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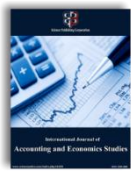

Digital Transformation, Technology Innovation, and Organizational Resilience in Manufacturing Firms: Empirical Evidence from Chinese Listed Companies

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Abstract

Based on the panel data of 1,154 listed manufacturing companies in China from 2013 to 2023, this study studies the impact of digital transformation in China's manufacturing industry on the organizational resilience of enterprises and further reveals the mediating effect of technological innovation and the moderating effect of supply chain concentration. The study found that the digital transformation of enterprises has a significant effect on improving organizational resilience, technological innovation plays a partial mediating role between digital transformation and organizational resilience, and supply chain concentration has a moderating effect. Heterogeneity analysis shows that the role of digital transformation in promoting organizational resilience is more significant in non-state-owned enterprises and small-scale enterprises. This study provides an evidence-based framework for listed manufacturing companies, which is conducive to guiding management actions and policy-making in these companies.

Keywords: *Digital Transformation; Organizational Resilience; Manufacturing Enterprises; Chinese Economy.*

1. Introduction

Over the past decade, digital transformation has evolved into a key strategy for businesses striving to boost operational effectiveness and performance in an increasingly turbulent global market. It enables enterprises to optimize resource allocation, accelerate innovation, and adapt to dynamic environments using technology like artificial intelligence. The Chinese government recognizes the strategic significance of digital transformation and has identified it as a key driver of economic and social development. It has introduced a series of policies to create favorable external conditions and provide resource support for enterprises.

China's manufacturing digitization shares common ground with global trends while also exhibiting unique characteristics driven by its specific economic and institutional context. Compared to EU firms prioritizing sustainability digitization (Daoud et al., 2025), Chinese enterprises emphasize supply chain resilience enhancement. In addition, emerging economies like India share similar patterns of SME digital adoption. However, China's landscape is shaped by the significant presence of state-owned enterprises (SOEs), which operate under distinct institutional constraints. Digital transformation in Chinese SOEs focuses more on stability results compared to non-state-owned enterprises (Shi et al., 2024). This is due to external regulatory bodies, laws, or industry regulations. Therefore, while SMEs in other emerging economies may have more flexibility in their digital adoption strategies, Chinese SOEs must navigate a more complex set of institutional pressures and internal challenges (Liu et al., 2024).

However, digital transformation offers growth and efficiency potential; it also brings obstacles such as technological barriers, organizational inertia, and resource constraints. Given the intricate operational environment and the increasingly entwined digital economy, key questions arise: How does digital transformation affect organizational resilience? What are the mechanisms and pathways behind it? Are there differentiated strategies and results under different market conditions and competitive landscapes?

Organizational resilience—the ability of an organization to quickly adapt, recover, and turn adversity into opportunities(Barton and Kahn, 2018)—consists of two key dimensions: stability (the ability to withstand risks and continue to develop) and flexibility (the agility to respond to disruptions) (Bothello et al.,2017; Williams et al.,2017). Resilience is an essential characteristic that allows businesses to withstand crises and transform them into opportunities in the current dynamic, unpredictable, and unclear environment(Bhamra et al.,2011). This is particularly important for Chinese manufacturing enterprises, as they are increasingly affected by global geopolitical tensions (e.g., US-China technological decoupling, Russia-Ukraine conflict) and ongoing supply chain restructuring. To this end, many enterprises are actively pursuing sustainable development through advanced manufacturing strategies, including intelligent, green, and high-end production methods (Shan et al.,2021). Existing research on organizational resilience mechanisms mainly focuses on external environmental factors, such as digital technology (Abidi et al.,2025; Copestake et al.,2024), digital transformation(Baiyere et al.,2020; Browder et al.,2023;

Li,P. et al.,2025), ESG performance (Wang,2024; Han et al.,2024), and environmental uncertainty (Lavarda and Leite,2022), and internal characteristics, such as slack resources(Tognazzo et al.,2016). Theoretical perspectives such as the resource-based view, dynamic capability theory, and stakeholder theory provide valuable frameworks for analyzing how digital transformation affects resilience (Nadeem et al.,2024; Mishra et al.,2024; Linnenluecke,2017). However, empirical evidence remains limited, particularly when it comes to manufacturing enterprises. Understanding how enterprises balance innovation vitality and resilience during digital transformation is a topic of considerable academic and practical importance, yet there is a substantial research deficit in this area.

Against this backdrop, this study explores two core research questions: (1) What role does digital transformation play in enhancing the organizational resilience of Chinese manufacturing enterprises? (2) Through what specific channels does digital transformation affect organizational resilience? Based on panel data of 1,154 listed manufacturing enterprises in China's A-share market from 2013 to 2023, this study explores how digital transformation drives organizational resilience through technological innovation and examines the moderating role of supply chain concentration.

This study has three contributions: First, this study conceptualizes organizational resilience from a long-term perspective, distinguishes between volatility and growth dimensions, and empirically analyzes how digital transformation enhances the resilience of Chinese manufacturing enterprises, thus responding to the ongoing debate on whether digital transformation enhances or weakens organizational resilience. Second, this study incorporates technological innovation into the analytical framework and identifies its mediating role in the relationship between digital transformation and resilience, thus enriching the research literature on the antecedent factors of organizational resilience and its formation mechanism. Finally, this study explores the boundary conditions under which digital transformation affects resilience from the perspective of supply chain relationship governance. It also uses a robust empirical approach to explore heterogeneity across industries, ownership structures, and regions.

2. Literature review and research hypotheses

2.1. Digital transformation and organizational resilience

In the era of the digital economy, the relationship between enterprise digital transformation and organizational resilience has attracted growing academic interest. Grounded in dynamic capability theory, digital transformation systematically enhances organizational resilience across three stages—crisis anticipation, rapid response, and post-crisis recovery—by reconfiguring resource portfolios, optimizing business processes, and strengthening adaptive capacities(Conz and Magnani, 2020). As such, digital transformation has become a core driver of organizational resilience in uncertain along changing contexts (Crespo et al.,2025). Digital innovation significantly enhances resilience, allowing manufacturers to respond efficiently to market volatility and operational challenges（Fanani et al.,2024).

