj (2024)

Source: Authors

These propositions will be empirically tested in a subsequent phase of data collection and structural equation modelling analysis using the 385-respondent sample from Shanxi Province manufacturing SMEs.

5. DISCUSSION

The proposed framework makes several contributions to the strategic management literature. It extends the application of Resource-Based Theory by demonstrating how successive capability-building processes can transform intellectual assets into performance outcomes. The serial mediation paradigm advances understanding beyond simple resource–performance links by illustrating how SMEs coordinate resources through sequential steps. By integrating digital technology and supply chain perspectives, the framework contributes to the expanding body of research on digital transformation and operational resilience in resource-constrained environments.

From a practical standpoint, the findings are expected to help SME managers make informed decisions about resource allocation. Investing in employee training and knowledge management may yield greater returns when combined with digital technology initiatives and supply chain resilience projects. Managers should focus on building absorptive capacity—the ability to recognise, assimilate, and apply external knowledge—to maximise the benefits of digital technology adoption.

Policymakers can utilise the framework to design targeted support programmes. Recommendations include establishing digital transformation centres offering technical training, creating supplier collaboration platforms that enhance resilience, and providing financial incentives for technology adoption. Regional policies should address infrastructure deficiencies that hinder digital technology adoption in inland provinces.

Several limitations should be acknowledged. First, the cross-sectional design limits causal inference; longitudinal studies would provide stronger evidence of the proposed mediation pathways. Second, the focus on Shanxi Province may limit generalisability to other Chinese provinces or emerging economies. Third, convenience sampling may introduce selection bias. Fourth, as a conceptual paper, the framework awaits empirical validation. Future research should test the proposed model using the planned quantitative data collection, explore moderating variables such as firm size and industry sub-sector, and extend the framework to other inland Chinese provinces or comparable emerging-economy contexts.

6. RECOMMENDATIONS

SME managers should prioritise integrated capability development. Investment in employee training and knowledge management programmes should be systematically combined with digital technology adoption initiatives and supply chain resilience projects. Managers should focus on building absorptive capacity to maximise the conversion of intellectual resources into operational and strategic advantages. Digital transformation should be approached incrementally, beginning with core process digitalisation before advancing to more sophisticated tools such as artificial intelligence and predictive analytics.

Policymakers and regional development agencies should design targeted support programmes for inland manufacturing hubs. Recommendations include establishing digital transformation centres offering technical training and advisory services, creating supplier collaboration platforms that enhance resilience across supply chain networks, and providing financial incentives for technology adoption. Regional policies should address the infrastructure deficiencies that hinder digital technology adoption in inland provinces such as Shanxi.

Future researchers should empirically validate the proposed serial mediation framework using the planned quantitative data collection from 385 Shanxi manufacturing SMEs. Longitudinal research designs would strengthen causal inference. Comparative studies across multiple Chinese provinces and other emerging economies would enhance the generalisability of the framework. Moderating variables such as firm size, industry sub-sector, and ownership structure should be explored.

7. CONCLUSION

This conceptual paper establishes a comprehensive framework examining how manufacturing SMEs in Shanxi, China, might leverage intellectual capabilities to enhance performance through the integration of digital technologies and the strengthening of supply chain resilience. Grounded in Resource-Based Theory, the study posits that intellectual capabilities alone are insufficient; they require complementary organisational capabilities to transform knowledge assets into operational advantages and competitive positioning. The proposed serial mediation mechanism—intellectual capability → digital adoption → supply chain resilience → performance—provides a nuanced understanding of how resources are orchestrated in small and medium-sized enterprises in emerging markets. By clarifying these pathways, the study offers theoretical insights into the development of dynamic capabilities and practical guidance for managers and policymakers seeking to enhance the competitiveness and sustainability of SMEs. As manufacturing SMEs navigate the post-pandemic landscape characterised by digital disruption and supply chain instability, comprehending these integrative relationships becomes increasingly essential. This study lays the groundwork for empirical investigation, ultimately guiding evidence-based strategies that empower SMEs to thrive in dynamic contexts through the strategic enhancement of intellectual capabilities, systematic technology integration, and proactive resilience development.

