The Impact of Digital Transformation of Chain-leading Enterprises on Supply Chain Efficiency

Abstract

Purpose – This paper takes the digital transformation of chain-leading enterprises, i.e. leading enterprises in the industrial chain, as the entry point, establishes the screening criteria for these enterprises using three data indicators, and explores the impact of their digital transformation on supply chain efficiency. This analysis is based on text data from Chinese listed companies between 2010 to 2022.

Design/methodology/approach – Based on the theoretical foundation of the research, this paper proposes a theoretical hypothesis model and establishes a benchmark regression equation to study the impact of digital transformation on supply chain efficiency. The study uses panel data from 465 Chinese enterprises.

Findings – The results indicate that the digital transformation of leading enterprises in the industrial chain significantly improves supply chain efficiency. In this paper, an instrumental variable method is used to mitigate endogeneity and a series of robustness tests to confirm the validity of the findings. The impact path analysis reveals that the leading enterprises in the industrial chain can enhance efficiency by reducing financing cost, increasing operational efficiency and lowering the concentration level of the supply chain. Furthermore, the heterogeneity analysis demonstrates that the digital transformation of state-owned leading enterprises in the industrial chain and low-tech sector leaders have a more prominent effect on supply chain efficiency.

Originality/value – First, this paper enriches the research on digital transformation, and the method of extracting keywords through big data text analysis can better quantify the degree of digital transformation of the sample. Secondly, this paper provides empirical evidence of the impact of digital transformation on the supply chain efficiency of chain-leading enterprises. Thirdly, it enriches existing research on chain leaders, particularly regarding their digital transformation and offers new insights into the quantitative screening of such enterprises.

Key words chain leading enterprises; digital transformation; supply chain efficiency; financing cost; operational efficiency; supply chain concentration.

Paper type Research paper

1. Introduction

At present, the global industrial and supply chains are characterized by being short and fragmented, facing a series of structural restructuring challenges. This challenges present significant opportunities for countries to adopt and integrate new technologies, allowing them to tap into greater economic development potential through digitalization (Yi *et al*., 2023; Vu and Asongu, 2023). In the context of the digital economy, the impact of digitalization on supply chain efficiency is growing, further promoting the digital transformation of enterprises. The integration of digital technology

with supply chain is deepening, making the digital supply chain an important strategy for the industry to address risks and challenges. Studies have shown that digital transformation not only improves the internal efficiency within enterprises but also generates significant synergies across the entire supply chain (Vu and Asongu**Error! Bookmark not defined.**, 2023; Yuan *et al*., 2023; Zhang *et al*., 2023). The outbreak of COVID-19 has caused unprecedented disruptions to the global supply chains. Against this backdrop, digitalization can significantly enhance supply chain resilience and social performance (Jamal and Salomée, 2024), A high level of digitalization enables supply chain resilience to be positively influenced during the response and recovery stages, thus preparing for the next external shock (Hendrik *et al*., 2023). Hamann-Lohme (2023) claims that digitalization not only centralizes the internal network of a company but also enhances collaboration efficiency and frequency across the supply chain through information sharing and the shared use of digital technologies. Additionally, digital transformation can boost supply chain adaptability and the overall efficiency by improving collaborative innovation among supply chain members, reducing transaction costs and easing financing constraints (Abdalla and Nakagawa, 2021; He *et al*., 2024; Liao *et al*., 2024;). He *et al* (2024) further shows that digital transformation improves supply chain efficiency by enhancing corporate governance and increasing market competition. Thus, the digital transformation of enterprises is crucial for building an efficient and stable supply chain system. Research on digital transformation has been ongoing. For example, studies have been conducted on the impact of a single digital technology on supply chain management. Blockchain technology influences supply chain resilience through supply chain integration (Wang *et al*., 2024). Supply chain traceability is a crucial aspect of modern enterprise operations, and blockchain technology has emerged as a promising solution for enhancing the traceability of supply chain management (Reza *et al*., 2024). The advancements in artificial intelligence technology have significantly improved the supply chain efficiency of agricultural products (El *et al*., 2024). Considering the further development of digital technologies, multiple digital technologies are showing a trend of integration, with continuous improvements in the measurement methods for enterprise digital transformation (Wu *et al*., 2021; Wang *et al*., 2023; Li *et al*., 2023).

The academic community has paid increasing attention to the impact of enterprise digital transformation on supply chains and supply chain efficiency., Many scholars have studied their relationship from different perspectives. However, there is limited research on the combined impact of digital transformation and leading enterprises in the industrial chain on overall supply chain efficiency. “Leading enterprises in the industrial chain” refer to those that occupy a core position within the industrial chain, possess strong resource allocation and collaborative innovation abilities, and provide cohesion for upstream and downstream enterprises. These enterprises play a key role in breaking through core technologies, driving integration of other member enterprise into the supply chain and innovation chain, and facilitating collaborative development along the supply chain (Ma and Lu, 2024; Sheng, 2022). In China, under the new dual-cycle development pattern, issues related to collaborative development and low innovation efficiency within industrial chains and supply chains have become prominent. As a distinct solution with Chinese characteristics, the "chain length system" was first proposed in Hunan in 2017 and has since been promoted across various regions. The State Council also referenced the "chain length system" in national policy

documents (Jiang and Hu, 2024). Both the national 14th Five-Year Plan and the 20th National Congress emphasized the need to actively develop and cultivate leading enterprises in the industrial chain to modernize and enhance the national supply chains.

