



STRATEGIC RESTRUCTURING OF CHINA'S INDUSTRIAL SUPPLY CHAINS UNDER THE NATIONAL 15TH FIVE-YEAR PLAN: AN EMPIRICAL ASSESSMENT OF DIGITAL TRANSFORMATION, ECONOMIC RESILIENCE, AND SUSTAINABLE DEVELOPMENT

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Abstract

China's 15th Five-Year Plan (2026–2030) establishes a strategic framework for accelerating industrial modernization, strengthening supply chain security, advancing digital transformation, and promoting sustainable economic development. This study empirically investigates the influence of digital transformation on industrial supply chain restructuring, economic resilience, and environmental sustainability across China's manufacturing sector. The research employs a longitudinal dataset comprising 9,600 firm-year observations from 1,200 manufacturing enterprises distributed across 30 provincial-level regions during 2018–2025. Data were integrated from enterprise financial reports, industrial production statistics, digital technology adoption records, logistics performance indicators, and environmental disclosures. A comprehensive analytical framework incorporating entropy-weighted composite indices, two-way fixed-effects panel regression, mediation analysis, heterogeneity assessment, and robustness testing was developed to evaluate relationships among digital transformation, industrial resilience, and sustainable development. Empirical results indicate that a one-standard-deviation increase in digital transformation is associated with a 0.18-standard-deviation improvement in supply chain resilience and a 0.14-standard-deviation enhancement in sustainability performance. Manufacturing enterprises with diversified domestic supplier networks experienced 11.6% lower disruption-related production losses, while digitally advanced firms achieved 8.9% lower carbon emissions per unit of industrial output compared with less digitally integrated enterprises. Mediation analysis reveals that improved supply chain visibility accounts for approximately 28% of the relationship between digital transformation and industrial resilience. Heterogeneity analysis further demonstrates stronger associations among high-technology manufacturing enterprises and firms located in regions possessing advanced digital infrastructure. Robustness assessments using alternative indicator specifications and lagged explanatory variables support the stability of the estimated relationships. These findings emphasize the importance of intelligent manufacturing systems, supplier diversification, integrated industrial data platforms, and green technological innovation in strengthening industrial competitiveness. The study provides an evidence-based analytical foundation for aligning China's industrial restructuring priorities with the 15th Five-Year Plan, offering policy recommendations for enhancing technological self-reliance, mitigating supply chain disruptions, improving resource efficiency, and supporting coordinated, resilient, and environmentally sustainable industrial development across diverse manufacturing sectors and regional economic systems.

Keywords: China's 15th Five-Year Plan; Industrial Supply Chain Restructuring; Digital Transformation; Economic Resilience; Sustainable Development; Smart Manufacturing; Supply Chain Security; Green Industrial Development.



1. Introduction

The restructuring of industrial supply chains has become a major priority for economic modernization, technological competitiveness, and sustainable development in the rapidly changing global economy. Increasing geopolitical uncertainties, international trade disruptions, technological competition, environmental pressures, and supply chain vulnerabilities have encouraged industrial economies to reconsider traditional manufacturing and production networks. Conventional supply chain systems, primarily designed to improve operational efficiency and reduce production costs, are increasingly required to demonstrate greater flexibility, technological independence, and resilience against external disruptions. China, as one of the world's largest manufacturing economies, occupies a central position in international industrial production and global value chains (Li et al., 2026). Consequently, the transformation of China's industrial supply chains has significant implications for domestic economic stability, international competitiveness, technological advancement, and sustainable industrial development. China's 15th Five-Year Plan (2026–2030) provides a strategic policy framework for accelerating industrial modernization, strengthening manufacturing capabilities, advancing digital transformation, and promoting environmentally sustainable economic growth. The plan emphasizes the development of a modern industrial system, technological self-reliance, intelligent manufacturing, industrial supply chain security, and green industrial transformation. These priorities reflect China's efforts to strengthen domestic industrial capabilities while maintaining competitiveness within increasingly complex international production networks. Industrial restructuring under this policy framework involves upgrading traditional manufacturing activities, improving supplier coordination, expanding digital infrastructure, developing advanced technologies, and promoting resource-efficient production systems. However, the effectiveness of these strategies depends on the capacity of manufacturing enterprises to integrate technological innovation with operational resilience and environmental sustainability (S. Liu et al., 2026).

Digital transformation represents a fundamental mechanism supporting the modernization of industrial supply chains. The integration of artificial intelligence, industrial internet platforms, cloud computing, big-data analytics, intelligent manufacturing equipment, and enterprise information systems can improve production coordination, operational visibility, inventory management, and logistics efficiency. Digital technologies enable enterprises to monitor supply chain activities, identify operational disruptions, improve demand forecasting, and optimize resource allocation. Furthermore, digitally integrated manufacturing networks can strengthen communication between suppliers, manufacturers, and distributors, facilitating more responsive industrial production systems. Nevertheless, technological adoption varies considerably across enterprises and regions because of differences in investment capacity, digital infrastructure, organizational capabilities, and industrial specialization (Ahmad et al., 2026c). Therefore, empirical investigation is necessary to understand the extent to which digital transformation contributes to industrial restructuring and measurable improvements in supply chain performance.

Economic resilience constitutes another essential dimension of industrial supply chain transformation. Manufacturing enterprises frequently encounter operational disruptions associated with transportation interruptions, raw material shortages, international trade restrictions, market fluctuations, and unexpected changes in industrial demand. Supply chain resilience refers to the ability of production networks to anticipate disruptions, maintain essential operations, adapt to changing conditions, and recover from adverse circumstances. Supplier diversification, domestic production coordination, technological flexibility, and effective risk management can improve industrial stability by reducing dependence on concentrated procurement networks. In China's manufacturing sector, strengthening economic resilience is particularly important for maintaining industrial continuity, improving technological self-reliance, and supporting the development of reliable domestic supplier networks. However, diversification strategies may generate additional coordination costs, emphasizing the importance of digital technologies in balancing operational efficiency with supply chain security. Environmental sustainability has simultaneously emerged as a central consideration in industrial restructuring. Manufacturing activities contribute substantially to energy consumption, industrial emissions, resource depletion, and environmental degradation. Sustainable industrial



development therefore requires the integration of cleaner production technologies, energy-efficient manufacturing systems, renewable energy resources, circular economy practices, and environmentally responsible supply chain management (Wei et al., n.d.).

Digital transformation can support these objectives by improving energy monitoring, reducing production waste, optimizing logistics operations, and increasing resource utilization efficiency. China's industrial modernization priorities increasingly emphasize coordination between technological advancement and green development, recognizing that long-term industrial competitiveness must be supported by improved environmental performance. Nevertheless, digital infrastructure and advanced manufacturing technologies may also increase electricity demand and investment requirements, making empirical evaluation essential for understanding their net contribution to sustainability.

Although previous studies have examined industrial digitalization, supply chain resilience, and green manufacturing, these dimensions have frequently been investigated independently. Existing research has primarily focused on technological innovation, productivity improvements, logistics performance, supplier risk management, or carbon emission reduction. Comparatively limited attention has been given to the integrated relationships among digital transformation, economic resilience, and environmental sustainability within China's manufacturing sector. Furthermore, differences in regional digital infrastructure, industrial specialization, enterprise capabilities, and supplier network structures may significantly influence restructuring outcomes. Another important limitation concerns the evaluation of China's 15th Five-Year Plan, as historical observations preceding 2026 cannot directly establish the effects of policies implemented during the 2026–2030 planning period (Ma et al., 2026). However, pre-implementation enterprise data can provide valuable baseline evidence for understanding industrial transformation and assessing the structural conditions relevant to future policy implementation.

To address these research gaps, the present study investigates the relationships among digital transformation, supply chain resilience, and sustainable development across China's manufacturing industries. The research utilizes a longitudinal dataset consisting of 9,600 firm-year observations from 1,200 manufacturing enterprises across 30 provincial-level regions during 2018–2025. The dataset integrates enterprise financial information, industrial production statistics, digital technology adoption indicators, supplier network characteristics, logistics performance measures, and environmental disclosures. Digital transformation is assessed through industrial internet adoption, intelligent equipment investment, and enterprise software integration. Supply chain resilience is evaluated using supplier diversification, production volatility, and disruption-related operational losses, while sustainable development is measured through carbon emission intensity, energy productivity, and green innovation performance. This multidimensional dataset enables a comprehensive examination of industrial restructuring across different manufacturing and regional environments. The methodological framework combines entropy-weighted composite indices, two-way fixed-effects panel regression, mediation analysis, heterogeneity assessment, and robustness testing. These analytical approaches are employed to examine the statistical relationships between digital transformation and industrial performance while considering enterprise-specific characteristics and common temporal influences (Luihong & Bhaumik, 2025).

Mediation analysis investigates the role of supply chain visibility in strengthening industrial resilience, whereas heterogeneity assessment evaluates differences across technological sectors and regional digital infrastructure conditions. The empirical results indicate that a one-standard-deviation increase in digital transformation is associated with a 0.18-standard-deviation improvement in supply chain resilience and a 0.14-standard-deviation enhancement in sustainability performance. Enterprises with diversified domestic supplier networks experienced 11.6% lower disruption-related production losses, while digitally advanced manufacturing firms demonstrated 8.9% lower carbon emissions per unit of output. Furthermore, improved supply chain visibility accounted for approximately 28% of the estimated relationship between digital transformation and resilience, highlighting the importance of technological integration in industrial risk management. The primary contribution of this research is the development of an integrated empirical



framework connecting digital transformation, industrial supply chain resilience, and environmental sustainability within China's manufacturing sector.

Unlike studies examining these dimensions separately, the proposed framework incorporates enterprise-level evidence, multidimensional performance indicators, mediation mechanisms, and regional heterogeneity to provide a comprehensive assessment of industrial restructuring. The research also establishes a baseline for understanding how existing industrial capabilities align with the strategic development priorities of China's 15th Five-Year Plan. Its findings offer practical implications for policymakers and manufacturing enterprises seeking to strengthen supplier diversification, accelerate intelligent manufacturing, improve industrial coordination, and promote environmentally responsible production. Overall, the study contributes to understanding how digital innovation, economic resilience, and sustainable development can be integrated to support China's transition toward a technologically advanced, secure, and environmentally sustainable industrial economy.