Organizational resilience typically unfolds in three phases: pre-adversity, during adversity, and post-adversity. In the pre-adversity phase, the integration of digital technologies facilitates the development of agile business models, improves market foresight, and enhances financial stability (Sajko et al.,2020; Duchek et al.,2020), thereby increasing risk resistance. Li et al(2025) indicate that digital transformation significantly improves early warning capabilities and financial redundancy in listed firms through process digitization and decision-making based on data. During the adversity phase, digital transformation promotes organizational agility by enabling rapid resource reallocation in response to environmental disruptions. Zhang and Hu(2023) found that manufacturing firms maintained production continuity during public health crises by utilizing digital tools to optimize supply chain collaboration. In the post-adversity phase, digital transformation facilitates the integration of resources and organizational learning through ambidextrous innovation—both exploratory and exploitative (Tarigan et al., 2025). For example, a case in point is a cosmetics company that successfully adjusted its marketing strategies and achieved post-crisis recovery by utilizing digital customer behavior analytics.

Therefore, digital transformation significantly enhances organizational resilience (Marie et al.,2024). This transformation empowers businesses to better navigate environmental uncertainties and intensify market competition (Nur et al.,2024). By adopting emerging technologies such as artificial intelligence, big data, blockchain, and the Internet of Things, companies can achieve more efficient operations, flexible supply chain management, and faster market responsiveness (Abbaraju et al.,2025). For instance, through digital transformation, enterprises can improve supply chain transparency and response speed, thereby strengthening supply chain resilience (Tarigan et al., 2025). Emerging studies indicate that digital transformation positively influences organizational resilience's development (adaptability enhancement) and stability (volatility mitigation) aspects(Tasic et al., 2019; Nelsa et al., 2025). On the one hand, it stabilizes stock returns by reducing volatility (Sajko et al., 2020; School et al., 2024). Through the utilization of digital technologies to mine unstructured data, improve decision-making processes, and reinforce internal controls and corporate governance, firms are better able to mitigate external uncertainties and accelerate recovery(Zhang and Hu,2023). On the other hand, digital transformation drives long-term growth by lowering production costs, scaling operations, and extending value chains(Duchek,2020; Cardoso et al., 2025). The codification of tacit production knowledge into structured data enhances automation and system synergy, thereby cultivating sustained competitive advantages even amid external shocks (Dhyanasaridewi et al., 2024). Therefore, this study put forward Hypothesis 1.

Hypothesis 1 (H1). Digital transformation has a positive effect on the organizational resilience of manufacturing enterprises.

H1a: Digital transformation reduces stock price volatility, reflecting improved stability.

H1b: Digital transformation sustains high-performance growth, reflecting enhanced flexibility.

2.2. The mediating role of technological innovation

Digital transformation and organizational resilience stand as two pivotal challenges confronting modern enterprises. Technological innovation serves as a crucial mediator between these two aspects, driving both performance enhancement and strategic flexibility(Guennoun et al., 2024). Digital transformation emphasizes leveraging digital technologies to reshape operational models and business processes, while organizational resilience focuses on an organization's capacity to adapt and recover from external shocks (Li et al., 2024). By translating the potential of digital transformation into tangible organizational resilience, technological innovation empowers businesses to better navigate uncertainties and risks.

Recent studies have increasingly explored ambidextrous innovation—encompassing both exploratory and exploitative forms—as a mediating mechanism through which digital transformation enhances resilience (Chen and Liu,2011; Talwar et al.,2024). Research validated the mediating role of ambidextrous innovation using large-scale survey data, showing that digital transformation positively influences resilience through both innovation types(Carugati et al., 2020). Empirical evidence highlighted that open innovation (e.g., patent collaboration networks) is a key pathway through which digital platforms facilitate cross-organizational knowledge flows, thereby improving

market adaptability and risk resistance (Guennoun et al., 2024). Recent research has highlighted that IT infrastructure can amplify the innovation-enhancing effects of digital transformation. By boosting innovation efficiency, this in turn indirectly promotes organizational resilience (Chen and Liu,2011). Additionally, big data analytics have been shown to considerably enhance supply chain resilience (Carugati et al., 2020; Fornasiero et al., 2024). Enterprises can become more flexible through open innovation and digital platforms, thereby maintaining a leading position in the highly competitive market (Talwar & Sinha, 2024).

Technological innovation strengthens organizational resilience in multiple ways. First, Digital transformation improves corporate dynamic capabilities through technological innovation (Zhan & Li, 2024). Dynamic capability refers to an organization's ability to integrate, build, and reconfigure internal and external resources to adapt to rapidly changing environments. Technological innovation serves as a key driver in achieving these capabilities. For instance, big data analytics can help businesses better understand market trends and customer needs, enabling them to make more informed decisions (Yoshikuni et al., 2024). Secondly, technological innovation enhances organizational resilience by promoting knowledge management (Aljehani et al., 2024). Knowledge management encompasses the acquisition, storage, sharing, and application of knowledge. Digital platforms facilitate cross-organizational knowledge flow, thereby strengthening market adaptability and risk resistance capabilities (Talwar & Sinha, 2024). Third, technological innovation directly supports enterprises' innovative activities, including exploratory innovation and exploitative innovation (Wang & Yan, 2024). Exploratory innovation involves developing new products, services, and processes, while exploitative innovation focuses on improving existing ones. Technological innovation provides the technical foundation and tools for both types of innovation (Wang et al., 2024).In addition, technological innovation can also help enterprises better respond to crises and challenges, such as developing new solutions to solve supply chain disruptions or changes in market demand (Fornasiero et al., 2024).

Several studies indicate that digital transformation significantly impacts the resilience of manufacturing enterprises (Zhan & Li, 2024). By adopting advanced digital technologies, manufacturers can enhance production efficiency, reduce costs, improve product quality, and better adapt to market changes and uncertainties. From a resource-based theory standpoint, digital technologies enable the integration of internal and external resources (e.g., data assets, supply chain networks), positioning technological innovation as a critical conduit linking digital transformation and resilience outcomes (Sun et al.,2025). Empirical evidence from China's manufacturing sector shows that digital transformation supports both short-term survival and long-term adaptability through ambidextrous innovation (Garrido-Moreno et al.,2024). Furthermore, enterprises can become more flexible through open innovation and digital platforms to maintain a leading position in the highly competitive market (Talwar & Sinha, 2024).

Hypothesis 2 (H2). Technological innovation mediates the relationship between digital transformation and organizational resilience.

2.3. The moderating role of supply chain concentration

Supply chain concentration (SCC)—defined as the degree of dependency on specific suppliers or customers—has emerged as a critical moderating variable in the digital transformation–resilience relationship(Lanier et al.,2020). At moderate levels, SCC can enhance supply chain efficiency through economies of scale, coordination, and value co-creation (Zhu et al.,2024). However, excessive SCC may reduce flexibility, hinder innovation, and weaken resilience due to over-reliance on a limited number of partners and increased governance complexity (Fan and He,2023). Existing literature suggests a nonlinear moderating effect: while moderate SCC fosters resource complementarity, high levels of concentration tend to introduce rigidity and suppress innovation (Jafari et al.,2022).