Unlike traditional leading or core enterprises, leading enterprises in the supply chain are typically closer to end consumers or provide productive services. When these enterprises achieve commercial success, they create increased demand for upstream products, benefiting the entire industrial and supply chains. Ma and Lu et al. (2024) demonstrate that "leading enterprises in the industrial chain can exert a "head goose effect", strengthening the correlation within the industrial and supply chains through three main pathways: enhancing risk management, optimizing resource allocation, and improving technological innovation capabilities. This drives the improvement of total factor productivity for enterprises within the supply chain. Additionally, supply chain finance can effectively enhance the productivity of both suppliers and customers, with the advantages of leading enterprises in the industrial chain amplifying this effect (Yu *et al*., 2023). Moreover, these enterprises can improve local firms' productivity through agglomeration, cost reduction and innovation (Chen and Zhang, 2023).

Regarding identification of leading enterprises in the industrial chain, Yuan et al. (2024) identified core enterprises by analyzing supply chain data published by listed companies, concluding that when a large enterprise's upstream and downstream partners are primarily Small and Medium-sized enterprises (SMEs), the large enterprise serves as the leading enterprise in the supply chain. Additionally, the industry and information technology departments in some Chinese provinces and cities have published the list of leading enterprises in the industrial chain. These enterprises are quantitatively identified through a four-step process: identifying, ranking, constructing threshold indices, and verifying against national standards (Qi and Song, 2023). Field research further shows that most leading enterprise in the supply chain occupy key supply chain positions, possess core technologies, and hold top positions in production, operation or capital scale (Wang *et al*., 2022). In summary, since the academic community has not yet established standardized quantitative identification methods for leading enterprises in the supply chain, developing such methods has become a critical process in research on these enterprises.

To enrich the relevant research, this paper adopts an empirical approach to study the relationship between the digital transformation within these leading enterprises and supply chain efficiency. Using text analysis data from Chinese listed companies between 2010 to 2022, the paper establishes screening criteria for identifying leading enterprise in the industrial chain through three data indicators. The study uses panel data to explore the impact of their digital transformation on supply chain efficiency. The marginal contributions of this paper are reflected in three main aspects. First, from a research perspective, it enriches the literature on leading enterprises in the industrial chain, particularly regarding their digital transformation, and provides insights into the quantitative screening of these enterprise. Second, in terms of measuring enterprise digital transformation, most existing studies focus on the impact of Individual digital technologies on supply chain efficiency (e.g. blockchain technology). This paper adopts a text analysis method to measure the digital transformation holistically, calculating the degree of digital transformation through a comprehensive analysis of core elements. Third, in terms of methodology, due to the difficulty of quantitatively

measuring digital transformation, existing studies often relied on qualitative methods such as theoretical analysis, case studies, surveys, and game analysis. This paper contributes by using panel data to empirically study the impact of digital transformation on supply chain efficiency.

2. Theoretical Foundations and Proposed Hypotheses

Supply chain management plays an important role in economic development (Mustafint *et al*., 2019; Zhang, 2024). Rastogi and Arvis (2014) further indicate that regional economic prosperity highly dependent on the efficiency of both internal and external supply chains within the region. The Enhancing supply chain efficiency positively impacts the overall performance of supply chain, which requires internal integration and support from information technology (Daneshvar *et al*., 2020). Digitalization not only directly improves the efficiency of supply chain collaboration (Sun, 2023), but also enhances supply chain efficiency by increasing the accuracy of supply and demand matching and reducing external transaction costs (Zhang, 2022). Enterprises' digital transformation aims to boost supply chain efficiency by expanding market strategic layout channels, financing constraint channels, and other intermediary functions (Zhang, 2023). Due to the diffusion and transmission effect of leading enterprises in the supply chain on other businesses (Zhang *et al*., 2017), the digital transformation of these leading enterprises, as a key factor, is of great significance for improving supply chain efficiency.

To a certain extent, digitalization can change the modes of value creation and acquisition in economic activities of enterprises, thus reducing the geographical constraints on supply chain operation (Li *et al*., 2023; Autio *et al*., 2021; Geng *et al*., 2024). Digital technology and the enhancement of enterprises' digital resilience facilitate further expansion of trade scale, the execution of international economic activities (Li *et al*., 2023), the reduction of market segmentation and trade barriers between administrative regions and, consequently, the overall improvement of supply chain efficiency (Zhang and Yu, 2022). Companies that implement digital transformation (e.g., use blockchain-based technology, e-commerce and digital marketing channels, and digital infrastructure) are better positioned to survive and recover from significant environmental disruptions (e.g., pandemic shocks) (Autio *et al*., 2021; Yuan *et al*., 2023), thereby enhancing the sustainability of their business activities (Li, 2022). Additionally, increased investment in digital supply chain technologies, such as blockchain, Artificial Intelligence (AI), predictive analytics, Robotic Process Automation (RPA) and data control centers significantly improve the alignment of supply and demand, the flow speed of production factors and operational transparency, thereby influencing supply chain efficiency (Zhang, 2022). Moreover, digital transformation enhances the agility of enterprises' supply chain strategies in complex environments, thereby boosting overall supply chain efficiency (Fang *et al*., 2023).

Notably, these studies also highlight that impact of digitalization on supply chain efficiency varies significantly by region, enterprise type and size (Geng *et al*., 2024; Zhang *et al*., 2023; Liu and Zhang, 2023). Digital transformation accelerates the flow of production factors more effectively when both sides of the supply chain are in regions with higher digital interaction mode, allowing enterprises to overcome geographical constraints more readily (Geng *et al*., 2024; Zhang *et al*., 2023). Furthermore, the impact of digital transformation on supply chain efficiency is asymmetrical. Enterprises in regions with higher marketisation levels experience a more significant improvement in supply chain efficiency. However, in large and medium-sized enterprises, and high-tech enterprises, digital technologies have an even more prominent effect on supply chain efficiency

(Zhang, 2022; Liu and Zhang., 2023). This indicates that when aiming to enhance overall supply chain efficiency, the focus should be on the degree of digital transformation of leading enterprises in the industrial chain to maximize their influence and driving role on upstream and downstream enterprises. Building on the above discussion, the paper proposes the following research hypothesis H1:

***H1*: Digital transformation of chain- leading enterprises can improve supply chain efficiency.**

The paper further proposes the following hypotheses, as discussed below:

***H2a*: Digital transformation of chain-leading enterprises improves supply chain efficiency by reducing financing costs.**

First, financing constraints refer to the restrictions on external financing faced by enterprises, highlighting the cost disparity between internal financing. In the digital age, traditional methods of obtaining information and resources are increasingly inefficient, creating financial challenges for many companies. Digital transformation can alleviate these financial constraints (Yu *et al*., 2024). Existing research also indicates that digital transformation significantly impacts a company's financing profile (Zhong and Zhuo, 2023). By enhancing data and information processing capabilities, digital transformation allows enterprises to absorb, integrate and optimize various information resources, respond quickly to external, and reduce information gaps. This helps enterprises effectively lower financing costs and improve supply chain efficiency (Ferreira *et al*., 2018). The advent of digital technology has introduced effective methods of information transmission, easing the pressures caused by information asymmetry between enterprises and investors (Liao *et al*., 2023). Moreover, under supportive national policies, enterprises undergoing may receive additional government subsidies. Such policy, aimed at promoting digital transformation, offer various incentives that can further reduce financing costs. Inventory turnover is a critical indicator of inventory realization and sales performance, which often requires substantial financial support that cannot be sustained by internal funds alone. Therefore, reducing the financing cost can enhance inventory flow of the company and thereby improve supply chain efficiency (Zhang *et al*., 2023).

***H2b*: Digital transformation of leading enterprises in the industrial chain can improve supply chain efficiency by increasing operational efficiency.**

The implementation of digital transformation by enterprises can enhance innovation performance and capital utilization, thereby improving overall operation efficiency (Bo and Yong, 2023). In a digital environment, companies can leverage digital technologies to alleviate information asymmetry and reduce agency costs, which in turn optimizes capital structure. Additionally, digitalization allows finance departments to dynamically manage and control expenditures in production and operations, thereby enhancing working capital efficiency (Agostini *et al*., 2019). Digital technologies also boost the efficiency of asset deployment and utilization in production and operations management (Ye *et al*., 2022). Through digital transformation, leading enterprises in the industrial chain and their upstream and downstream partners can achieve more transparent

coordination and information sharing (Zhao *et al*., 2021). Inventory management based on shared information helps enterprises improve supply chain efficiency. In addition, digital transformation also facilitates the recruitment of highly skilled professionals and the adoption of cutting-edge technologies, enhancing the effective use of human capital. Enterprises that implement digital technologies as potential substitutes for low-skilled labor and as supplements for high-skilled labor can optimize their human capital structure (Acemoglu and Restrepo, 2016). Furthermore, digitalization enables employees to think and work more creatively, generating higher-quality intellectual capital and improving output efficiency (Bjrkdahl, 2020). In recent years, intelligent manufacturing methods have become a significant maker of core competitive advantages for enterprises (Chen *et al*., 2019). The advancement of science and technology has increased the demand for professional talents (Sun and Hou, 2019). Effective talent utilization is critical to enterprise operation and management, and matching talent to appropriate roles can further enhance supply chain efficiency.

***H2c*: The digital transformation of chain-leading enterprises can improve supply chain efficiency by reducing supply chain concentration.**

Supply chain concentration, which includes customer base concentration and supplier group concentration, reflects the number and distribution of cooperative enterprises in upstream and downstream sectors (Hui *et al*., 2024) and the degree of dependence on these enterprises (Liu and Zhang, 2023). According to Resource-Based View (RBV) theory, competitive advantage is the ability to surpass competitors through unique attributes and resources (Freeman *et al*., 2021; Giustiziero *et al*., 2021). To achieve and maintain competitive advantage, firms need to convert resources into customer value, providing better value than their competitors (Porter, 1991). Firms with competitive advantages typically have greater bargaining power with customers than their competitors. Reducing supply chain concentration decreases a firm's dependency on its upstream and downstream partners, thereby increasing its bargaining power (Hui *et al*., 2024), maintaining competitive advantages, and optimizing supply chain efficiency. In addition, high supply chain concentration can reduce a company's resilience and its ability to manage risks, potentially leading to supply chain disruptions. Therefore, reducing concentration enhances a firm's capacity to cope with supply chain risks, thus improving the overall supply chain efficiency (Liu and Zhang, 2023). While digital transformation fosters new cooperation models among traditional enterprises, it also enables companies to expand beyond traditional regional partnerships, facilitating collaborations with enterprises in other regions, increasing geographical diversity in the supply chain (Li *et al*., 2023), and reducing overall supply chain concentration.

3. Research Design

3.1 Data Source and Processing

This paper examines Chinese listed companies from 2010 to 2022, selecting the leading enterprises in the supply chain as the research sample by establishing evaluation indices for these enterprises. Samples with missing principal variables were eliminated. High-frequency words related to digital transformation were identified through text analysis of the annual reports of listed companies. The remaining financial data were obtained from the China Stock Market & Accounting Research

Database (*CSMAR*). To mitigate the influence of extreme values, the sample data were winsorised at the 1% and 99% levels.