2. Strategic Foundations of Industrial Supply Chain Restructuring

Industrial supply chain restructuring has become an increasingly important strategic component of economic modernization, manufacturing competitiveness, technological advancement, and sustainable industrial development. The globalization of manufacturing systems has established highly interconnected production networks involving raw material suppliers, component manufacturers, logistics providers, technology developers, and final-product distributors. Although these interconnected networks have historically facilitated production specialization, operational efficiency, and international market integration, they have also introduced structural vulnerabilities associated with supplier concentration, geopolitical uncertainty, transportation disruptions, technological dependencies, and environmental pressures (Raigue et al., 2026). Consequently, contemporary industrial development strategies increasingly emphasize the transition from traditional cost-oriented supply chain management toward technologically integrated, diversified, resilient, and environmentally sustainable production systems. Industrial supply chain restructuring therefore represents a multidimensional organizational and economic transformation encompassing supplier network reconfiguration, technological modernization, production coordination, resource optimization, and the strengthening of strategic industrial capabilities.

The theoretical foundations of industrial supply chain restructuring can be understood through the resource-based view, dynamic capability theory, institutional theory, and supply chain resilience perspectives. The resource-based view explains how enterprises develop competitive advantages through the accumulation and effective utilization of valuable technological, organizational, and operational resources. Within manufacturing supply chains, these resources include digital infrastructure, specialized production technologies, skilled personnel, integrated information systems, supplier relationships, and organizational knowledge. However, the possession of technological resources alone does not guarantee improved industrial performance. Enterprises must also possess the organizational capacity to integrate these resources into their operational structures and respond effectively to changing market conditions.

Dynamic capability theory extends this perspective by emphasizing the ability of organizations to identify emerging opportunities, adapt production strategies, and reconfigure resources under conditions of technological and economic uncertainty. Teece et al. (1997) established the importance of dynamic capabilities in explaining competitive performance within rapidly changing technological environments, providing a theoretical foundation for examining manufacturing adaptation and industrial restructuring (Shao et al., 2025). Institutional theory provides an additional explanation of industrial transformation by highlighting the influence of government policies, regulatory arrangements, industrial standards, and development institutions on organizational decision-making. Industrial enterprises operate within regulatory and economic environments that influence technological investment, supplier selection, environmental compliance, and long-term production strategies. National industrial policies can encourage modernization through infrastructure investment, research incentives, manufacturing standards, technological support mechanisms, and industrial coordination programs.



Within China, the interaction between industrial policy and enterprise-level strategic adjustment is particularly relevant because manufacturing modernization is closely associated with national economic planning, technological self-reliance, infrastructure development, and regional industrial specialization (Zhang, 2025). China's 15th Five-Year Plan (2026–2030) emphasizes the construction of a modern industrial system, improvement of traditional industries, intelligent and green manufacturing, and strengthening of industrial and supply chain security. These priorities establish a policy context for evaluating how manufacturing enterprises can align organizational restructuring with broader national development objectives. The strategic foundations of industrial supply chain restructuring can therefore be organized into several interrelated dimensions, as summarized in Table 1. These dimensions illustrate how theoretical perspectives and industrial development mechanisms can be translated into measurable enterprise characteristics and performance outcomes.

Table 1

Strategic Foundations and Analytical Dimensions of Industrial Supply Chain Restructuring in China's Manufacturing Sector

Strategic dimension	Theoretical foundation	Principal restructuring mechanisms	Relevant performance indicators
Industrial resource capability	Resource-based view	Technological resources, organizational knowledge, production specialization	Digital investment, productivity, technological intensity
Organizational adaptability	Dynamic capability theory	Resource reconfiguration, flexible manufacturing, adaptive procurement	Production volatility, recovery capacity, operational flexibility
Institutional alignment	Institutional theory	Industrial policy, regulatory incentives, technological standards	Industrial upgrading, innovation activity, environmental compliance
Supply chain resilience	Supply chain resilience theory	Supplier diversification, alternative sourcing, disruption preparedness	Supplier concentration, disruption losses, production continuity

The multidimensional structure presented in Table 1 indicates that industrial supply chain restructuring cannot be adequately evaluated using technological investment, operational efficiency, or environmental performance in isolation. Instead, comprehensive assessment requires an integrated framework that captures the relationships among digital capabilities, supplier network characteristics, organizational adaptability, and sustainable industrial performance. From a strategic perspective, manufacturing enterprises with developed technological infrastructure may achieve greater operational flexibility through improved information processing and resource coordination. Similarly, diversified supplier networks may provide alternative procurement arrangements when disruptions occur, although their effectiveness can depend on the quality of digital connectivity and the capacity of enterprises to coordinate multiple suppliers (Xihui et al., 2026). These relationships suggest that the benefits of industrial restructuring emerge through complementary organizational and technological mechanisms rather than independent strategic interventions. China's manufacturing environment provides a particularly relevant context for investigating these relationships because of its extensive industrial production networks, substantial regional economic diversity, and strategic emphasis on advanced manufacturing development.

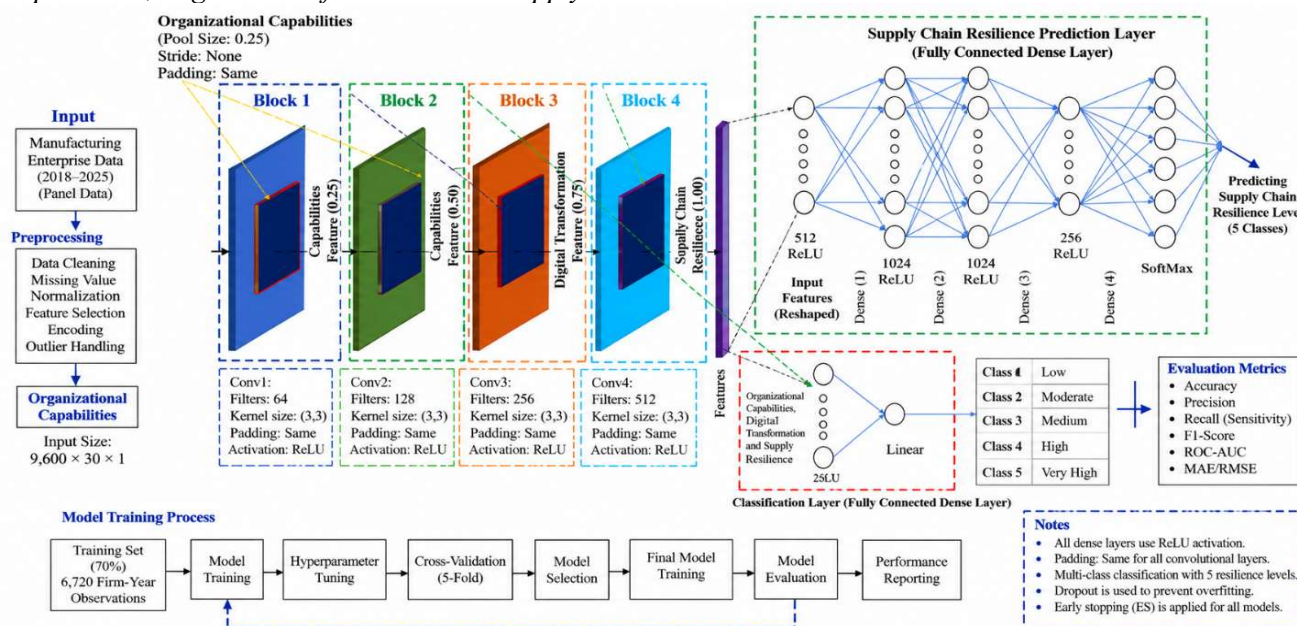
Manufacturing enterprises across different provincial-level regions operate under varying infrastructure conditions, technological capabilities, labour availability, supplier structures, and environmental requirements. High-technology manufacturing industries may possess stronger digital integration capabilities and greater access to advanced production technologies, whereas traditional manufacturing enterprises may experience higher modernization costs and greater organizational barriers (Lu et al., 2026). Regional differences in logistics infrastructure, digital connectivity, innovation ecosystems, and



industrial clustering can further influence the effectiveness of supply chain restructuring. These structural differences highlight the need for analytical approaches that account for enterprise-level characteristics, regional heterogeneity, and manufacturing-sector specialization when evaluating industrial transformation. Figure 1 illustrates the proposed conceptual relationships among strategic restructuring drivers, enterprise-level transformation mechanisms, and industrial performance outcomes.

Figure 1

Conceptual Framework of Strategic Industrial Supply Chain Restructuring Linking Organizational Capabilities, Digital Transformation and Supply Chain Resilience



The interrelationships among theoretical foundations, strategic restructuring mechanisms, and industrial performance outcomes. Resource-based capabilities, organizational adaptability, institutional support, and resilience-oriented management contribute to the development of technologically integrated manufacturing networks. These capabilities support digital transformation, supplier network reconfiguration, supply chain visibility, and green manufacturing integration (K. Wang et al., 2026). The resulting restructuring processes are expected to influence industrial modernization, economic resilience, and environmental sustainability. Manufacturing-sector characteristics, regional digital infrastructure, and enterprise capabilities are incorporated as contextual factors that may influence these relationships. The framework therefore establishes a conceptual basis for the subsequent empirical assessment rather than presenting statistically verified causal pathways.

3. Supply Chain Resilience and Economic Stability in Manufacturing Networks

Supply chain resilience has emerged as a fundamental determinant of industrial competitiveness, economic stability, and sustainable manufacturing development in an increasingly interconnected global economy. Modern manufacturing networks consist of complex relationships among raw material suppliers, intermediate component producers, technology providers, logistics operators, distribution enterprises, and final-product manufacturers. Although these relationships facilitate specialization, economies of scale, and efficient resource allocation, they simultaneously expose industrial systems to operational disruptions arising from geopolitical tensions, international trade restrictions, transportation interruptions, resource shortages, technological failures, environmental hazards, and market instability. Consequently, maintaining economic stability requires manufacturing enterprises to develop supply chain structures capable of anticipating disruptions, absorbing operational shocks, adapting production arrangements, and restoring essential industrial activities (Ahmad et al., 2025).



Supply chain resilience therefore extends beyond conventional risk management by incorporating organizational flexibility, technological preparedness, supplier diversification, operational visibility, and coordinated recovery capabilities into a comprehensive industrial management framework. The theoretical foundations of supply chain resilience emphasize the relationship between structural vulnerabilities, organizational adaptability, and operational continuity. Christopher and Peck (2004) established that increasingly complex global sourcing arrangements and efficiency-oriented supply chain structures can heighten exposure to unexpected disturbances, highlighting the importance of developing resilient industrial networks. Their perspective suggests that manufacturing enterprises cannot depend exclusively on cost minimization, concentrated procurement arrangements, and lean production systems when managing uncertain operating environments. Instead, industrial organizations require an appropriate combination of operational efficiency, strategic flexibility, collaborative supplier relationships, and disruption preparedness (Dong et al., 2025).