Recent studies found that supplier concentration positively moderates the link between digital transformation and firm performance in manufacturing(Fan and He,2023). Conversely, high SCC can exacerbate data silos and conflicts of interest, thereby stifling open innovation and diminishing resilience. Furthermore, the moderating effect of SCC may vary depending on industry dynamism. In highly dynamic sectors such as electronics, the growth-inhibiting effects of SCC are more pronounced due to rapid technological change and heightened competitive pressures.

Therefore, supply chain concentration brings a series of complex challenges and opportunities. There are also conflicting views on how supply chain concentration affects organizational resilience. The moderating role of Supply Chain Concentration (SCC) is typically nonlinear (Liu et al., 2024). While moderate SCC can promote resource complementarity and efficiency, high levels of concentration often introduce rigidity and inhibit innovation (Sharma et al., 2024). Digital transformation provides tools and strategies to manage SCC risks, but their effectiveness depends on industry vitality and specific implementation methods. To address these complexities, companies must adopt holistic approaches that consider diversity, visibility, collaboration, and proactive risk management, while also paying attention to broader economic and policy environments (Cheng et al., 2024).

Hypothesis 3 (H3). Supply chain concentration moderates the relationship between digital transformation and organizational resilience (volatility/growth).

H3a: SCC negatively moderates the digital transformation-volatility link, but only at low-to-moderate SCC levels.

H3b: SCC attenuates the digital transformation-growth link, with effects contingent on industry dynamism.

Building upon this theoretical framework, the present study investigates the mechanisms through which digital transformation enhances organizational resilience. Specifically, it introduces technological innovation as a mediating variable and supply chain concentration as a moderating variable to construct a comprehensive analytical model (as illustrated in Figure 1).

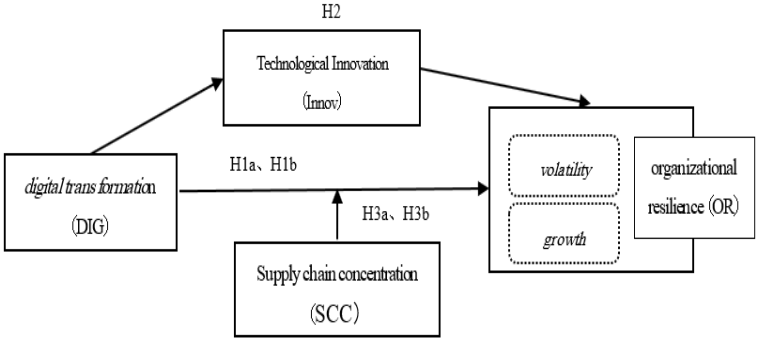

Fig. 1: Conceptual Framework.

Figure 1 formalizes the theoretical framework, delineating three constitutive mechanisms that collectively explicate how digital transformation (DIG) engenders organizational resilience (OR):

1) Core Relationships: Direct Effects (Hypothesized Paths H1a/H1b): DIG → Stock return volatility (negative path) and DIG → Sales growth sustainability (positive path). Volatility and growth constitute the dual dimensions of OR.
2) Mediation Pathway (Hypothesized Path H2): DIG Technological Innovation (Innov) → Resilience (OR). Theoretical Significance: Positions innovation as the generative mechanism translating digital capabilities into resilience outcomes.
3) Moderation Mechanism (Hypothesized Paths H3a/H3b): Supply Chain Concentration (SCC) moderates the effects of DIG on both dimensions of OR.Critical Annotation.

3. Methodology

3.1. Model specification

This study selected 1,154 manufacturing companies in China's Shanghai and Shenzhen A-shares from 2013 to 2023 as research samples. The reason for selecting them as samples is that these companies started digital transformation earlier, invested more, and had more active digital transformation activities. This study filtered and processed the data using the operations:

1) Eliminate ST and *ST enterprise data.
2) Eliminate samples with major missing key data.
3) Eliminate samples with abnormal data.
4) To control the impact of extreme values, the data was shrunk by 1% up and down. Finally, 12,694 observations were obtained. In addition, the data are all from the CSMAR.

3.2. Variable setting

3.2.1. Independent variable: digital transformation (DIG)

At present, it is still challenging to accurately describe the degree of digital transformation of enterprises. This paper draws on the structured feature word graph proposed by Wu et al. (2021) and uses the frequency of the keyword "digital transformation" in the annual reports of listed companies to construct a digital transformation index. The methodology follows these steps: First, all sample companies 'annual reports were organized and converted into plain text format. Second, drawing from Wu Fei et al.'s (2021) research, we constructed seed terms for digital transformation across three dimensions—strategy, technology, and practice. Using corpora from the "2020 China Enterprise Digital Transformation Research Report," "Special Action Plan for SME Digital Empowerment," and recent Government Work Reports, we expanded these seed terms to establish a dictionary of key digital transformation keywords. These were then matched with textual content to form a comprehensive digital transformation feature lexicon. Finally, Python programming was employed to segment and extract digital transformation-related lexical elements from annual reports, with word counts calculated for each term's occurrence. In addition, since word frequency data has a typical "right-biased" feature, this paper uses the natural logarithm of the total word frequency plus 1 to measure the digital transformation of enterprises.

Digital transformation is a multifaceted process that involves changes to business models, processes, and organisational culture (Nadkarni & Prügl, 2020). Although keyword frequency analysis provides a scalable metric for quantifying digital transformation efforts, it may overlook qualitative dimensions.Keyword frequency reduces this complexity to a single number, failing to capture the strategic depth or innovative nature of the changes (Kao et al., 2024). For instance, a company might mention "artificial intelligence" frequently in its annual report but only be using AI for basic automation tasks, such as robotic process automation (RPA) in back-office functions. This contrasts sharply with another company that mentions AI less often but has deeply integrated machine learning into its core product offerings, customer service, and decision-making processes. The keyword frequency metric would not distinguish between these scenarios, even though the latter reflects a more profound digital transformation. Future studies could combine text analysis with primary data (e.g., case studies, technology audit scores) to capture implementation maturity."

3.2.2. Dependent variable: organizational resilience (OR)

This paper refers to the measurement method of ORTIZ-DE-MANDOJANA and BANSAL and measures it by mining public financial data. This paper explains organizational resilience through two dimensions: financial volatility and performance growth. Among them, financial volatility is measured by the standard deviation of the monthly stock returns of the enterprise; performance growth ability is measured by the accumulation of net sales growth over three years. Finally, the entropy method is used to comprehensively calculate the organizational resilience variable.