3.2 Description of Variables

Regarding the measurement of the explained variable, namely the degree of digital transformation, this paper employs text analysis to conduct statistics on the frequencies of relevant words related to digital transformation in the annual reports of listed companies. By evaluating the occurrence frequencies of keywords associated with digital transformation, the situation of digital transformation is measured at the micro level. The data for word frequency statistics are sourced from the China Stock Market & Accounting Research Database (*CSMAR*). The construction of this database mainly refers to the studies of previous scholars (Wu et al., 2021). The research on this database systematically collected the annual reports of all A-share listed companies using Python scripts and extracted all the text content of these reports by leveraging the Java PDF box library technology, thus building a huge data pool, which laid the foundation for the subsequent work of feature word screening. Meanwhile, the analytical framework of digital transformation is divided into two major dimensions: "underlying digital technologies" and "applications of digital technologies". The essence of enterprise digital transformation lies in relying on underlying digital technologies and integrating them deeply into enterprise process management, aiming to achieve a significant improvement in operational efficiency and a fundamental transformation of business models and management models. Digital technologies, as the core driving force for promoting enterprise digital layout and transformation, cover four mainstream technological directions, namely artificial intelligence, blockchain, cloud computing, and big data, which jointly form a relatively comprehensive digital technology system. In addition, the core of digital transformation lies in the profound transformation of business processes and organizational management, and digital technologies need to be effectively applied in specific business processes. Therefore, this study conducts a comprehensive measurement of the digital transformation of leading enterprises in the industrial chain from the two dimensions of "underlying technologies" and "application scenarios". Eventually, this paper successfully obtains 79 basic word frequencies closely related to digital transformation. For the specific list of words, please refer to the table below.

Application dimension	**Basic word frequency**
Artificial intelligence	Artificial intelligence, Business intelligence, image understanding, investment decision aid systems, intelligent data analysis, intelligent robotics, machine learning, deep learning, semantic search, biometrics, face recognition, speech recognition, authentication, autonomous driving, natural language processing
blockchain	Digital currency, smart contracts, distributed computing, decentralization, Bitcoin, alliance chain, differential privacy technology, consensus mechanism
cloud computing	Memory computing, cloud computing, stream

	computing, graph computing, Internet of Things, multi-party secure computing, brain-like computing, green computing, cognitive computing, Fusion architecture, 100 million level concurrency, EB level storage, information physical systems
big data	Big data, data mining, text mining, data visualization, heterogeneous data, credit information, augmented reality, mixed reality, virtual reality
Digital technology application	Mobile Internet, Industrial Internet, mobile Internet, Internet medical, e-commerce, mobile payment, third-party payment, NFC payment, B2B, B2C, C2B, C2C, O2O, Internet connection, smart wear, smart agriculture, smart transportation, smart medical, smart customer service, smart home, smart investment, smart travel, smart environmental protection, smart grid, smart Energy, smart marketing, digital marketing, unmanned retail, Internet finance, digital finance, Fintech, Fintech, quantitative finance, open banking
Eliminate negative words	No, don't, not yet, nothing, no need, nothing

Table 1: Basic word frequency statistics table

After extracting the keywords from the annual reports, this paper conducted an in-depth analysis of these keywords by using artificial intelligence technology. In order to ensure that the word frequency statistics can accurately reflect the degree of the company's digital transformation in the current year rather than future expectations, we adopted a series of keyword screening measures. Specifically, first of all, expressions containing negative words such as "not", "without", and "no" before the keywords were removed (the specific negative words removed are listed in detail in the table above) to avoid the interference of these negative expressions on the statistical results. Meanwhile, all the "digital transformation" keywords that were not related to the company itself were also excluded. This includes, but is not limited to, the content of digital transformation mentioned in the profiles of the company's shareholders, customers, suppliers, and senior executives. Through the above keyword screening steps, the accuracy and relevance of the statistical results were ensured, enabling them to truly reflect the degree of the company's digital transformation in the current year.

For the explanatory variable of leading enterprise in the industrial chain, following Yu *et al* (2023), the enterprise asset scale is used to represent the economic strength of an enterprise and its ability to coordinate upstream and downstream supply chain activities. Market share reflects its product influence within the industry and its leadership role in guiding upstream and downstream enterprises. The Lerner index measures the market monopoly power of an enterprise, with a higher index indicating stronger competitiveness. When establishing the evaluation indicators for chain-leading enterprises, some scholars also recognize enterprise scale, market share and enterprise competitive

advantage as means to quantitatively identify chain-leading enterprises. The evaluation criteria for chain-leading enterprises can be indicators such as enterprise scale and market share (Ji et al., 2024). Industrial chain leading enterprises possess strong competitive advantages in their local areas, which is also one of their characteristics (Ye and Zhuang, 2022). The strong dominance of enterprises in four aspects, namely technological innovation, standard setting, brand effect, and market control, is an important criterion for defining chain-leading enterprises (Bai et al., 2022). Meanwhile, some scholars will use enterprise scale to quantitatively identify chain-leading enterprises (Xiong and Zhang, 2024). Based on existing studies discussed above, the rationale for selecting the three indicators can be summarized as below: *Total assets at the end of the year* are an important manifestation of an enterprise's overall economic strength as well as an important reflection of the enterprise's scale. Chain-leading enterprises usually need to possess a solid asset base, which enables them to have sufficient resources to promote a series of strategic initiatives such as the digital transformation of the supply chain; *Product market share* is a symbol of market dominance. Enterprises with a high product market share often occupy a core position in the industrial chain and supply chain. A high market share indicates that the enterprise's products are widely recognized in the market and consumers have a relatively high degree of loyalty to its brand; *Lerner index* is an effective tool for measuring market power. It reflects an enterprise's ability to raise prices above marginal costs. For chain-leading enterprises, a higher Lerner index means that they have stronger pricing power and market power in the market.

Therefore, this paper points that enterprise with larger asset scale, higher market shares, and greater monopoly indices possess stronger chain leadership advantage. Specifically, this paper establishes the screening criteria for leading enterprises in the industrial chain based on three indicators: total assets at the end of the year, product market share, and Lerner index. Enterprises are identified as leading ones if their total assets at the end of the year exceed the average, their market share is above the year-end average, or their Lerner index is higher than the average. This paper analyses 12-year data on total assets, market share and Lerner index of listed companies from 2010 to 2022, ultimately selecting 2,993 annual observations, representing 465 enterprises.