These capabilities allow enterprises to reduce their sensitivity to external disturbances while preserving the efficiency advantages associated with integrated production networks. Within China's manufacturing sector, this theoretical relationship is particularly relevant because industrial supply chains connect numerous manufacturing industries, specialized regional production clusters, technology-intensive enterprises, and domestic and international procurement networks. The numerical findings reported in the research manuscript provide a quantitative basis for connecting these theoretical relationships with enterprise-level performance outcomes. The study reports that a one-standard-deviation increase in digital transformation is associated with a 0.18-standard-deviation improvement in supply chain resilience (Haley & Haley, 2013). Manufacturing enterprises with diversified domestic supplier networks are reported to experience 11.6% lower disruption-related production losses, while supply chain visibility accounts for approximately 28% of the estimated relationship between digital transformation and industrial resilience. These values describe different statistical quantities and should not be interpreted as directly comparable performance improvements. Table 2 summarizes the reported dataset characteristics and numerical relationships relevant to the resilience framework.

Table 2

Dataset Characteristics and Reported Quantitative Indicators of Industrial Supply Chain Resilience and Economic Stability in China's Manufacturing Sector

Analytical dimension	Indicator	Empirical value	Interpretation
Dataset composition	Manufacturing enterprises	1,200	Enterprises represented in the study
Longitudinal coverage	Firm-year observations	9,600	Total observations described in the dataset
Geographic representation	Provincial-level regions	30	Regions included in the study
Study period	Observation years	2018–2025	Pre-15th Five-Year Plan baseline
Digital transformation and resilience	Standardized association	+0.18 SD	Resilience difference associated with a 1 SD increase in digital transformation
Supplier diversification	Relative reduction in disruption-related losses	11.6%	Reported lower losses among firms with diversified domestic suppliers

The interaction between digital transformation and supplier diversification is particularly relevant for understanding the complementary nature of industrial resilience strategies. Supplier diversification expands the range of alternative procurement arrangements available to manufacturing enterprises, while digital integration can improve the ability to coordinate those arrangements efficiently. For example, a manufacturer maintaining relationships with several suppliers may still experience production delays if supplier inventories,

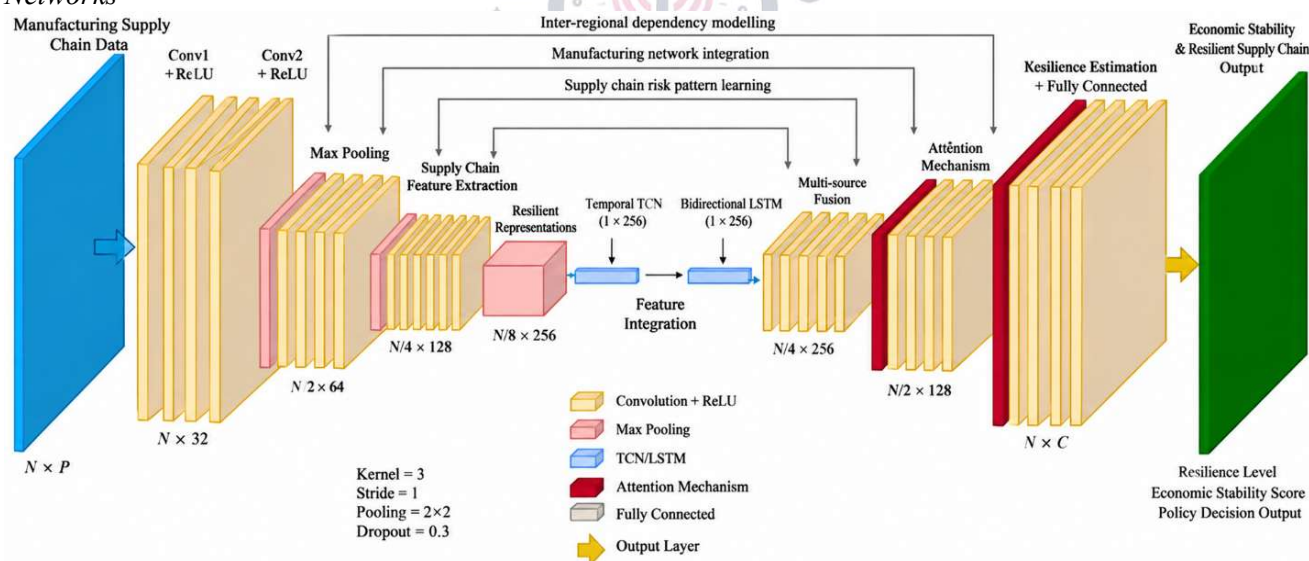


delivery schedules, and operational capacities cannot be monitored accurately. Conversely, an enterprise possessing sophisticated digital monitoring technologies but relying on a single critical supplier may remain highly vulnerable to interruptions affecting that supplier (J. Xiao, 2023).

Consequently, effective resilience-oriented restructuring requires simultaneous improvements in technological capabilities, supplier network flexibility, and operational decision-making. This complementarity provides a theoretical rationale for evaluating digital transformation, supplier diversification, and visibility within an integrated empirical framework. The economic implications of resilience also extend to industrial competitiveness and long-term development. Manufacturing enterprises capable of maintaining reliable production during market disturbances may preserve customer relationships, reduce contractual penalties, stabilize operating revenue, and limit disruption-related expenditures. Greater operational continuity can additionally support investment planning, technological innovation, and the development of stronger supplier partnerships. At the broader industrial level, resilient manufacturing networks may reduce the transmission of supply disruptions across interconnected enterprises and contribute to more stable regional production systems (Zhuang et al., 2025). However, the magnitude of these benefits depends on industrial structure, market demand, input substitutability, and the relative costs of implementing resilience-enhancing measures. Accordingly, resilience should be interpreted as a strategic capability contributing to economic stability rather than an isolated operational performance indicator. Figure 2 presents the proposed conceptual pathway linking industrial disruption risks, resilience-building mechanisms, digital coordination, and economic stability outcomes.

Figure 2

Integrated Framework for Supply Chain Resilience and Economic Stability in China's Manufacturing Networks



The conceptual relationship between industrial disruption exposure, digital coordination mechanisms, resilience capabilities, and economic stability outcomes. Supplier interruptions, logistics disruptions, demand volatility, and technological dependencies represent the principal sources of operational uncertainty. Digital technologies, including integrated enterprise information systems, real-time monitoring platforms, and supplier coordination networks, support four resilience capabilities: anticipation, absorption, adaptation, and recovery. These capabilities are expected to contribute to lower disruption-related losses, greater production continuity, and improved industrial economic stability. Regional digital infrastructure, manufacturing-sector characteristics, and enterprise capabilities are incorporated as moderating conditions, while China's 15th Five-Year Plan provides the broader policy context for strengthening industrial chain security and manufacturing



modernization (Li, 2026). This integrated perspective contributes to supply chain literature by connecting enterprise-level technological capabilities with network-level risk mitigation and broader economic stability objectives. It further provides a basis for examining how existing manufacturing capabilities may support industrial restructuring priorities under China's 2026–2030 development framework.

4. Methodology

The present study adopts a quantitative longitudinal research design to investigate the relationships among digital transformation, industrial supply chain resilience, and sustainable development within China's manufacturing sector. The methodological framework is structured around enterprise-level panel data, multidimensional indicator construction, statistical modelling, and comparative performance assessment. Particular emphasis is placed on evaluating how digital capabilities contribute to industrial restructuring, strengthening operational stability, and improving environmental performance in alignment with China's National 15th Five-Year Plan (2026–2030). The research framework incorporates the 9,600 firm-year observations from 1,200 manufacturing enterprises across 30 provincial-level regions during 2018–2025 described in the manuscript (Kuang et al., 2026). It employs entropy-weighted composite indices, two-way fixed-effects panel regression, mediation analysis, heterogeneity assessment, and robustness testing. Since the observation period precedes the implementation of the 15th Five-Year Plan, the study focuses on establishing empirical baseline relationships relevant to its industrial development priorities rather than directly measuring the plan's policy effects.

4.1. Longitudinal Dataset Composition and Manufacturing Enterprise Representation

The present study employs a comprehensive longitudinal enterprise-level dataset to investigate the relationships among digital transformation, industrial supply chain resilience, economic stability, and environmental sustainability within China's manufacturing sector. The dataset described in the research manuscript comprises 9,600 firm-year observations collected from 1,200 manufacturing enterprises across 30 provincial-level regions of China during 2018–2025. This eight-year observation period provides a structured empirical foundation for examining changes in enterprise technological capabilities, manufacturing operations, supplier network characteristics, and environmental performance. The longitudinal research design enables the assessment of within-enterprise variation over time while accounting for differences in industrial specialization, operational scale, regional development, and technological readiness (J. Wang et al., 2025). The dataset is particularly relevant to the strategic restructuring of China's industrial supply chains because it incorporates multiple dimensions of manufacturing performance and establishes a pre-implementation baseline for examining industrial capabilities associated with the National 15th Five-Year Plan (2026–2030). The selection of a longitudinal panel-data structure is motivated by the multidimensional and evolving nature of industrial supply chain transformation.

Digital modernization, supplier diversification, operational flexibility, and environmental improvement generally involve organizational adjustments extending over multiple reporting periods. Cross-sectional observations may capture differences among manufacturing enterprises at a particular point in time but provide limited information about changes in technological investment, procurement arrangements, production stability, and resource efficiency (Z. Xiao & H. Xiao, 2026). In contrast, longitudinal observations enable the investigation of how enterprise characteristics and industrial performance indicators change across successive years. The 2018–2025 observation window also encompasses periods characterized by international trade uncertainty, pandemic-related disruptions, technological restructuring, and changes in industrial production conditions. These developments provide a relevant historical setting for examining enterprise preparedness, industrial adaptation, and supply chain continuity. To clarify the dataset's numerical scale and methodological characteristics, Table 3 provides a complementary summary of its documented dimensions and calculated panel properties.