3.2.3. Mediating variable: technological innovation (Innov)

Due to the tendency of manufacturing enterprises to invest in technological R&D and the availability of data on the amount of R&D investment, this article refers to the approach of Yin et al. (2025) and measures enterprise technological innovation by the logarithm of enterprise R&D expenditure. The larger the value, the higher the level of enterprise technological innovation.

3.2.4. Moderating variable: supply chain concentration (SCC)

The concentration of a company's supply chain is affected by the scale and stability of its business with upstream and downstream companies. The larger and more stable the business scale of both parties, the higher the concentration of the supply chain. This paper uses the average of the purchase amount and sales share of the top five suppliers and the top five customers to measure the concentration of a company's supply chain.

3.2.5. Control variables

This paper selects enterprise size (Size), listing age (Age), debt-to-asset ratio (Lev), return on equity (ROE), net profit margin of total assets (ROA), and the shareholding ratio of the largest shareholder (TOP1) as control variables. At the same time, to control the possible impact of enterprise and time factors, enterprise and year fixed effects are added in the empirical study. The specific variable definitions are shown in Table 1.

Table 1: Variable Definitions and Descriptions

Variable Type	Variable Name	Symbol	Definition
Explanatory Variable	Digital Transformation	DIG	Entropy weighted index manually calculated based on keyword frequency in annual reports
Explained Variable	Organizational Resilience	Volatility	Standard deviation of monthly stock returns.
		Growth	Three-year cumulative net sales growth.
Mediating Variable	Technological Innovation	Innov	Natural logarithm of R&D expenditure.
Moderating Variable	Supply Chain Concentration	SCC	Average of the top five suppliers' procurement share and the top five customers' sales share.
Control Variables	Firm Size	Size	Natural logarithm of total assets.
	Firm Age	Age	Natural logarithm of (current year–IPO year + 1).
	Leverage Ratio	Lev	Total liabilities divided by total assets.
	Return on Equity(ROE)	ROE	Net profit divided by shareholders' equity.
	Return on Assets (ROA)	ROA	Net profit divided by total assets.
	Ownership Concentration	TOP1	Shares held by the largest shareholder divided by total shares.

3.3. Model design

To test the aforementioned research hypotheses, this paper constructs the following model: Formula (1) is a fixed effect regression model, which tests whether enterprise digital transformation (DIG) can improve organizational resilience (OR), that is, to test H1a and H1b; Formulas (2) to (3) are mediation effect models, which examine the mediating effect of technological innovation (Innov) in the process of enterprise digital transformation on organizational resilience, that is, to test H2; Formula (4) is used to test the moderating effect of supply chain concentration (SSC), that is, whether it directly affects the relationship between the dependent variable and the core independent variable.

$$\mathrm{OR}_{i,t} = \alpha_0 + \alpha_1 \mathrm{DIG}_{i,t} + \sum \alpha_2 \mathrm{Contrals}_{i,t} + \varepsilon_{i,t} \quad (1)$$

$$\mathrm{Innov}_{i,t} = \beta_0 + \beta_1 \mathrm{DIG}_{i,t} + \sum \beta_2 \mathrm{Contrals}_{i,t} + \mu_{i,t} \quad (2)$$

$$\mathrm{OR}_{i,t} = \gamma_0 + \gamma_1 \mathrm{DIG}_{i,t} + \gamma_2 \mathrm{Innov}_{i,t} + \sum \gamma_3 \mathrm{Contrals}_{i,t} + \omega_{i,t} \quad (3)$$

$$\mathrm{OR}_{i,t} = \delta_0 + \delta_1 \mathrm{DIG}_{i,t} + \delta_2 \mathrm{SSC}_{i,t} + \delta_3 \mathrm{DIG}_{i,t} \times \mathrm{SSC}_{i,t} + \sum \delta_4 \mathrm{Contrals}_{i,t} + \sigma_{i,t} \quad (4)$$

The variables in the models are defined as follows: $\mathrm{OR}_{i,t}$ represents organizational resilience; $\mathrm{DIG}_{i,t}$ represents digital transformation; $\mathrm{Innov}_{i,t}$ represents technological innovation; $\mathrm{SSC}_{i,t}$ represents supply chain concentration; and $\sum \mathrm{Contrals}_{i,t}$represents control variables. The subscripts i and t denote firms and years, respectively. $\varepsilon_{i,t}$、$\mu_{i,t}$、$\omega_{i,t}$、$\sigma_{i,t}$represent the random error terms of the models.

4. Empirical analysis and test results

4.1. Descriptive statistics

Table 2 provides a more thorough understanding of the distribution characteristics of each variable. Among the explained variables, organizational resilience, the mean value of financial volatility (Volatility) is 0.229, the standard deviation is 0.054, and the minimum and maximum values are 0.038 and 0.482, respectively, indicating that there are certain differences in the stability of market performance among manufacturing enterprises. Another indicator reflecting the growth of enterprises, sales growth rate (Growth), has a mean value of 0.615, a maximum value close to 1, and a minimum value of 0.039, indicating that some enterprises have achieved high sustained growth, while some enterprises have grown more slowly. The core explanatory variable, digital transformation (DIG), has a mean value of 2.081, a maximum value of 6.308, a minimum value of 0.693, and a standard deviation of 1.150, indicating that there is obvious heterogeneity among enterprises in the digitalization process. Some enterprises have greatly promoted digital construction, while some enterprises are still in the initial stage. In terms of mediating variables, the mean of technological innovation (Innov) is 18.409, and the standard deviation is 1.467, indicating that there are large differences in R&D investment among enterprises. The mean of the moderating variable supply chain concentration (SCC) is 0.491, and the standard deviation is 0.074, indicating that most enterprises tend to be moderately concentrated in the supply chain layout, and there are fewer cases of extreme concentration or extreme dispersion.

In addition, among the control variables, the mean of enterprise size (Size) is 22.439, with a moderate fluctuation range; the means of ROE and ROA are 0.038 and 0.032, respectively, indicating that the overall profitability of the enterprise is relatively low; the mean of enterprise leverage ratio (Lev) is 0.421, which has certain debt pressure; and the mean shareholding ratio of controlling shareholders (TOP1) is 31.8%, which is a typical feature among Chinese listed companies.

In summary, the sample data distribution is generally reasonable, and there is a basis for subsequent regression analysis.