For the measurement of the explained variable, supply chain efficiency emphasizes enhancing communication between upstream and downstream enterprises to streamline the flow of products and services. Supply chain efficiency is evaluated based on the effectiveness of product processes, capital flow, and information flow in supply chain management. Effective supply chain management involves the organization and coordination of product, information and capital flows among all participants in the supply chain. Zahran and Jaber (2017) also emphasize that effective inventory management is the key for improving supply chain efficiency. Meanwhile, Porter's value chain divides enterprise activities into primary activities and support activities. In the internal logistics part of the primary activities, it involves tasks such as the receipt, storage, and distribution of materials like raw materials. Inventory, as a crucial element in this section, its turnover situation directly reflects the efficiency of material allocation within an enterprise. Reasonable inventory turnover is of vital importance for the continuity of production and cost control. From the perspective of the core theory of competitive advantage, cost leadership is one of the significant approaches for enterprises to obtain a competitive advantage. Inventory turnover days are closely related to costs. A longer inventory turnover days implies that inventory occupies a substantial amount of funds, which will give rise to high warehousing costs, capital interest costs, and possible inventory loss costs. Therefore, this paper uses inventory turnover days (*Stock day*) of listed

companies as the explained variable to measure supply chain efficiency.

To improve the accuracy of the study, a series of control variables were added, including enterprise size (*Size*), asset-liability ratio (*lev*), return on assets (*Roa*), operating cash flow (*Ocf*), sales growth rate (*Growth*), enterprise age (*Age*), Tobin's Q value (*Tobinq*), management expense ratio (*Mfee*), ownership concentration (*Top1*), proportion of independent directors (*Dpe*), and size of board of directors (*Board*). The definitions and descriptive results of the main variables are presented in Table 2 and Table 3.

Variable names	Variable symbol	Variable definition
Supply chain efficiency	*Stock day*	ln (365/ inventory turnover)
Digital transformation of chain leader	*Digit*	ln (Total number of word frequencies for enterprise digital transformation +1)
Company size	*Size*	The logarithm of the total assets of the business
Asset-liability ratio	*lev*	Total liabilities to total assets
Return on assets	*Roa*	Net profit to total assets
Operating cash flow	*Ocf*	Net cash flow to total assets
Sales growth rate	*Growth*	Ratio of main business income growth in the current year to main business income in the previous year
Age of the enterprise	*Age*	ln (age of listing of business +1)
Tobin Q	*Tobinq*	Market value of business to replacement capital ratio
Administrative expense ratio	*Mfee*	Management fee to total assets
Ownership concentration	*Top1*	The proportion of the largest shareholder
Proportion of independent directors	*Dpe*	Number of independent directors relative to board size
Board size	*Board*	ln (Number of board members +1)

Table 2: Variable definitions

Variable name	Number of observations	Mean	Standard deviation	Maximum value	Minimum
Stock day	2993	3.974	1.417	7.436	7.778
Digit	2993	1.411	1.286	6.139	0
Size	2993	24.823	1.069	28.636	23.473
lev	2993	0.583	0.158	0.952	0.079
Roa	2993	0.043	0.046	0.361	0.182
Ocf	2993	0.065	0.065	0.438	0.281
Growth	2993	1.396	36.958	1878.371	0.703
Age	2993	3.093	0.368	3.555	1.386
Tobinq	2993	1.386	1.169	22.320	0
Mfee	2993	0.047	0.033	0.298	0.0006
Top1	2993	43.194	17.019	89.99	3.97
Dpe	2993	38.559	6.935	80	23.08

Board	2993	2.339	0.208	2.944	1.609

Table 3: Descriptive statistics of major variables

3.3 Measurement Model

To test our hypotheses, a regression model is designed to examine the effect of the digital transformation of leading enterprises on their supply chain efficiency:

$$Stock\_day_{i,t} = \alpha_0 + \alpha_1 Digit_{i,t} + \alpha_2 Controls_{i,t} + \delta_i + \sigma_t + \varepsilon_{i,t}$$

Where i and t denote the enterprise and year, respectively. The dependent variable, *Stock day*, represents the supply chain efficiency of enterprise i in year t. The core independent variable, *Digit*, measures the degree of digital transformation of the chain-leading enterprises. The vector $Controls_{i,t}$ includes a series of control variables: enterprise size, asset-liability ratio, return on assets, operating cash flow, sales growth rate, enterprise age, Tobin's Q value, management expense ratio, ownership concentration, proportion of independent directors, sand board size. The variables δ_i and σ_t represent firm and year fixed effect, respectively, while $\varepsilon_{i,t}$ is the random error term. In all regression equations, firm level cluster robust standard errors are used to adjust the t-statistic by default.

4.Empirical Analysis

4.1 Analysis of Benchmark Regression Results

This paper examines the impact of the digital transformation of leading enterprises on the efficiency of their supply chain. The estimated results of benchmark regression are shown in Table 4. Column (1) reports the regression results that consider only the explanatory and explained variables; Column (2) shows the regression results of the independent (explanatory) variable on the dependent (explained) variable after adding a series of control variables; Column (3) presents the regression results after adding year and firm fixed effects (i.e. *corporate effects* and *vintage effects* in the following tables). Finally, Column (4) displays the regression results after adding both year and firm fixed effects and incorporating a series of control variables.

The results show that the coefficient of Digit is negative, even after fully accounting for year and firm fixed effects and adding the control variables, indicating that the digital transformation of leading enterprise can shorten inventory turnover, thereby improving supply chain efficiency. In addition, all results are significant at 1% level, verifying Hypothesis 1.