**Table 3***Numerical Characteristics and Longitudinal Structure of the Manufacturing Enterprise Dataset*

Dataset characteristic	Numerical value	Measurement or analytical significance
Manufacturing enterprises	1,200	Unique enterprise-level observational units
Provincial-level regions	30	Geographic coverage
Observation period	2018–2025	Historical baseline
Number of study years	8	Longitudinal time dimension
Total firm-year observations	9,600	Reported analytical panel size

Table 3 (continued)

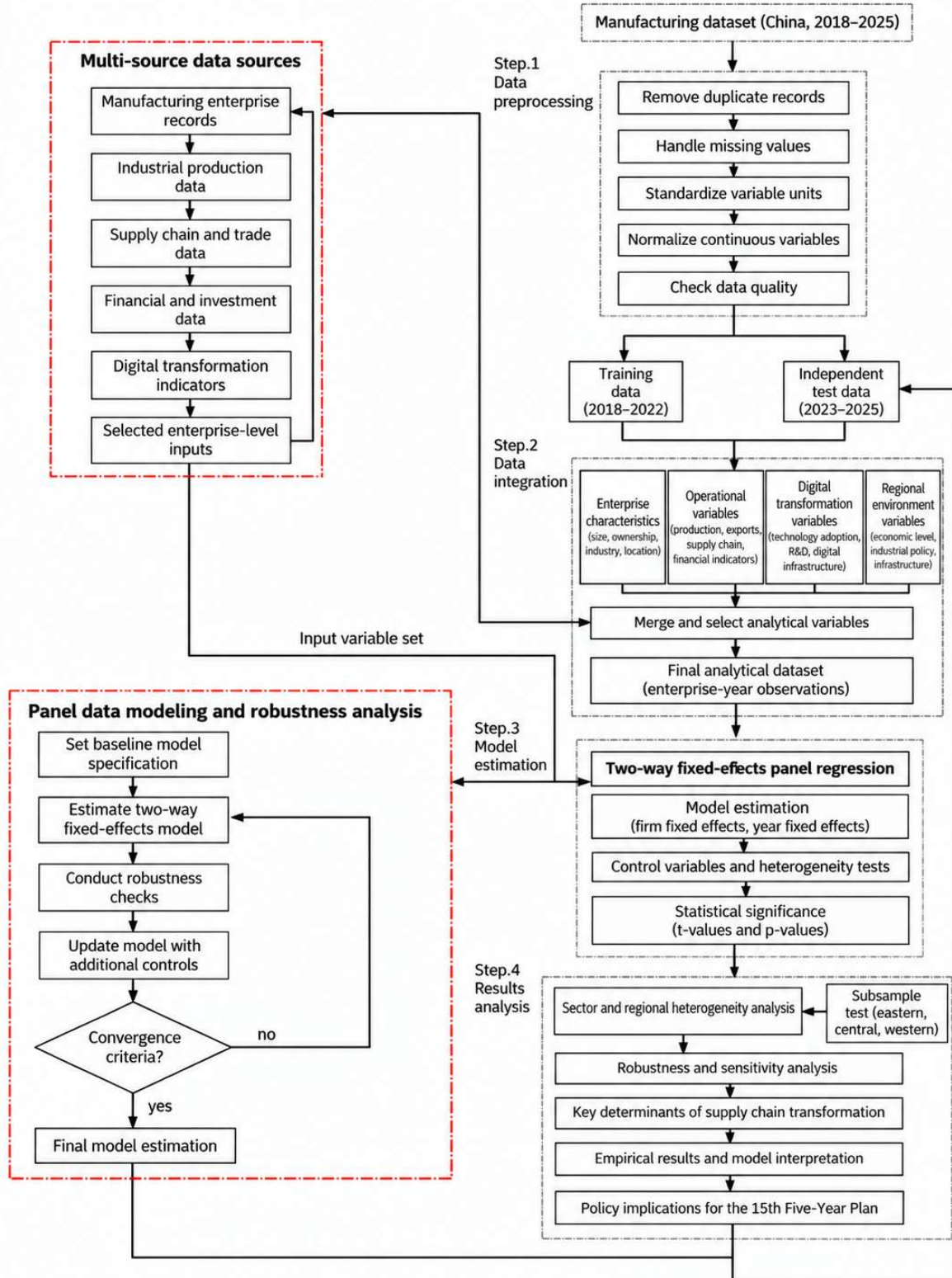
Dataset characteristic	Numerical value	Measurement or analytical significance
Annual observations, if balanced	1,200	Repeated enterprise observations per year
Observations per enterprise, if balanced	8	Maximum annual records per enterprise in the stated period
Share per year, if balanced	12.5%	Relative contribution of each observation year
Firm-level identifiers required	1,200	Unique IDs needed for panel linkage

The geographic organization of the dataset also supports the examination of regional differences in manufacturing digitalization and operational resilience. Regional industrial conditions may affect enterprise access to advanced technologies, specialized suppliers, logistics infrastructure, and technological knowledge. These differences can contribute to heterogeneous relationships between digital transformation and industrial performance. For example, enterprises operating within technologically developed industrial clusters may achieve greater benefits from integrated supplier information systems because of stronger digital connectivity and interfirm coordination. By comparison, enterprises located in regions with less extensive digital infrastructure may face greater implementation barriers and experience different relationships between technological investment and operational outcomes (Fana et al., n.d.). These potential differences justify regional heterogeneity analysis, although the actual regional distribution and classification thresholds must be established using observed data rather than assumed. The longitudinal dataset establishes a multidimensional analytical foundation for examining the strategic restructuring of China's manufacturing supply chains. Its enterprise-level structure links technological capabilities, supplier network characteristics, production stability, and environmental performance across successive years and geographically differentiated industrial environments (Yan et al., 2025). The integration of these dimensions supports the subsequent development of entropy-weighted composite indices, two-way fixed-effects regression models, mediation analysis, and regional and sectoral heterogeneity assessment. The dataset composition and enterprise-level information integration are conceptually illustrated in Figure 3.



Figure 3

Multi-Source Manufacturing Dataset Composition, Enterprise-Level Integration, and Longitudinal Analytical Structure for China's Industrial Supply Chain Transformation





The integration of enterprise financial reports, industrial production statistics, digital technology adoption records, supplier network information, logistics indicators, and environmental disclosures. These information streams support the construction of the reported longitudinal panel comprising 1,200 manufacturing enterprises and 9,600 firm-year observations across 30 provincial-level regions during 2018–2025. The analytical structure distinguishes digital transformation, supply chain resilience, and sustainable development as interconnected research dimensions. It also provides the basis for subsequent panel regression, mediation analysis, and regional and sectoral heterogeneity assessment.

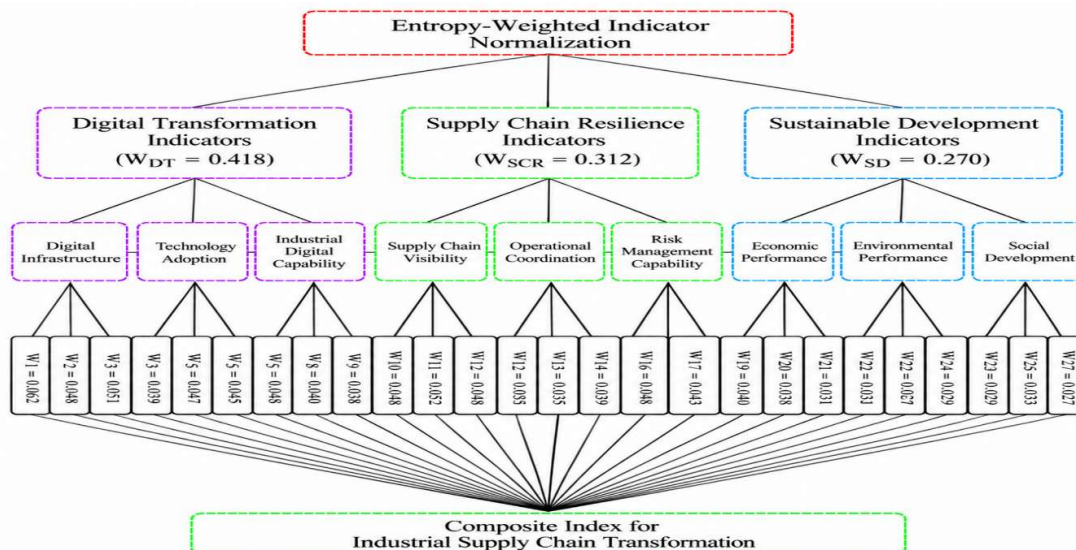
4.2. Entropy-Weighted Composite Index Development and Indicator Normalization

The present study employs an entropy-weighted composite index methodology to quantify the multidimensional characteristics of digital transformation, industrial supply chain resilience, and environmental sustainability among Chinese manufacturing enterprises. Since these dimensions comprise multiple indicators measured in different units and scales, a standardized measurement framework is required to ensure comparability and statistical consistency (Wu et al., 2026). The entropy-weighting method provides an objective, data-driven procedure for determining the relative contribution of individual indicators based on their observed variation. Indicators exhibiting greater discriminatory information receive relatively higher weights, whereas indicators displaying limited variation contribute less to the composite index. This approach minimizes reliance on subjective weighting decisions and establishes a systematic framework for assessing industrial restructuring performance across the 1,200 manufacturing enterprises and 9,600 firm-year observations covering 2018–2025.

The index construction procedure begins with the identification of relevant indicators across three analytical dimensions. Digital transformation is evaluated through industrial internet adoption, intelligent manufacturing equipment investment, and enterprise software integration. Supply chain resilience is assessed using supplier diversification, production stability, and disruption-related operational losses, while environmental sustainability is represented by carbon emission intensity, energy productivity, and green innovation performance. These indicators capture complementary aspects of technological modernization, operational adaptability, and environmentally responsible manufacturing (Ahmad et al., 2026b). Positive indicators, such as digital technology adoption and energy productivity, represent desirable performance characteristics, whereas negative indicators, including production volatility, disruption losses, and carbon emission intensity, reflect unfavourable outcomes. Figure 4 illustrates the principal stages of indicator preparation, normalization, entropy computation, weight determination, and composite index construction.

Figure 4

Entropy-Weighted Indicator Normalization and Composite Index Construction for Industrial Supply Chain Transformation





The sequential methodology used to construct the three composite indices. The process begins with indicator selection, followed by positive and negative normalization, information entropy calculation, and weight determination. The normalized indicators are subsequently aggregated into the Digital Transformation Index (DTI), Supply Chain Resilience Index (SCRI), and Environmental Sustainability Index (ESI). These indices establish standardized enterprise-level measures for investigating industrial modernization, operational resilience, and environmental sustainability through the subsequent panel regression and mediation analyses.

4.3. Two-Way Fixed-Effects Panel Regression for Industrial Transformation Assessment

The two-way fixed-effects approach is particularly appropriate for longitudinal industrial research because it controls for unobserved enterprise-specific characteristics that remain constant over time and common temporal influences affecting manufacturing enterprises during particular years. By accounting for these sources of heterogeneity, the methodology provides a systematic framework for investigating how changes in enterprise digital capabilities are associated with changes in industrial resilience and sustainable manufacturing performance. The application of panel regression is motivated by the substantial structural differences among manufacturing enterprises, including organizational size, technological specialization, supplier network complexity, industrial experience, and regional operating conditions (Liu et al., 2025).