Table 2: Descriptive Statistical Analysis

Variable	N	Mean	Std. Dev	Min	Max
DIG	12,694	2.081	1.150	0.693	6.308
Volatility	12,694	0.229	0.054	0.038	0.482
Growth	12,694	0.615	0.201	0.039	0.978
Innov	12,694	18.409	1.467	10.909	25.025
SCC	12,694	0.491	0.074	0.366	0.634
Size	12,694	22.439	1.198	19.520	27.640
Age	12,694	2.487	0.569	0.000	3.526
ROE	12,694	0.038	2.696	-66.535	281.989
ROA	12,694	0.032	0.089	-3.200	1.408
Lev	12,694	0.421	0.196	0.008	2.861
TOP1	12,694	0.318	0.139	0.018	0.891

4.2. Correlation analysis

To preliminarily determine the linear relationship between the main variables, this paper conducted a Pearson correlation analysis, and the results are shown in Table 3.

From the perspective of correlation coefficients, the core explanatory variable DIG is negatively correlated with Volatility (coefficient is -0.022) and positively correlated with Growth (coefficient is 0.019) in the two dimensions of organizational resilience, but neither has reached the significance level, indicating that further reliance on regression models is needed to confirm their true relationship. The correlation coefficient between DIG and technological innovation (Innov) is -0.033, which is also not significant, indicating that although the two are closely related in theory, their correlation is not strong, eliminating the risk of multicollinearity. There is a significant positive correlation between the mediating variable Innov and Growth (coefficient is 0.121), and it also shows a weak positive correlation with ROA and ROE, which is consistent with the logic that innovation investment helps to improve the quality of corporate operations. The moderating variable SCC is significantly positively correlated with Volatility (0.102) and significantly negatively correlated with Growth (-0.103), suggesting that supply chain concentration may increase risks and inhibit growth. In terms of control variables, enterprise size (Size) has a high correlation with Innov (0.763), and is also positively correlated with Growth and ROA, indicating that large enterprises are more inclined to increase innovation investment and achieve performance growth; while the correlation between ROE and ROA is strong (0.138), and its correlation coefficient with variables such as TOP1 is low, indicating that the risk of multicollinearity between control variables is small.

Overall, the correlation between variables is basically in line with expectations, and there is no serious collinearity problem, which provides a data basis for subsequent multivariate regression analysis.

Table 3: Correlation Analysis

	DIG	Volatility	Growth	Innov	SCC	Size	Age	Lev	ROE	ROA	TOP1
DIG	1										
Volatility	-0.022	1									
Growth	0.019	-0.107***	1								
Innov	-0.033	0.059	0.121***	1							
SCC	0.014	0.102***	-0.103***	0.062*	1						
Size	-0.068	0.094***	0.131***	0.763***	0.071***	1					
Age	-0.062	0.087***	0.112***	0.274***	0.133***	0.407***	1				
Lev	-0.070	0.004	-0.012	0.289***	0.010	0.434***	0.286***	1			
ROE	-0.011	-0.009	0.013	0.013	0.015	0.000	0.001	-0.021	1		
ROA	0.006	0.018	0.027	0.115***	0.032*	0.080***	-0.038*	-0.380***	0.138***	1	
TOP1	0.011	-0.018	0.030	0.101***	-0.052***	0.161***	-0.043**	0.020	0.008	0.121***	1

Note: * p < 0.1, ** p < 0.05, *** p < 0.01.

4.3. Baseline regression analysis

4.3.1. Main effect test

In Table 4, digital transformation (DIG) has a significant positive impact on the comprehensive index of organizational resilience (OR) and its two sub-dimensions. In column (1), the coefficient of DIG on comprehensive organizational resilience (OR) is 0.053 (p<0.01), indicating that digital transformation has significantly improved the overall resilience of manufacturing enterprises. In column (2), the coefficient of DIG on financial volatility (Volatility) is -0.046 (p<0.01), indicating that digital transformation helps enterprises reduce financial risks and market volatility and enhance stability. In column (3), the impact of DIG on sales growth (Growth) is 0.061 (p<0.01), indicating that digital transformation can significantly promote the sustained growth of corporate performance. In summary, hypotheses H1a and H1b are significantly supported.

In terms of control variables, enterprise size (Size) is positive in all three models and significant at the 10% level, indicating that larger enterprises are more resilient. The leverage ratio (Lev) is negative, while both ROE and ROA are positive, reflecting that companies with strong profitability and sound financial structure demonstrate stronger organizational resilience.

Table 4: Benchmark Regression Results

Variable	OR	Volatility	Growth
DIG	0.053***	-0.046***	0.061***
	(3.76)	(-3.95)	(4.13)
Size	0.017*	-0.015*	0.019*
	(1.91)	(-1.82)	(1.89)
Age	-0.002	0.002	-0.003
	(-0.49)	(0.46)	(-0.61)
Lev	-0.027**	0.018*	-0.024**
	(-2.29)	(1.92)	(-2.11)
ROE	0.015***	-0.010***	0.017***

	(3.61)	(-3.51)	(3.48)
ROA	0.021**	-0.015**	0.019**
	(2.18)	(-2.17)	(2.20)
TOP1	0.009**	-0.005*	0.008**
	(2.14)	(-1.73)	(2.04)
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
N	12,694	12,694	12,694
Agd.R^2	0.091	0.085	0.093

* p < 0.1, ** p < 0.05, *** p < 0.01.

4.3.2. Mediation effect test

Table 5 presents evidence supporting the mediating role of technological innovation (Innov) in the relationship between digital transformation (DIG) and organizational resilience (OR). The findings reveal a clear pathway:

(1) Digital Transformation Fuels Innovation: Column (1) demonstrates that increased digital transformation investment (DIG) significantly boosts technological innovation (Innov), evidenced by a positive coefficient of 0.083 ($p < 0.01$). This confirms that DIG effectively stimulates firms' innovation activities. In practical terms, this means that as companies invest more in digital tools and processes (e.g., AI analytics, automation platforms), they tend to ramp up their R&D spending to develop or integrate new technologies.

(2) Innovation Enhances Resilience: Columns (2) to (4) show that higher levels of technological innovation (Innov) themselves lead to significant improvements in overall organizational resilience (coefficient = 0.051, $p < 0.01$) and its two core dimensions: it reduces financial volatility (coefficient = -0.024, $p < 0.05$) and promotes sustained performance growth (coefficient = 0.039, $p < 0.01$). This suggests that the innovations spurred by digital investment (e.g., new products, optimized processes, data-driven insights) directly contribute to making firms more adaptable and robust.