ACKNOWLEDGEMENTS

REFERENCES

1. Aljuboori, Z. M., Singh, H., Haddad, H., Al-Ramahi, N. M., & Ali, M. A. (2021). Intellectual capital and firm performance correlation: The mediation role of innovation capability in Malaysian manufacturing SMEs perspective. Sustainability, 14(1), 154.
2. Barney, J. (1991). Firm resources and sustained competitive advantage. Journal of Management, 17(1), 99–120.
3. Basit, A., Wang, L., Javed, A., Shoaib, M., & Aslam, M. U. (2024). Investigating digital technologies' effect on firm resilience during COVID-19. International Journal of Operations & Production Management.
4. Bhatti, S. H., Sumbal, M. S., Ahmed, A., & Golgeci, I. (2024). Digital strategy and firm performance: Examining mediation of digital platform capabilities and culture. Technological Forecasting and Social Change, 198, 123026.
5. Blichfeldt, H., & Faullant, R. (2021). Performance effects of digital technology adoption and product & service innovation – A process-industry perspective. Technovation, 105, 102275.
6. Cahyono, S., & Ardianto, A. (2024). Intellectual capital and firm performance in Indonesian non-financial firms. Journal of Intellectual Capital, 25(2), 445–468.
7. Chen, J., Zhu, Z., & Xie, H. (2004). Measuring intellectual capital: A new model and empirical study. Journal of Intellectual Capital, 5(1), 195–212.
8. Chen, X., Sun, C., & Wang, F. (2025). Digital technology innovation and enterprise performance: Supply chain resilience mediation. Supply Chain Management Review, 30(1), 112–128.
9. Ding, B., Yang, X., Gao, T., Liu, Z., & Sun, Q. (2024). Confirmation of a measurement model for hospital supply chain resilience. Frontiers in Public Health, 12, 1369391.
10. Dnb.com. (2025). Business directory: Manufacturing companies in Shanxi, China. Retrieved January 13, 2025, from https://www.dnb.com/business-directory/company-information.manufacturing.cn.shanxi.html
11. Gao, Y., Tian, X., & Xu, J. (2024). Intellectual capital and financial performance: Board diversity's moderating role in Chinese agricultural firms. Agricultural Economics, 55(3), 421–439.
12. Garengo, P., Biazzo, S., & Bititci, U. (2005). Performance measurement systems in SMEs: A review for a research agenda. International Journal of Management Reviews, 7(1), 25–47.
13. Gu, Z. (2024). A comparative analysis of financing channels for small and medium-sized enterprises (SMEs). Highlights in Business, Economics and Management, 25, 134–145.

14. Hamidu, Z., Boachie-Mensah, F., & Issau, K. (2023). Supply chain resilience and performance of manufacturing firms: Role of supply chain disruption. Journal of Manufacturing Technology Management, 34(5), 898–921.
15. Helfat, C. E., Kaul, A., Ketchen, D. J., Jr., Barney, J. B., Chatain, O., & Singh, H. (2023). Renewing the resource-based view: New contexts, new concepts, and new methods. Strategic Management Journal, 44(6), 1357–1390.
16. Jikhan, F., Muftiadi, A., & Alexandri, M. (2023). The effect of intellectual capital on firm performance: A state of the art. Jurnal Ilmiah Akuntansi dan Bisnis, 18(2), 245–268.
17. Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. Educational and Psychological Measurement, 30(3), 607–610.
18. Kumar, R. R., & Raj, A. (2024). Big data adoption and organisational performance: Innovation and supply chain integration mediation. International Journal of Production Economics, 268, 109112.
19. Li, X., Wu, T., Zhang, H., & Yang, D. (2022). Digital technology adoption and sustainable development performance of strategic emerging industries. Journal of Organizational and End User Computing, 34(9), 1–23.
20. Liu, L., Zhang, J., Xu, J., & Wang, Y. (2022). Intellectual capital and financial performance of Chinese manufacturing SMEs: An analysis from different industry types. Sustainability, 14(17), 10657.
21. Martín-De-Castro, G., Delgado-Verde, M., López-Sáez, P., & Navas-López, J. (2011). Towards 'An intellectual capital-based view of the firm': Origins and nature. Journal of Business Ethics, 98(4), 649–662.
22. Meier, J. (2024). Supply chain resilience in Swiss manufacturing: Proactive measures and firm performance. Operations Management Research, 17(2), 334–351.
23. Özşahin, M., Çallı, B., & Coskun, E. (2022). ICT adoption scale development for SMEs. Sustainability, 14(22), 14897.
24. Sarker, B., Sarker, D., Shaha, S., Saha, D., & Sarker, S. (2024). Why apply SPSS, SmartPLS and AMOS: An essential quantitative data analysis tool for business research. International Journal of Research and Innovation in Social Science, 8(9), 1764–1781.
25. Sharabati, A. A., Ali, A. A. A., Allahham, M., Hussein, A. M. A., Alheet, A. F., & Mohammad, A. S. (2024). The impact of digital marketing on SME performance. Sustainability, 16(19), 8667.
26. Shi, X., & Iqbal, Q. (2020). Chinese SMEs in Industry 4.0. In Research anthology on cross-industry challenges of Industry 4.0 (pp. 1242–1265). IGI Global.
27. Sun, J. (2024). Research on the development of digital economy in Shanxi Province in the era of artificial intelligence. Journal of Electrical Systems, 20(3), 1648–1662.
28. Teece, D. J. (2007). Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. Strategic Management Journal, 28(13), 1319–1350.
29. Tufan, C., Çiğdem, Ş., Kılıç, Y., & Sayar, G. (2024). Agility and resilience in supply chains: Investigating their roles in enhancing financial performance. Sustainability, 16(17), 7842.
30. Vandenbosch, B. (1999). An empirical analysis of the association between the use of executive support systems and perceived organisational competitiveness. Accounting, Organizations and Society, 24(1), 77–92.
31. Yang, M., Fu, M., & Zhang, Z. (2021). The adoption of digital technologies in supply chains: Drivers, process and impact. Technological Forecasting and Social Change, 169, 120795.