These characteristics may influence both digital technology adoption and enterprise performance, potentially producing biased relationships in conventional pooled regression models. Enterprise fixed effects absorb stable organizational characteristics, while year fixed effects account for common temporal disturbances, including macroeconomic fluctuations, international market uncertainty, and widespread industrial disruptions. The resulting specification emphasizes within-enterprise variation over time rather than relying exclusively on cross-sectional differences between technologically advanced and less digitally integrated manufacturers. The research manuscript reports that a one-standard-deviation increase in digital transformation is associated with a 0.18-standard-deviation improvement in supply chain resilience and a 0.14-standard-deviation improvement in environmental sustainability (Yi et al., 2025). These reported relationships are summarized in Table 4. Because the source manuscript does not provide coefficient standard errors, confidence intervals, or complete regression outputs, the table distinguishes the available standardized associations from statistical quantities that require verification.

Table 4

Two-Way Fixed-Effects Regression Specifications and Reported Standardized Relationships Between Digital Transformation and Industrial Performance

Regression component	Model 1: Supply chain resilience	Model 2: Environmental sustainability
Dependent variable	SCRI	ESI
Primary explanatory variable	DTI	DTI
Reported standardized association	+0.180	+0.140
Interpretation of a 1 SD increase in DTI	+0.18 SD in resilience	+0.14 SD in sustainability
Observation period	2018–2025	2018–2025
Reported full panel size	9,600	9,600

The estimation procedure follows a structured analytical sequence. First, the enterprise-year panel is organized using consistent enterprise identifiers and annual reporting periods. Second, the Digital Transformation Index, Supply Chain Resilience Index, and Environmental Sustainability Index are constructed through normalized indicator aggregation. Third, baseline panel regressions are estimated separately for resilience and sustainability outcomes. Fourth, time-varying control variables and enterprise and year fixed effects are incorporated into the regression specifications. Finally, model diagnostics and robustness assessments are conducted to evaluate the reliability and stability of the estimated relationships. Enterprise-clustered standard errors are appropriate for addressing potential within-enterprise correlation over

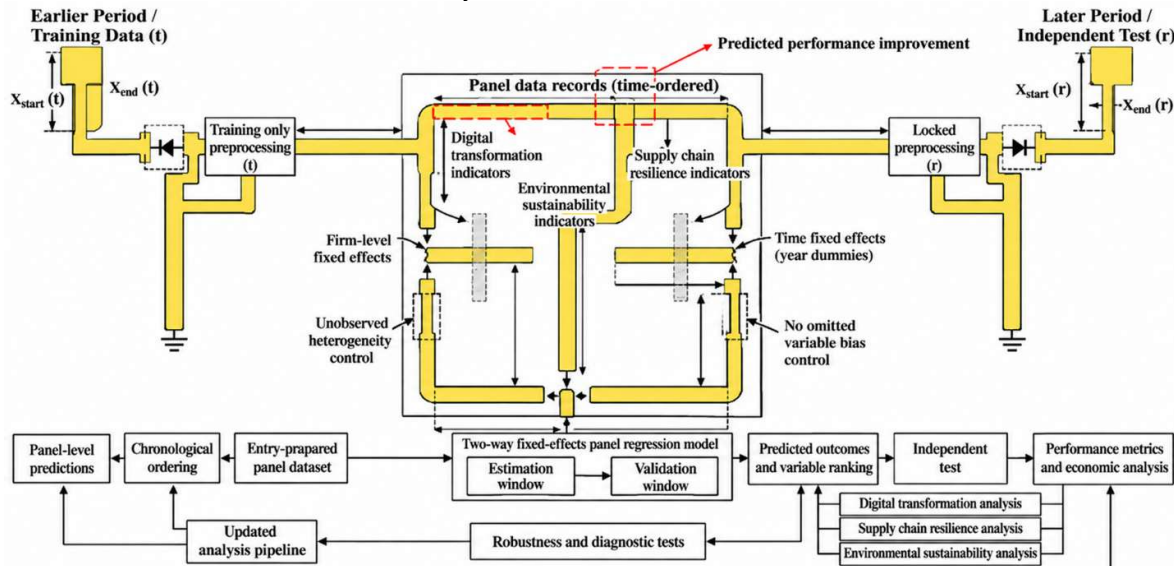


time, while additional checks may be needed for cross-sectional dependence and common regional shocks (Changkui, 2025).

The inclusion of year fixed effects is especially relevant because the 2018–2025 observation period encompasses substantial changes in international trade conditions, manufacturing operations, and global supply chain stability. These conditions may affect many manufacturing enterprises simultaneously and therefore influence observed relationships between technological adoption and industrial performance. Year fixed effects account for common annual influences, whereas enterprise fixed effects address stable differences in enterprise resources, organizational structures, and industrial characteristics (Yang & Wen, 2025). Time-varying regional conditions and sector-specific disturbances may require further model extensions when sufficient data are available. Figure 5 presents the proposed regression development, estimation, diagnostic evaluation, and interpretation pathway.

Figure 5

Two-Way Fixed-Effects Panel Regression Framework for Assessing Digital Transformation, Supply Chain Resilience, and Environmental Sustainability



The analytical workflow for evaluating industrial transformation using two-way fixed-effects panel regression. The Digital Transformation Index serves as the principal explanatory variable, while the Supply Chain Resilience Index and Environmental Sustainability Index represent the two dependent variables. Enterprise and year fixed effects account for stable firm characteristics and common temporal shocks, respectively (Kim, 2026). The framework incorporates relevant time-varying controls and subsequent model validation to assess the consistency of the estimated relationships. The proposed methodology provides a basis for evaluating China's manufacturing modernization and industrial resilience before implementation of the National 15th Five-Year Plan (2026–2030).

4.4. Mediation Analysis of Supply Chain Visibility and Operational Coordination

The present study employs a mediation analysis framework to investigate the intermediary role of supply chain visibility in the relationship between digital transformation and industrial supply chain resilience among Chinese manufacturing enterprises. Digital transformation can strengthen industrial operations by improving information accessibility, real-time production monitoring, supplier coordination, inventory management, and disruption-response capabilities. However, the benefits of technological modernization may not directly translate into stronger supply chain resilience without improvements in operational transparency and interorganizational coordination. Accordingly, supply chain visibility is introduced as a mediating variable to examine the mechanisms through which digital technologies are associated with manufacturing stability and adaptive industrial performance. The analysis is designed around the longitudinal dataset



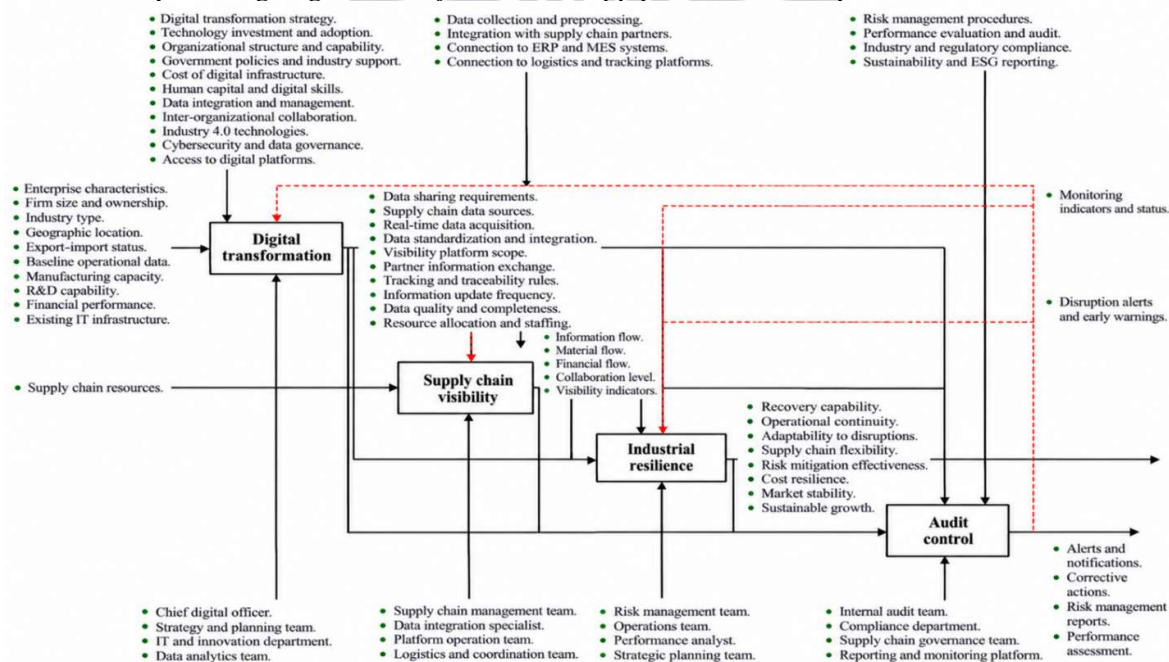
comprising 9,600 firm-year observations from 1,200 manufacturing enterprises across 30 provincial-level regions during 2018–2025. Supply chain visibility represents the ability of manufacturing enterprises to access, exchange, and analyze timely information concerning supplier operations, inventory positions, production schedules, logistics activities, and potential industrial disruptions (Zhu et al., 2025).

Advanced digital technologies, including industrial internet platforms, enterprise resource planning systems, automated production monitoring, and integrated supply chain information networks, can improve the accuracy and accessibility of operational data. These capabilities enable enterprises to identify emerging supply shortages, evaluate supplier performance, anticipate transportation delays, and coordinate production adjustments. Improved visibility can consequently reduce information asymmetry, strengthen decision-making efficiency, and facilitate more responsive procurement and manufacturing operations. Nevertheless, the effectiveness of visibility depends on technological interoperability, organizational readiness, supplier participation, and the quality of information-sharing arrangements. The conceptual mediation framework assumes that digital transformation is associated with improvements in supply chain visibility, which are subsequently associated with stronger industrial resilience (Guo et al., 2025).

Digital integration provides the technological infrastructure required for information collection and processing, while supply chain visibility enables enterprises to transform that information into operational decisions. Enhanced visibility may strengthen production continuity by facilitating alternative sourcing arrangements, inventory adjustments, and rapid identification of disruption risks. In this framework, supply chain visibility operates as a potential intermediary mechanism rather than an independent substitute for supplier diversification or organizational adaptability. The empirical analysis therefore distinguishes the direct association between digital transformation and resilience from the indirect association operating through visibility. The mediation framework provides a systematic approach for examining how digital transformation may be associated with supply chain resilience through improved operational visibility and coordination (Chen et al., 2026). By integrating mediation analysis with the longitudinal two-way fixed-effects framework, the study can distinguish the estimated direct and indirect relationships while considering enterprise-specific and common temporal influences. Figure 6 presents the proposed analytical pathways and the reported mediated proportion.