(3) Partial Mediation: Crucially, when the mediator (Innov) is added to the model linking DIG directly to OR and its dimensions (Columns (2)-(4) vs. the baseline in Table 4), the positive effect of DIG remains significant but its magnitude decreases slightly. This pattern is characteristic of a partial mediation effect. In essence, digital transformation strengthens resilience not only directly (perhaps through improved efficiency or decision-making) but also importantly by acting as a catalyst for technological innovation, which in turn builds resilience.

Therefore, Hypothesis H2 is supported: Technological innovation serves as a significant partial mediator between digital transformation and organizational resilience. This underscores that fostering innovation is a key mechanism through which digital investments enhance a firm's ability to withstand shocks and sustain growth.

Table 5: Results of Mediation Effect

Variable	Innov	OR	Volatility	Growth
DIG	0.083***	0.035***	-0.029***	0.046***
	(6.21)	(2.78)	(-2.62)	(3.91)
Innov	-	0.051***	-0.024**	0.039***
		(4.02)	(-2.13)	(3.44)
Size	0.026**	0.015*	-0.013*	0.017*
	(2.41)	(1.89)	(-1.78)	(1.87)
Age	-0.004	-0.002	0.002	-0.003
	(-0.72)	(-0.46)	(0.47)	(-0.61)
Lev	-0.031**	-0.024**	0.016*	-0.021**
	(-2.58)	(-2.20)	(1.88)	(-2.09)
ROE	0.019***	0.014***	-0.009***	0.016***
	(4.11)	(3.55)	(-3.46)	(3.50)
ROA	0.023**	0.020**	-0.014**	0.018**
	(2.28)	(2.14)	(-2.16)	(2.22)
TOP1	0.010**	0.009**	-0.006*	0.008**
	(2.18)	(2.11)	(-1.75)	(2.03)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	12,694	12,694	12,694	12,694
Agd.R^2	0.162	0.154	0.144	0.151

* p < 0.1, ** p < 0.05, *** p < 0.01.

4.3.3. Moderating effect test

Table 6 examines whether supply chain concentration (SCC) alters the strength of the relationship between digital transformation (DIG) and organizational resilience. The analysis, which includes the interaction term DIG×SCC, reveals a significant moderating effect with nuanced impacts:

1) Moderating Effect Identified: The statistically significant interaction term (DIG×SCC) across all three dependent variables confirms that SCC acts as a moderator. This means the impact of digital transformation on resilience isn't uniform; it depends on how concentrated a firm's supply chain relationships are.
2) Volatility: The interaction term has a positive coefficient (0.021, $p < 0.05$) for financial volatility. While DIG itself helps reduce volatility, this beneficial effect is weakened when SCC is high. High reliance on a few suppliers/customers makes it harder for digital tools to fully dampen financial risk, even with transformation efforts.
3) Growth: Conversely, the interaction term has a negative coefficient (-0.027, $p < 0.05$) for sales growth. The positive impact of DIG on driving sustained growth (Table 4) is diminished under conditions of high SCC. Concentrated supply chains may limit the agility and market responsiveness gains digital transformation could otherwise unlock for growth.

These results verify Hypotheses H3a and H3b. They highlight a critical caveat: Although digital transformation intrinsically enhances resilience, an overly concentrated supply chain acts as a constraint. High SCC weakens DIG's effectiveness in both mitigating financial risk and fueling performance growth. For managers, this implies that diversifying supply chain partners can significantly amplify the

resilience benefits derived from digital investments. The findings suggest that decentralized supply networks possess greater inherent adaptability and synergy potential when undergoing digital transformation.

Table 6: Results of Moderation Effect

Variable	(1) OR	(2) Volatility	(3) Growth
DIG	0.067***	-0.041***	0.059***
	(4.23)	(-3.88)	(4.19)
SCC	-0.032**	0.026**	-0.030**
	(-2.34)	(2.12)	(-2.28)
DIG × SCC	-0.029**	0.021**	-0.027**
	(-2.17)	(2.03)	(-2.07)
Size	0.018*	-0.014*	0.020*
	(1.91)	(-1.76)	(1.91)
Age	-0.001	0.002	-0.003
	(-0.46)	(0.47)	(-0.61)
Lev	-0.026**	0.019*	-0.023**
	(-2.19)	(1.93)	(-2.10)
ROE	0.015***	-0.011***	0.016***
	(3.54)	(-3.61)	(3.49)
ROA	0.020**	-0.016**	0.019**
	(2.22)	(-2.21)	(2.24)
TOP1	0.009**	-0.006*	0.008**
	(2.07)	(-1.76)	(2.05)
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	12,694	12,694	12,694
Adj.R^2	0.157	0.148	0.152

* p < 0.1, ** p < 0.05, *** p < 0.01.

4.4. Endogeneity test

4.4.1. Lagged variables

The effect of enterprise digital transformation takes a certain period to manifest in enterprise practice, and there is a time lag effect, which may have a delayed impact. To solve the endogeneity problem caused by reverse causality, this paper takes a lagged treatment of the core independent variable "digital transformation", that is, the current organizational resilience is regressed with the previous digital transformation (F.DIG), and the results are shown in Table 7. The results in Table 7 show that F.DIG still has a significant impact on comprehensive organizational resilience and its two dimensions, and the direction is consistent with the baseline model (0.051, -0.036, and 0.057, respectively), which verifies the existence of the lag effect and maintains robustness and further excludes strong reverse causal effects.

Table 7: Lagged One-Period Regression Results

Variable	(1) OR	(2) Volatility	(3) Growth
F.DIG	0.051***	-0.036***	0.057***
	(3.56)	(-3.18)	(3.91)
SCC	-0.030**	0.025**	-0.027**
	(-2.26)	(2.07)	(-2.19)
F.DIG × SCC	-0.027**	0.020**	-0.025**
	(-2.08)	(2.02)	(-2.04)
Size	0.017*	-0.014*	0.018*
	(1.86)	(-1.76)	(1.82)
Age	-0.002	0.002	-0.003
	(-0.45)	(0.46)	(-0.61)
Lev	-0.025**	0.017*	-0.022**
	(-2.11)	(1.83)	(-2.05)
ROE	0.015***	-0.010***	0.016***
	(3.50)	(-3.42)	(3.40)
ROA	0.020**	-0.014**	0.018**
	(2.10)	(-2.11)	(2.18)
TOP1	0.009**	-0.005*	0.008**
	(2.08)	(-1.69)	(2.01)
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	11,539	11,539	11,539
Adj.R^2	0.093	0.084	0.095

* p < 0.1, ** p < 0.05, *** p < 0.01.

4.4.2. Instrumental variables

In practice, the improvement of digital transformation will enhance the organizational resilience of enterprises; on the other hand, companies with stronger organizational resilience are also more capable and have the foundation to promote a higher level of digital transformation. To alleviate the endogenous influence of self-selection and reverse causality, this paper adopts the instrumental variable method for a robustness test.