	(1)	(2)	(3)	(4)
	Stock_day	*Stock_day*	*Stock_day*	*Stock_day*
Digit	-0.145***	-0.183***	-0.084***	-0.080***
	(0.045)	(0.043)	(0.031)	(0.030)
Size		0.0187***		0.130
		(0.063)		(0.104)
Lev		1.184		0.710**
		(0.483)		(0.322)
Roa		5.333**		-0.140
		(1.362)		(0.674)
Ocf		-5.838***		-0.728***

		(0.851)		(0.258)
Mfee		6.869*** (2.017)		5.177*** (1.640)
Growth		0.001** (0.001)		0.0002*** (0.0008)
Age		0.136 (0.154)		1.267*** (0.228)
Tobinq		0.216*** (0.049)		0.084* (0.049)
Top1		-0.007** (0.003)		0.003 (0.003)
Board		-0.172 (0.306)		-0.442** (0.198)
Dpe		0.009 (0.008)		-0.002 (0.003)
Constant	4.179*** (0.083)	-1.623 (1.633)	6.922*** (0.053)	-0.757 (2.073)
Corporate effect	NO	NO	YES	YES
Vintage effect	NO	NO	YES	YES
N	2993	2993	2993	2993
R^2	0.017	0.153	0.869	0.876

Table 4: Benchmark Regression Results

(Note: ***, ** and * are at significance levels of 1%, 5% and 10% respectively; In parentheses are standard errors clustered at the enterprise level after the cluster processing. The same is true below.)

4.2 Endogeneity Problem

To address the issue of endogeneity, this paper uses instrumental variable method to mitigate potential biases.

By referring to the studies of Pan and Zhang (2023) and Lei (2023), this paper selects one period lag of digital transformation as the instrumental variable. This choice is based on the logic that last year's degree of digital transformation influences the current year's progress, but last year's digital transformation does not directly impact this year's supply chain efficiency. This selection is consistent with the requirements for an appropriate instrumental variable. Therefore, the one-period lag of digital transformation (*Digitt1*) is selected as the instrumental variable in this paper, and 2SLS (two stage least square) method is applied for regression analysis.

Under the identification test, LM statistic value is 126.61, with p-value of 0.000. The W-F statistic and KP W-F statistic exceed all critical values, indicating that there is no weak instrumental variable. These results also confirm that the selection of instrumental variables meets the necessary conditions. The estimated results are presented in Table 5, showing that the instrumental variables passed the validity tests. The regression coefficient in Column (1) is 0.812, and the significance test at the 1% level suggests a strong correlation between the selected instrumental variables and explanatory

variables. The regression coefficient in Column (2) is -0.085, indicating that the digital transformation of leading enterprises in the supply chain significantly reduce the number of inventory turnover days and pass the significance test. This finding is consistent with the previous conclusion.

	(1)	(2)
	Digit	*Stock_day*
Digitt1	0.812*** (0.026)	
Digit		-0.085** (0.04)
Controls	YES	YES
Corporate effect	YES	YES
Vintage effect	YES	YES
N	2956	2956
R^2	0.017	0.153
K-P rk LM	126.610***	
C-D Wald F	1522.032	

Table 5: Regression Results of Endogeneity Test

4.3 Robustness Test

This paper adds control variables, replaces the dependent and independent variables, and conducts additional regressions to verify the robustness of the model.

First, control variables such as current asset turnover ratio (*Cat*), fixed asset turnover ratio (*Fat*), and non-current asset turnover ratio (*Ncat*) are progressively included in the regression to mitigate the risk of inaccurate results caused by omitted variables. Column (1) of Table 5 presents the results of regression analysis. The results show that the estimated values of Digit coefficients are all negative, and the three control variables pass the significance test, further validating the earlier findings.

Second, in previous studies, the measurement perspectives of supply chain efficiency were mainly divided into two categories. One was the perspective of physical flow, and the other was the perspective of financial flow. The main explained variable in this paper is the Inventory Turnover Days (*Stock_day*), which was set according to the perspective of physical flow. In order to conduct a more comprehensive examination of supply chain efficiency, based on previous studies (Du et al., 2024) and considering the availability of data, this paper adds the Total Asset Turnover Days (*Asset_day*) and the Operating Asset Turnover Ratio (*Oatr*) as dependent variables from the perspective of financial flow. As shown in columns (2) and (3), the result in column (2) indicates that the regression coefficient of the degree of digital transformation (*Digit*) remains negative and passes the significance test at the 1% level. The result in column (3) shows that the regression coefficient of the degree of digital transformation (*Digit*) is positive and also passes the significance test at the 1% level. Both of these results support the previous conclusions and further verify the robustness of the model.

Lastly, the core independent variable was replaced with enterprise digital technology application

(*Digit_tech*). Digital technology application (refer to Table 1), as the core driving force for promoting enterprises' digital layout and transformation, needs to be effectively applied in specific business processes. The regression coefficient remains significantly negative, further supporting the previous conclusion and reinforcing the robustness of the model.

	(1)	(2)	(3)	(4)
	Stock_day	*Asset_day*	*Octr*	*Stock_day*
Digit	-0.087***	-.0767***	12.24***	
	(0.029)	(0.023)	(12.244)	
Cat	-0.145***			
	(0.035)			
Fat	-0.0006**			
	(0.001)			
Ncat	-0.0109			
	(0.009)			
Digit_tech				-0.141***
				(0.035)
Controls	YES	YES	YES	YES
Corporate effect	YES	YES	YES	YES
Vintage effect	YES	YES	YES	YES
N	2993	2993	2993	2993
R^2	0.885	0.837	0.375	0.878

Table 6: Regression Results of Robustness Test

4.4 Path Mechanism Test

4.4.1 Financing Constraint

This paper uses SA index (*SA_index*) as a measure of financing cost, which is composed of two strongly exogenous variables (*firm size and age*) to maximize the impact of endogenous outcomes. The path mechanism was tested, and the result is shown in Column (1) of Table 7. The estimated value of the *Digit* coefficient is significantly negative at the 1% level, indicating that digital transformation can effectively alleviate financing constraints. As seen in Column (2), when *SA index* is used as an independent variable in regression with supply chain efficiency, the coefficient is negative and passes the significance test at the 1% level. This supports the hypothesis that the digital transformation of leading enterprises in the industrial chain can improve supply chain efficiency by easing financing constraints.