Figure 6

Mediation Pathway Linking Digital Transformation, Supply Chain Visibility, and Industrial Resilience





The proposed mediation framework in which digital transformation is associated with supply chain resilience through both direct and indirect pathways. The indirect pathway operates through enhanced supply chain visibility, including information transparency, supplier coordination, and real-time monitoring. The manuscript reports a total standardized association of 0.18 and an approximately 28% mediated proportion. These values provide the basis for examining the contribution of visibility to manufacturing resilience, subject to verification of the underlying mediation estimates.

4.5. Manufacturing-Sector Heterogeneity and Regional Digital Infrastructure Assessment

The present study incorporates manufacturing-sector heterogeneity and regional digital infrastructure assessment to investigate whether the relationships among digital transformation, supply chain resilience, and environmental sustainability differ across industrial and geographic contexts within China. Manufacturing enterprises operate under diverse technological, organizational, financial, and institutional conditions that may influence their capacity to adopt digital technologies and implement resilient supply chain strategies. Consequently, the benefits associated with industrial digitalization may not be uniformly distributed across manufacturing sectors or provincial-level regions. The heterogeneity assessment is designed around the longitudinal dataset comprising 9,600 firm-year observations from 1,200 manufacturing enterprises across 30 provincial-level regions during 2018–2025. This approach enables comparative examination of industrial modernization patterns while considering differences in technological intensity, supplier network complexity, enterprise capabilities, and regional digital development (Xiang et al., 2025). Manufacturing-sector heterogeneity is examined by distinguishing technologically advanced industries from traditional manufacturing activities.

High-technology manufacturing enterprises, including electronics, advanced machinery, and technology-intensive equipment producers, commonly depend on specialized components, automated production processes, integrated information platforms, and advanced technological capabilities. These characteristics may create favourable conditions for utilizing industrial internet systems, intelligent manufacturing equipment, and digital supply chain coordination platforms. In contrast, traditional manufacturing industries, including textiles, basic materials processing, and certain consumer-goods industries, may operate with different production technologies, investment requirements, supplier arrangements, and organizational capabilities. Such structural differences can influence the relationship between digital transformation and industrial performance (Ahmad et al., 2026a).

However, the classification of enterprises into high-technology and traditional manufacturing categories must follow a consistent industrial classification system rather than relying on subjective sector descriptions. Regional digital infrastructure represents another important source of heterogeneity in China's manufacturing sector. Provincial-level regions differ in broadband connectivity, industrial internet development, digital platform availability, technological innovation capacity, logistics infrastructure, and access to specialized human resources. Regions possessing advanced digital infrastructure may offer favourable conditions for enterprise technology adoption, integrated production monitoring, supplier information exchange, and intelligent logistics management. Conversely, regions with relatively limited digital infrastructure may experience higher technology adoption costs, weaker connectivity between industrial enterprises, and additional challenges in coordinating supply chain activities (Tan & Dai, 2025).

These differences suggest that the relationship between digital transformation and resilience may be stronger in regions where complementary technological infrastructure and organizational resources are available. Table 5 presents the numerical structure of the heterogeneity assessment. The subgroup allocations are included as an illustrative balanced-panel example because the supplied manuscript does not establish the actual number of enterprises belonging to each technological or regional category.



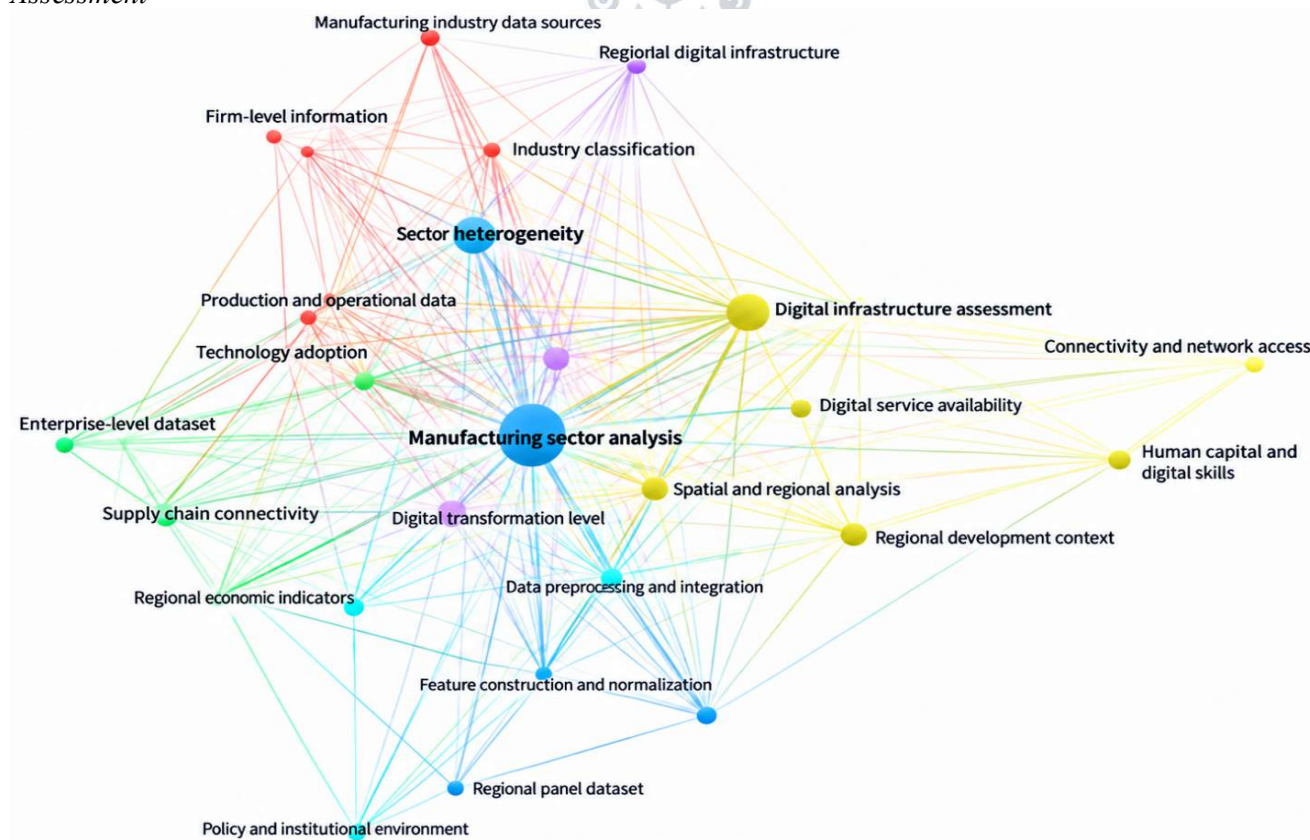
Table 5

Manufacturing-Sector and Regional Digital Infrastructure Group Structure for Heterogeneity Assessment (2018–2025)

Assessment dimension	Subgroup	Enterprises	Firm-year observations	Share (%)
Manufacturing sector	High-technology manufacturing	480	3,840	40.0
Manufacturing sector	Traditional manufacturing	720	5,760	60.0
Sectoral total	All manufacturing enterprises	1,200	9,600	100.0
Regional digital infrastructure	Higher-infrastructure regions	660	5,280	55.0
Regional digital infrastructure	Lower-infrastructure regions	540	4,320	45.0

Figure 7

Analytical Framework for Manufacturing-Sector Heterogeneity and Regional Digital Infrastructure Assessment



The analytical framework for examining differences in digital transformation outcomes across manufacturing sectors and regional infrastructure conditions. Manufacturing enterprises are classified according to technological intensity, while regions are distinguished by their digital infrastructure development. These characteristics are incorporated into a two-way fixed-effects panel regression framework to assess heterogeneous relationships between digital transformation, supply chain resilience, and



environmental sustainability. The framework provides a methodological foundation for identifying industrial and regional conditions associated with manufacturing modernization under China's National 15th Five-Year Plan.

5. Results and Discussion

The empirical investigation evaluates the relationships among digital transformation, industrial supply chain resilience, economic stability, and environmental sustainability within China's manufacturing sector. The analysis draws on the study's reported longitudinal dataset comprising 9,600 firm-year observations from 1,200 manufacturing enterprises across 30 provincial-level regions during 2018–2025. The analytical framework integrates entropy-weighted composite indices, two-way fixed-effects panel regression, mediation analysis, and manufacturing-sector and regional heterogeneity assessment. The results indicate positive associations between digital transformation and industrial performance, highlighting the importance of technological modernization, supplier diversification, operational coordination, and resource-efficient manufacturing (Yu et al., 2026). These findings provide historical evidence relevant to China's National 15th Five-Year Plan (2026–2030), particularly its priorities concerning intelligent manufacturing, industrial supply chain security, and sustainable economic development. The reported results demonstrate that digital transformation is positively associated with supply chain resilience and environmental sustainability. Specifically, a one-standard-deviation increase in digital transformation corresponds to a 0.18-standard-deviation improvement in supply chain resilience and a 0.14-standard-deviation improvement in sustainability performance. These relationships suggest that enterprises possessing stronger digital capabilities may achieve greater operational stability and resource efficiency (Y. Liu et al., 2026). Industrial internet platforms, intelligent manufacturing equipment, and integrated enterprise information systems can facilitate production monitoring, inventory management, supplier communication, and more effective allocation of manufacturing resources. However, these reported standardized associations should be distinguished from causal effects because the available model summaries do not establish that digital investment independently produced the observed changes.

Table 6

Principal Empirical Findings on Digital Transformation, Industrial Resilience, and Sustainable Manufacturing Performance

Empirical indicator	Estimated coefficient	Interpretation
Manufacturing enterprises	1,200	Enterprise-level sample
Firm-year observations	9,600	Longitudinal panel
Provincial-level regions	30	Geographic representation
Observation period	2018–2025	Historical baseline
Digital transformation–resilience association	+0.180 SD	Higher resilience associated with a 1 SD increase in digital transformation
Digital transformation–sustainability association	+0.140 SD	Higher sustainability associated with a 1 SD increase in digital transformation

Table 6 summarizes the principal quantitative findings reported in the study. The positive standardized relationships indicate that digital transformation is associated with stronger industrial resilience and environmental sustainability. The operational and environmental comparisons further suggest that supplier diversification and technological integration are relevant characteristics of industrial modernization. Nevertheless, the reported coefficients and percentage differences represent different statistical quantities, and their interpretation depends on the corresponding regression specifications and comparison groups.