This paper selects the total volume of regional telecommunications business from 2013 to 2023 as the instrumental variable. The main reasons are as follows: First, the communication service level, telecommunications optical cable capacity, and communication service capacity of the enterprise's region affect the enterprise's acceptance of information technology, which meets the correlation condition. Second, telecommunications services are part of urban public utilities and do not directly affect the organizational resilience of enterprises, which meets the externality condition. Therefore, this paper uses the IV-2SLS method to estimate. After estimation using the IV-2SLS

method, the impact of DIG on OR is 0.093 (p<1%), on Volatility is -0.058 (p<1%), and on Growth is 0.105 (p<1%). The significance and direction of the coefficients match those of the prior regression, confirming the model's robustness and the effectiveness of the instrumental variables and further enhancing the persuasiveness of the causal inference.

Table 8: Instrumental Variable Test Results

Variable	(1) OR	(2) Volatility	(3) Growth
DIG	0.093***	-0.058***	0.105***
	(3.98)	(-3.65)	(4.21)
Size	0.015*	-0.013*	0.017*
	(1.81)	(-1.73)	(1.89)
Age	-0.002	0.002	-0.003
	(-0.47)	(0.44)	(-0.60)
Lev	-0.024**	0.017*	-0.022**
	(-2.16)	(1.91)	(-2.08)
ROE	0.014***	-0.010***	0.016***
	(3.49)	(-3.52)	(3.45)
ROA	0.019**	-0.014**	0.017**
	(2.15)	(-2.17)	(2.24)
TOP1	0.008**	-0.006*	0.007**
	(2.04)	(-1.72)	(2.01)
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	12,694	12,694	12,694
Adj.R^2	0.087	0.079	0.090

* p < 0.1, ** p < 0.05, *** p < 0.01.

4.5. Robustness test

This study conducts a robustness test by replacing variables. For the explained variable "organizational resilience", we use the standard deviation of weekly stock returns to recalculate the return volatility (volatility2) and use the cumulative growth of total assets of the enterprise to replace sales growth (growth2). For the explanatory variable "digital transformation", we use CSMAR's digital transformation index of listed companies as the replacement variable (DIG2) and perform logarithmic processing on it to reduce the degree of dispersion. This paper uses the standard deviation of weekly stock returns (Volatility2) and the total asset growth rate (Growth2) as the replacement of the explained variables in Table 9, and the explanatory variable uses the CSMAR digitalization index to replace DIG (DIG2). The regression results show that DIG2 still significantly affects organizational resilience, and the direction remains unchanged (-0.037, 0.050). The interaction term with the moderating variable is also significant, indicating that the main effect and moderating effect are still robust under different measurement methods.

Table 9: Robustness Test Results

Variable	volatility2	growth2
DIG2	-0.037***(-3.44)	0.050***(3.92)
SCC	0.023**(2.06)	-0.026**(-2.17)
DIG2 × SCC	0.019**(2.00)	-0.023**(-2.08)
Size	-0.011*(-1.74)	0.016*(1.81)
Age	0.001(0.43)	-0.002(-0.55)
Lev	0.014*(1.88)	-0.020**(-2.04)
ROE	-0.009***(-3.39)	0.015***(3.48)
ROA	-0.013**(-2.16)	0.017**(2.21)
TOP1	-0.005*(-1.72)	0.007**(2.00)
Firm FE	Yes	Yes
Year FE	Yes	Yes
N	12,694	12,694
Adj. R^2	0.085	0.091

* p < 0.1, ** p < 0.05, *** p < 0.01.

4.6. Heterogeneity analysis

To further explore whether there are differences in the impact of digital transformation on the organizational resilience of different manufacturing companies, this paper divides the total sample according to the nature and size of the enterprise and conducts a heterogeneity analysis.

4.6.1. Heterogeneity analysis of property rights

Due to differences in ownership structure, Chinese manufacturing enterprises have different resource endowments and competitive environments, resulting in significant differences in their degree of digital transformation and organizational resilience needs. Compared with non-state-owned enterprises, state-owned enterprises generally have greater resource advantages and are less dependent on digital technologies during the development and transformation process. In addition, state-owned enterprises are more susceptible to organizational inertia and path dependence, which may weaken the effectiveness of digital transformation in improving organizational resilience.

To test the differences in the effects of digital transformation among different ownership types, this study divides the samples into state-owned enterprises and non-state-owned enterprises and conducts regression analysis separately. The results in Table 10 show that in the state-owned enterprise sample, the impact of DIG on Volatility and Growth is -0.029 and 0.043, respectively, which are significant but slightly smaller, while in non-state-owned enterprises, the impact coefficients are -0.050 and 0.064, respectively, which are more significant. This shows that in non-state-owned enterprises, the role of digital transformation in promoting organizational resilience is more obvious, which may be due to their higher market sensitivity, decision-making flexibility, and adaptability to new technologies. In contrast, institutional rigidity in state-owned enterprises limits the marginal impact of digital transformation on growth, thus reducing the explanatory

power of the model. Moreover, the volatility-reducing effect of digital transformation is more pronounced in non-state-owned enterprises than in state-owned enterprises. This suggests that digital transformation has a stronger positive impact on the risk mitigation dimension of organizational resilience in non-state-owned enterprises, highlighting the importance of ownership structure in shaping the outcomes of digital transformation initiatives.

Tab. 10: Tests for Heterogeneity of Soes and Non-Soes

Variable	State-Owned Enterprises		Non-State-Owned Enterprises	
	Volatility	Growth	Volatility	Growth
DIG	-0.029**	0.043***	-0.050***	0.064***
	(-2.12)	(2.89)	(-3.71)	(4.13)
Size	-0.012*	0.014	-0.015*	0.020*
	(-1.78)	(1.48)	(-1.86)	(1.92)
Age	0.002	-0.003	0.002	-0.002
	(0.46)	(-0.54)	(0.45)	(-0.60)
Lev	0.016*	-0.021**	0.019*	-0.026**
	(1.90)	(-2.15)	(1.94)	(-2.30)
ROE	-0.010***	0.014***	-0.011***	0.017***
	(-3.38)	(3.47)	(-3.55)	(3.62)
ROA	-0.013**	0.018**	-0.016**	0.021**
	(-2.19)	(2.13)	(-2.22)	(2.28)
TOP1	-0.006*	0.007*	-0.005*	0.009**
	(-1.71)	(1.77)	(-1.69)	(2.08)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	4,576	4,576	8,118	8,118
Adj.R^2	0.077	0.087	0.084	0.094

* p < 0.1, ** p < 0.05, *** p < 0.01.