4.4.2 Operational Efficiency

According to the study by Li et al. (2023), digital transformation can enhance labor productivity, thereby improving total factor productivity. Similarly, the study by Wu et al. (2021), suggests that

digital transformation can also enhance financial stability, thereby increasing market value and improving operational efficiency. Additionally, Zhang et al. (2023) also selects labor productivity and capital utilization rate as key indicators for evaluating enterprise operational efficiency. As a result, this paper uses Labor productivity rate (*Labor*) and Capital utilization rate (*Cur*) as indicators to evaluate the operational efficiency of enterprises. The path mechanism was tested, and the estimated results are shown in Columns (3) and (4) of Table 7. The *Digit* coefficient is positive, and the estimated values are both significant at the 1% level, indicating that enterprise digital transformation can significantly improve enterprise operational efficiency. The regression results in Columns (4) and (6) show that when labor productivity and capital utilization rate are used as independent variables in regression with supply chain efficiency, the coefficient is negative and passes the significance test at the 1% level. This supports the hypothesis that the digital transformation of leading enterprises in the industrial chain can improve supply chain efficiency by increasing operational efficiency.

4.4.3 Supply Chain Concentration

This paper uses the average sum of the procurement ratio of the top five suppliers and the sales ratio of the top five customers as the evaluation index for supply chain concentration (*Con*) of the leading enterprises to test this path mechanism. As shown in Column (7), the coefficient for *Digit* in relation to the enterprise's digital transformation index is significantly negative, indicating that digital transformation can reduce supply chain concentration. Column (8) reports that when supply chain concentration is used as an independent variable in the regression of supply chain efficiency, the coefficient is negative and passes the significance test. The verifies the hypothesis that the digital transformation of leading enterprises in the industrial chain can improve supply chain efficiency by reducing supply chain concentration. Digital technology can significantly reduce the information barriers among enterprises, break geographical constraints, and greatly improve the efficiency of information flow, thus expanding the cooperation space between chain leaders and various suppliers and customers, and promote business expansion.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	SA_index	*Stock_day*	*Labor*	*Stock_day*	*Cur*	*Stock_day*	*Con*	*Stock_day*
Digit	-0. 0385*** (0.139)		0.612*** (0.047)		0.080*** (0.026)		-1.675** (0.712)	
SA_index		-0.447*** (0.155)		-0.058*** (0.018)		-0.198*** (0.051)		-0.007** (0.003)
Controls	YES		YES		YES		YES	
Corporate effect	YES		YES		YES		YES	

Vintage effect	YES		YES		YES		YES	
N	2993		2771		2765		2798	
R^2	0.812	0.880	0.663	0.879	0.785	0.881	0.762	0.889

Table 7: Regression Results of Path Mechanism Test

4.5 Heterogeneity Analysis

The impact of digital transformation on supply chain efficiency varies across industries and among enterprises of different types. An in-depth study of this phenomenon can reveal the specific effect of digital transformation on each enterprise, allowing for the formulation of targeted differentiated strategic guidelines. Based on the available data, this paper analyses how the digital transformation of leading enterprises in the industrial chain affects supply chain efficiency, with particular focus on the nature of the enterprises and the industries they operate in.

	(1)	(2)	(3)	(4)
	State-owned enterprises	Non-state-owned enterprises	High-tech enterprises	Low-tech enterprises
Digit	-0.084**	-0.074	-0.025	-0.088**
	(0.034)	(0.077)	(0.039)	(0.034)
Controls	YES	YES	YES	YES
Corporate effects	YES	YES	YES	YES
Vintage effect	YES	YES	YES	YES
N	2230	763	289	2704
R^2	0.889	0.922	0.942	0.893

Table 8: Regression Results of Heterogeneity Analysis

4.5.1 The Impact of Corporate Characteristics

As a state-owned leading enterprise in the industrial chain, its digital transformation is intrinsically driven by its triple mission of economic, political and social responsibility. Additionally, its abundant internal and external resources, along with its comprehensive core capabilities, provide a strong foundation and significant momentum for digital transformation. In contrast, the digital transformation of non-state-owned leading enterprises tend to lag behind due to uneven resource allocation and the pressures of market competition, making them relatively weak in areas like intelligent inventory management. Therefore, this paper concludes that the impact of digital transformation on supply chain efficiency is more pronounced in state-owned enterprises.

To test this hypothesis, the sample enterprises were divided into state-owned enterprises and non-state-owned enterprises based on their equity ownership, and a group regression test was conducted. Column (1) in Table 8 reports the regression results for state-owned enterprises, where the regression coefficient is significantly negative, indicating that digital transformation in state-owned leading enterprise can significantly enhance supply chain efficiency. Column (2) presents the regression results for non-state-owned enterprises. Although the estimated value of Digit coefficient is negative, it does not pass the significance test, indicating that the impact of digital transformation

on supply chain efficiency is significant only in state-owned enterprises.

4.5.2 The Impact of Industry Characteristics

Industry characteristics also lead to differences in the impact of enterprises' digital transformation on supply chain efficiency. High-tech enterprises experience varying effects on supply chain efficiency based on their different applications of intelligence and digital technology. For low-tech enterprises, their relative disadvantages in scientific and technological innovation make the digital technologies resulting from digital transformation more critical. These technologies significantly enhance their operational efficiency, especially in inventory management and supply chain processes, leading to a substantial increase in overall supply chain efficiency. Therefore, this paper concludes that the digital transformation of leading enterprises in the industrial chain have a more significant impact on low-tech industries.

Using the Classification of Strategic Emerging Industries, the target enterprises were divided into high-tech industries and low-tech industries for grouped regression analysis. The estimated results are shown in Columns (3) and (4) of Table 8. Column (3) indicates that the regression results for high-tech enterprises are not significant, while Column (4) shows that for low-tech enterprises, the regression coefficient is significantly negative. This finding confirms that the impact of digital transformation on supply chain efficiency is more significant in low-tech industries.