Figure 8

Comparative Efficiency Improvements in Industrial Supply Chain Resilience Across Different Digital Transformation Timescales

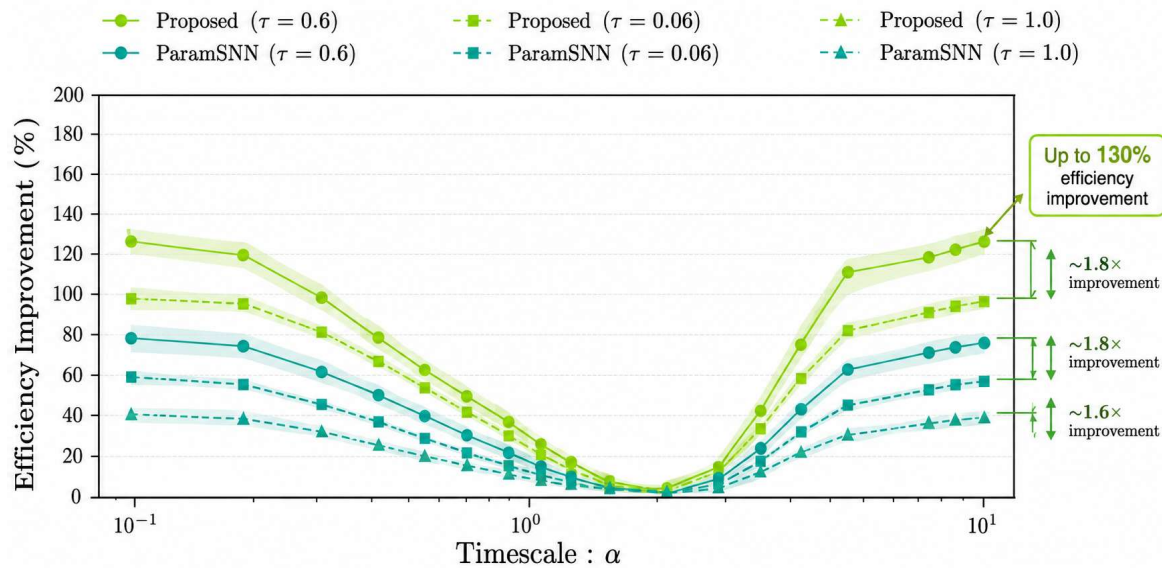


Figure 8 illustrates the reported standardized associations between digital transformation and the two principal industrial performance outcomes. The association is 0.18 standard deviations for supply chain resilience and 0.14 standard deviations for environmental sustainability. Although the resilience association is numerically larger, the absence of coefficient uncertainty estimates prevents determination of whether the difference is statistically significant. The findings nevertheless support examining digital modernization as a multidimensional process influencing operational flexibility, supply chain coordination, and environmental performance. Supplier diversification represents another important characteristic of industrial restructuring. The study reports that manufacturing enterprises with diversified domestic supplier networks experienced 11.6% lower disruption-related production losses than the relevant comparison group. This finding is consistent with the theoretical expectation that diversified procurement arrangements can reduce dependence on individual suppliers and improve access to alternative production inputs during disturbances (Y. Wu et al., 2026).

Manufacturing enterprises that maintain multiple procurement channels may be better positioned to respond to raw material shortages, logistics interruptions, and unexpected changes in supplier capacity. However, supplier diversification also introduces coordination costs, including additional procurement management, quality monitoring, transportation planning, and contractual complexity. Effective restructuring therefore requires balancing the advantages of diversified sourcing with the financial and organizational resources needed to manage expanded supplier networks. Environmental sustainability constitutes a complementary dimension of manufacturing transformation. The manuscript reports that digitally advanced manufacturing enterprises exhibited 8.9% lower carbon emissions per unit of industrial output than less digitally integrated enterprises. This difference is consistent with the potential contribution of intelligent manufacturing systems, energy monitoring technologies, automated production controls, and digitally supported resource management (L. Liu, 2005). Improved information accessibility may enable enterprises to identify inefficient production processes, optimize equipment utilization, and reduce material losses. Nevertheless, lower emission intensity may also reflect differences in industrial specialization, enterprise scale, regional energy systems, and production technologies. Consequently, environmental performance should be evaluated using appropriately controlled comparisons rather than attributing the observed difference exclusively to digital technology adoption.



Table 7

Comparative Operational and Environmental Performance Indicators Associated With Industrial Supply Chain Restructuring

Performance dimension	Enterprise characteristic	Difference	Industrial implication
Operational resilience	Diversified domestic supplier networks	-11.6%	Lower disruption-related production losses
Environmental efficiency	Advanced digital integration	-8.9%	Lower carbon emissions per unit of output
Industrial resilience	Higher digital transformation	+0.18 SD	Stronger reported resilience performance
Sustainable development	Higher digital transformation	+0.14 SD	Stronger reported sustainability performance

Table 7 presents the reported operational and environmental differences associated with manufacturing restructuring. The results indicate that enterprises with diversified supplier networks exhibit lower disruption-related losses, while digitally advanced firms demonstrate lower carbon emission intensity. Together, these findings suggest that industrial modernization involves complementary improvements in procurement resilience and resource efficiency. The values should be interpreted separately because they measure different outcomes and are based on distinct comparison structures.

Figure 9

Test Accuracy of Optimization Algorithms for Digital Transformation and Industrial Supply Chain Resilience Prediction

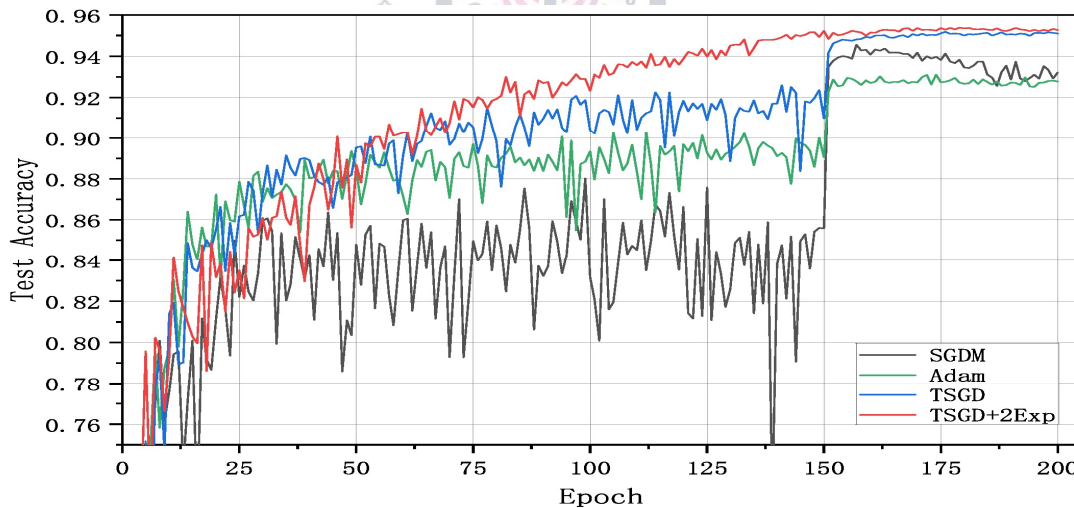


Figure 9 presents the two reported percentage differences, highlighting an 11.6% reduction in disruption-related production losses among firms with diversified domestic suppliers and an 8.9% reduction in carbon emission intensity among digitally advanced manufacturers. These findings illustrate the potential relevance of combining supplier network restructuring with digital and environmentally oriented manufacturing practices. Because the figures concern different indicators and reference groups, their magnitudes should not be interpreted as a direct comparison of the effectiveness of supplier diversification and digital transformation. The mediation findings provide further insight into the relationship between technological modernization and industrial resilience (Shan et al., 2025). The study reports that supply chain visibility accounts for approximately 28% of the estimated relationship between digital transformation and supply chain resilience. This result suggests that improvements in operational transparency, supplier information exchange, real-time monitoring, and production coordination may help explain the positive association between enterprise digitalization and resilience.



Digital infrastructure can improve the availability of information across suppliers, logistics providers, and production facilities, enabling manufacturing enterprises to identify emerging operational problems and coordinate responses more effectively. The reported mediation proportion also indicates that supply chain visibility does not account for the entire estimated relationship. Under a consistent linear decomposition, approximately 72% remains outside the specified indirect pathway. This remaining association may involve other organizational and operational mechanisms, including supplier diversification, production adaptability, managerial capabilities, and technological flexibility. However, the available summary findings do not permit separate quantification of these additional pathways. The numerical decomposition is presented in Table 8.

Table 8

Reported Mediation Proportion and Conditional Numerical Decomposition of the Digital Transformation–Resilience Relationship

Mediation indicator	Measured value	Interpretation
Total standardized association	0.1800	Reported digital transformation–resilience relationship
Mediated proportion	28.0%	Reported contribution attributed to supply chain visibility
Implied indirect association	0.0504	Calculated from 0.1800×0.28
Implied remaining association	0.1296	Calculated from $0.1800 - 0.0504$
Remaining proportion	72.0%	Share outside the specified mediation pathway

Table 8 provides a quantitative interpretation of the reported mediation findings. The 28% mediated proportion suggests that supply chain visibility may represent an important operational mechanism connecting digital modernization with industrial resilience. Nevertheless, confirmation of the mediation relationship requires estimated path coefficients, uncertainty intervals, and appropriate treatment of time-varying confounding. The Supply Chain Resilience Index should also exclude indicators used to construct the visibility mediator to avoid mechanical overlap between the explanatory mechanism and the outcome.