4.6.2. Analysis of the heterogeneity of enterprise scale attributes

According to Table 11, in small manufacturing companies, the impact of digital transformation on volatility and growth is more significant (-0.052, 0.065), higher than that of large companies (-0.032, 0.041). This shows that digital transformation has a stronger leverage effect in small companies, which rely more on digital tools to improve resilience and growth capabilities when resources are relatively limited. However, large companies may have relatively limited transformation incentive effects due to existing institutional redundancy and path dependence.

Tab. 11: Heterogeneity Test Results between Enterprise Scale

Variable	Large-scale enterprises		Small-scale enterprises	
	Volatility	Growth	Volatility	Growth
DIG	-0.032**	0.041***	-0.052***	0.065***
	(-2.06)	(2.83)	(-3.89)	(4.17)
Size	-0.011*	0.013	-0.015*	0.020*
	(-1.75)	(1.41)	(-1.83)	(1.90)
Age	0.002	-0.003	0.002	-0.003
	(0.45)	(-0.51)	(0.47)	(-0.63)
Lev	0.017*	-0.023**	0.019*	-0.025**
	(1.88)	(-2.12)	(1.91)	(-2.31)
ROE	-0.010***	0.015***	-0.011***	0.017***
	(-3.39)	(3.45)	(-3.51)	(3.60)
ROA	-0.014**	0.019**	-0.015**	0.021**
	(-2.15)	(2.16)	(-2.20)	(2.24)
TOP1	-0.005*	0.008*	-0.006*	0.009**
	(-1.74)	(1.95)	(-1.77)	(2.10)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	6,288	6,288	6,406	6,406
Adj.R^2	0.081	0.091	0.089	0.097

* p < 0.1, ** p < 0.05, *** p < 0.01.

5. Conclusion and recommendations

5.1. Research conclusions

Using the panel data of A-share listed companies from 2013 to 2023, this study examines the mediating role of technological innovation and the moderating role of supply chain concentration. The empirical findings are as follows: (1) Digital transformation significantly improves the organizational resilience of manufacturing enterprises, indicating that it plays a vital role in enhancing the adaptability and sustainability of enterprises in a dynamic environment; (2) Technological innovation plays a partial mediating role in the relationship between digital transformation (DIG) and organizational resilience (OR), indicating that digital transformation promotes organizational resilience by improving the technological innovation capability (Innov) of enterprises; (3) Supply chain concentration (SCC) plays a moderating role in the relationship between digital transformation and organizational resilience. Specifically, SCC weakens the risk mitigation effect of digital transformation but enhances the growth promotion effect of digital transformation; (4) Heterogeneity analysis shows that the effects of digital transformation vary significantly among different enterprise types and scales. Non-state-owned enterprises and in small-scale enterprises gain greater marginal benefits from digital transformation.

5.2. Practical implications

Practical implications are provided for enterprises in the context of increasing market uncertainty. First, manufacturing enterprises should steadily advance digital transformation. In the current era, digital transformation is a crucial means to enhance organizational resilience and effectively respond to external shocks. Firms should regard digital transformation as a core strategic initiative, leveraging data resources and digital technologies to drive organizational restructuring and resource reallocation.

Second, enterprises should actively pursue technological innovation and R&D. Digital transformation not only entails technological application but also serves as a catalyst for innovation. Small and medium-sized manufacturing firms should establish collaborative innovation mechanisms involving industry, academia, and research institutions. These enterprises should accelerate the commercialization and application of technological achievements and deepen the integration of technological innovation with digital technologies such as AI, big data, and blockchain. By strengthening their technological innovation capabilities, enterprises can better integrate internal and external resources, improve their crisis recovery capacity, and thus enhance overall organizational resilience.

Third, supply chain management should be strategically optimized. For firms with high supply chain dependency, it is essential to improve both the diversity and resilience of supply chain networks. During the process of digital transformation, enterprises must avoid overlooking informal governance mechanisms such as relational contracts. Instead, they should foster stronger communication and information sharing with supply chain partners, building cooperative relationships based on mutual trust to enhance collective risk resistance. Additionally, digital technologies can be leveraged to optimize supply chain operations, enabling real-time visibility and intelligent decision-making across the supply chain.

Fourth, governments at all levels should accelerate the development of a supportive macro environment for the digital economy. This includes strengthening the policy and institutional frameworks that facilitate digital transformation in the manufacturing sector. Specific measures may include building platforms for sharing digital achievements to promote technological exchange and collaboration across industrial chains; implementing supportive policies and establishing dedicated funds to subsidize digital transformation initiatives; and investing in digital infrastructure to provide a robust external environment conducive to enterprise-level digital advancement and enhanced resilience in the face of systemic risks.

While digital transformation (DT) enhances organizational resilience, it also introduces challenges such as cybersecurity vulnerabilities, implementation costs, and workforce displacement (Serac, 2023). Centralized data systems expand the attack surface, exposing firms to greater cyber risks; implementation costs impose a disproportionate burden on SMEs with a manufacturing focus, with ROI timelines averaging 3.2 years (Rawindaran et al., 2025). Automation—a key DT component—correlates with reduced low-skill employment, requiring significant reskilling investments (Huang, 2024). To address these trade-offs, policy interventions like cyber insurance pools and SME DT subsidies are needed (Nazim et al., 2025).

5.3. Limitations and perspectives

Several limitations remain and warrant further investigation in future research. Firstly, the study is limited by the scope of its data sample. The data were primarily drawn from manufacturing firms listed on the Shanghai and Shenzhen stock exchanges between 2013 and 2023, which may restrict the breadth and representativeness of the findings. Future research could expand the sample to include a more diverse range of firm types, such as non-listed firms or those in other sectors, and cover a broader geographic scope to enhance the generalizability of the results.

Secondly, there is potential for refinement in the measurement of key variables. While the study utilized multiple approaches to assess digital transformation, organizational resilience, and technological innovation, these metrics could be further improved. For instance, digital transformation could be measured more comprehensively by evaluating the extent and effectiveness of specific digital technology applications. Similarly, organizational resilience could incorporate additional dimensions, such as employee engagement, customer loyalty, and adaptability to external shocks.

Thirdly, future research should explore the long-term and dynamic effects of digital transformation. This study primarily focused on short-term impacts. Longitudinal studies are needed to examine how the role of digital transformation evolves and how firms' needs and responses change across different stages of development. Such research would provide deeper insights into the sustained value and strategic importance of digital transformation in enhancing organizational resilience.

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