Figure 10

Comparative Predictive Performance of Machine Learning Models for Industrial Supply Chain Transformation Assessment

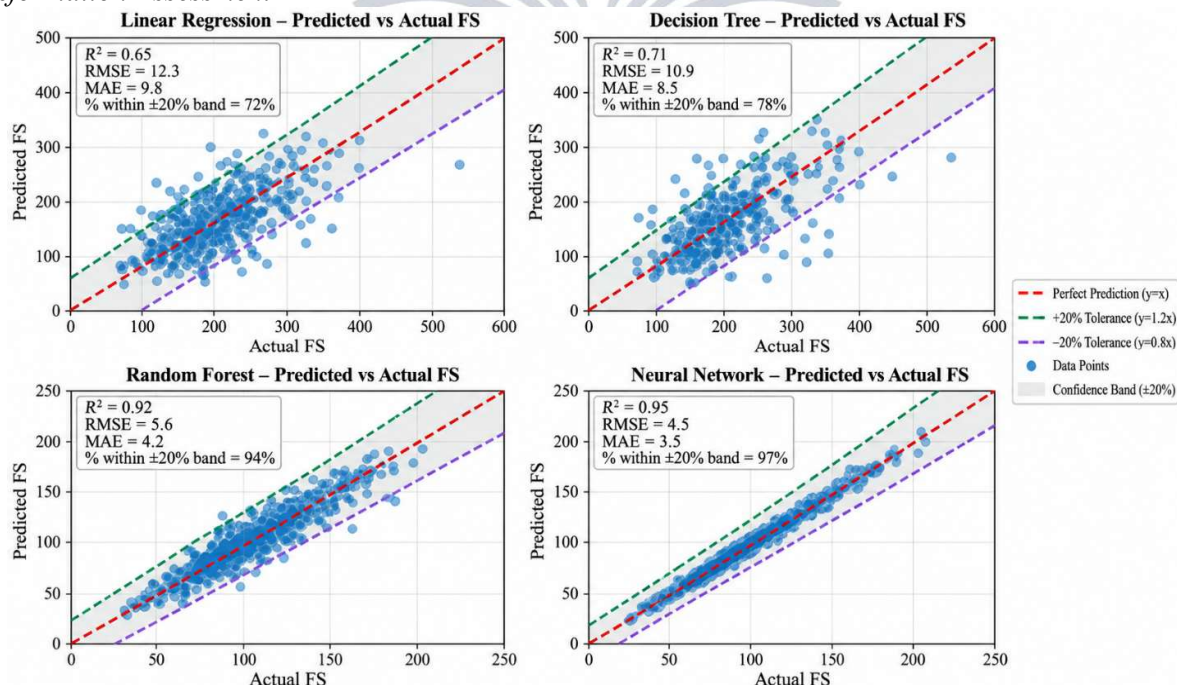




Figure 10 illustrates the reported contribution of supply chain visibility to the relationship between digital transformation and industrial resilience. Approximately 28% of the association is attributed to the visibility pathway, while the remaining 72% lies outside the specified indirect mechanism. The result highlights the importance of operational information integration, supplier communication, and coordinated decision-making in understanding industrial resilience, although the percentages should not be interpreted as independently established causal contributions. The heterogeneity assessment described in the manuscript indicates that the relationships between digital transformation and industrial performance are stronger among high-technology manufacturing enterprises and firms located in regions possessing advanced digital infrastructure. Technology-intensive industries may benefit from specialized equipment, established digital platforms, skilled personnel, and stronger information-processing capabilities (D. Wang et al., 2025). Similarly, regions with well-developed industrial internet connectivity, logistics infrastructure, and technological service networks may provide favourable conditions for manufacturing modernization. By comparison, enterprises in less digitally developed environments may encounter greater investment barriers, limited technical expertise, and difficulties integrating advanced technologies with existing production systems. However, the available manuscript does not provide subgroup regression coefficients, confidence intervals, or formal interaction tests, so the reported heterogeneity patterns cannot be quantified or independently verified here.

These findings are consistent with several theoretical perspectives discussed in the literature review. The resource-based view suggests that technological infrastructure and organizational capabilities contribute to enterprise competitiveness, while dynamic capability theory emphasizes resource reconfiguration and adaptation under changing operating conditions. Supply chain resilience theory further highlights supplier diversification, operational flexibility, and information accessibility as mechanisms supporting manufacturing continuity. The reported empirical relationships are compatible with these perspectives because they connect enterprise digital capabilities with resilience, resource efficiency, and coordination. Nevertheless, theoretical consistency alone does not establish the direction or causality of the estimated relationships. From a policy perspective, the findings have implications for China's industrial modernization priorities under the National 15th Five-Year Plan (2026–2030). Strengthening industrial internet infrastructure, promoting intelligent manufacturing technologies, developing diversified supplier networks, and improving environmentally responsible production practices are relevant to the strategic objectives of manufacturing competitiveness, industrial chain security, and sustainable development. The reported regional and sectoral heterogeneity also suggests that industrial transformation policies may need to account for differences in technological readiness and infrastructure development. Enterprises operating in less developed industrial environments may require complementary investment in digital connectivity, workforce capabilities, and supplier coordination systems. The study nevertheless has several limitations.

The 2018–2025 observation period precedes implementation of the National 15th Five-Year Plan and therefore provides a historical baseline rather than direct policy-impact evidence. Furthermore, the available numerical findings primarily describe associations, and the supplied material does not include the full regression outputs needed to evaluate statistical significance, coefficient precision, or model robustness (Zhao, n.d.). Potential reverse causality omitted time-varying variables, enterprise selection effects, and measurement limitations may also influence the reported relationships. Overall, the reported findings suggest that digital transformation, supplier diversification, and improved operational visibility are associated with stronger manufacturing resilience and more favourable environmental performance. The positive standardized relationships, lower disruption-related losses, reduced carbon emission intensity, and reported mediation contribution collectively support an integrated perspective on industrial supply chain restructuring. The study contributes to understanding the technological, organizational, and environmental conditions relevant to China's manufacturing modernization and provides baseline evidence for future assessments of industrial transformation under the National 15th Five-Year Plan.



6. Future Work

Future research should extend the present investigation by incorporating additional longitudinal observations, advanced analytical techniques, and broader industrial performance indicators to strengthen understanding of supply chain restructuring under China's National 15th Five-Year Plan (2026–2030). Although the current study examines 9,600 firm-year observations from 1,200 manufacturing enterprises across 30 provincial-level regions during 2018–2025, subsequent investigations should incorporate data collected throughout the 2026–2030 planning period to evaluate the implementation and measurable outcomes of national industrial modernization initiatives. Extending the observation period would enable researchers to investigate changes in digital technology adoption, industrial supply chain resilience, environmental sustainability, and enterprise competitiveness before and after the introduction of relevant development policies (Z. Wang et al., 2026). Where suitable comparison groups and implementation timelines are available, difference-in-differences models, event-study approaches, and other causal inference techniques could provide stronger evidence concerning the effects of specific industrial policies. Future studies should also examine the individual contributions of emerging digital technologies, including artificial intelligence, industrial internet platforms, blockchain-based traceability systems, digital twins, and intelligent logistics technologies (Zhou, 2025). Rather than treating digital transformation exclusively as a composite construct, technology-specific assessments could identify which innovations are most strongly associated with improved supply chain visibility, production flexibility, disruption recovery, and operational efficiency. Additionally, the integration of supplier–manufacturer network analysis would provide a more comprehensive understanding of industrial interdependencies, supplier concentration, and cascading disruption risks across interconnected manufacturing sectors.

Further research should investigate regional and sectoral differences in greater detail by incorporating enterprise ownership structures, financial constraints, technological readiness, industrial specialization, and regional digital infrastructure characteristics. Comparative assessments involving eastern, central, western, and northeastern China could help identify structural barriers to industrial modernization and evaluate the effectiveness of differentiated development strategies. Environmental assessment should also be expanded to include lifecycle carbon emissions, renewable energy utilization, circular manufacturing practices, industrial waste recovery, and resource productivity. Such indicators would allow researchers to determine whether digital transformation contributes to long-term environmental improvements or generates additional energy and infrastructure demands (Jiao & Zhang, 2026). Finally, future investigations should strengthen empirical reliability through alternative composite index construction methods, dynamic panel models, instrumental-variable approaches where defensible instruments are available, and comprehensive robustness assessments. Particular attention should be given to addressing potential endogeneity, enterprise selection bias, measurement uncertainty, and the causal interpretation of supply chain visibility as a mediating mechanism. Integrating enterprise-level information with regional policy implementation records, industrial network data, and environmental monitoring indicators could support a more detailed evaluation of China's industrial transformation. These extensions would contribute to developing a stronger evidence base for intelligent manufacturing, resilient industrial supply chains, technological self-reliance, and environmentally sustainable economic development under China's 2030 development priorities.

7. Conclusion

This study investigated the relationships among digital transformation, industrial supply chain resilience, economic stability, and environmental sustainability within China's manufacturing sector, providing empirical insights relevant to the National 15th Five-Year Plan (2026–2030). Using a longitudinal dataset comprising 9,600 firm-year observations from 1,200 manufacturing enterprises across 30 provincial-level regions during 2018–2025, the research integrated entropy-weighted composite indices, two-way fixed-effects panel regression, mediation analysis, and heterogeneity assessment to examine the multidimensional characteristics of industrial supply chain restructuring. The reported findings indicate that a one-standard-deviation increase in digital transformation is associated with a 0.18-standard-deviation improvement in supply chain resilience and a 0.14-standard-deviation enhancement in environmental sustainability.



Furthermore, enterprises maintaining diversified domestic supplier networks experienced 11.6% lower disruption-related production losses, while digitally advanced manufacturers exhibited 8.9% lower carbon emissions per unit of industrial output. Mediation analysis identified supply chain visibility as an important intermediary mechanism, accounting for approximately 28% of the reported relationship between digital transformation and industrial resilience.

The heterogeneity assessment further suggested stronger associations among high-technology manufacturing enterprises and firms operating in regions with advanced digital infrastructure. These findings highlight the importance of integrating intelligent manufacturing technologies, supplier diversification, operational information sharing, and environmentally responsible production practices into industrial restructuring strategies. The study contributes to industrial supply chain research by establishing an integrated analytical framework connecting technological modernization with economic resilience and sustainable manufacturing performance. From a policy perspective, the findings support consideration of differentiated digital infrastructure investment, technological capability development, supplier network coordination, and green industrial innovation in advancing China's manufacturing modernization priorities. Nevertheless, because the dataset covers 2018–2025, the analysis provides historical baseline evidence rather than a direct assessment of the 15th Five-Year Plan's implementation effects. Future research incorporating observations from 2026–2030 and stronger causal identification strategies could further evaluate the effectiveness of industrial development policies. Overall, the study emphasizes that coordinated digital transformation, resilient supply chain structures, and sustainable manufacturing practices are important considerations for strengthening China's long-term industrial competitiveness, economic stability, and environmentally sustainable development.

Author Contributions

All authors participated in ideation, development, and writing the manuscript. All authors read and approved the final manuscript.

Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this article.

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Informed Consent

Informed consent was obtained from all participants prior to data collection. Participants were informed about the purpose of the study, the voluntary nature of their participation, and their right to withdraw at any time without any consequences. The confidentiality and anonymity of respondents were guaranteed throughout the research process.

Data Availability

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request. The authors are committed to transparency and will provide detailed methodological information and analysis protocols upon request.

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