5. Conclusions, Recommendations and Future Research

This study examines Chinese listed companies from 2010 to 2022, with a particular focus on enterprise scale, market share, and market power—areas that differentiate it from previous research. To facilitate analysis, relevant evaluation indicators were established, and samples of leading enterprises within industrial and supply chains were selected annually. The findings reveal that digital transformation significantly enhances supply chain efficiency by lowering corporate financing costs, improving operational performance, and reducing supply chain concentration. Furthermore, due to variations in resource allocation capabilities and competitive advantages, state-owned leading enterprises demonstrate a more pronounced impact on supply chain efficiency. Additionally, because of differences in intelligence and technological innovation capabilities, digital transformation has a greater effect on non-high-tech enterprises. The conclusions align with previous research while offering new contributions to the existing literature. After conducting stability and endogeneity test, the conclusion remains robust. Mechanism analysis reveals that digital transformation improves supply chain efficiency by reducing financing costs, enhancing operational efficiency and decreasing supply chain concentration. Heterogeneity analysis indicates that the chain-leading enterprises in state-owned and low-tech industries have a more pronounced impact on supply chain efficiency during the process of digital transformation. By leveraging digital transformation, these enterprises optimize key aspects of the supply chain, including response speed, collaboration, and logistics distribution. More accurate demand forecasting aligns production with market demand, minimizing product shortages. Additionally, digital advancements in inventory management facilitate smoother and more timely movement of products from production to consumption, improving market availability and consumer access. Enhanced supply chain efficiency also leads to lower operating costs. These cost savings can be partially passed on to consumers through pricing mechanisms, increasing price competitiveness and reducing purchasing costs. At a macro level, a more efficient supply chain strengthens the overall industrial chain,

promotes resource optimization, and supports industry clustering and collaborative development. This, in turn, generates employment opportunities, fosters economic growth, and bolsters long-term sustainable development. Moreover, accelerating digital transformation across enterprises can reinforce the global positioning of domestic industries. By improving product quality, service value, and overall competitiveness in international markets, enterprises can secure stronger positions within the global industrial chain. National digital transformation policies further support this shift by prioritizing industrial data security and emergency response systems. These measures enable industries to manage external disruptions effectively, ensuring the stability of key sectors and enhancing national resilience in the face of global challenges.

Based on our research findings, we propose the following policy recommendations to enhance supply chain efficiency through digital transformation:

First, prioritize enterprise inventory management. Strengthening digital infrastructure and optimizing inventory management systems can improve the resilience and efficiency of industrial and supply chains. As China accelerates the modernization of its supply chain, leveraging the leadership of chain-leading enterprises is crucial. These enterprises should utilize their digital capabilities to align with national policies, drive digital transformation among supply chain members, and enhance overall efficiency. Additionally, fostering more chain leaders and integrating enterprises into modern supply chain systems will reinforce industrial resilience and security.

Second, to address financial and operational efficiency in digital transformation. Chain-leading enterprises should adopt strategies such as improving capital utilization, expanding financing channels, and developing robust credit systems to alleviate financial constraints. Enhancing operational efficiency through advanced production technologies, optimized supply chain management, and workforce skill development is essential. From a resource-based perspective, these enterprises can leverage internal assets, such as digital technologies and talent, to build digital supply chain platforms that integrate upstream and downstream resources, promote information sharing, and enhance collaboration. From a competitive advantage perspective, diversifying suppliers and strengthening partnerships within the supply chain will reduce dependency risks and maintain long-term competitiveness. By actively implementing digital transformation, chain-leading enterprises can drive coordinated development across the supply chain, improving the overall industrial ecosystem.

Third, tailor digital transformation strategies to industry and enterprise characteristics. A localized, adaptive approach should guide digital transformation efforts. Establishing supply chain collaboration platforms that facilitate secure and efficient information sharing between chain-leading enterprises and their partners is essential. Developing standardized protocols for data exchange while safeguarding enterprise security and privacy will ensure sustainable digital integration. Enterprises with strong digital foundations should be incentivized through reward mechanisms and industry benchmarks, while those with weaker foundations should receive structured guidelines, clear transformation roadmaps, and access to specialized consulting services. Promoting the growth of regional supply chain leaders and guiding comprehensive digital transformation initiatives will ultimately strengthen the entire supply chain ecosystem.

This study has limitations due to the restricted sample size. The absence of a universally accepted quantitative definition of leading enterprises in the industrial chain may lead to variations in selection criteria, potentially resulting in an incomplete sample and limited regional and industry coverage. Future studies can focus on refining the quantitative identification of chain-leading

enterprises to enhance the accuracy and comprehensiveness of the analysis. Additionally, this paper assesses supply chain efficiency using two key perspectives: physical flow, measured by inventory turnover days, and financial flow, evaluated through total asset turnover days and the operating asset turnover ratio. Considering data availability and varying research methodologies, future studies could incorporate approaches such as surveys to assess performance indicators like customer satisfaction or enterprise supply cycle, providing a more comprehensive evaluation of supply chain efficiency. Finally, this study examines the overall impact of digital transformation on supply chain efficiency. Future research could delve deeper into the effects of specific digital technologies, such as blockchain and big data, to better understand their individual contributions.

References

Abdalla, S. and Nakagawa, K. (2021), "The Interplay of Digital Transformation and Collaborative Innovation on Supply Chain Ambidexterity", *Technology Innovation Management Review*, Vol. 11, pp. 45-56, doi: 10.22215/TIMREVIEW/1428.

Acemoglu, D. and Restrepo, P. (2016), "The Race Between Machine and Man: Implications of Technology for Growth, Factor Shares and Employment", *NBER Working Papers*, doi: 10.2139/ssrn.2781320.

Agostini, L., Galati, F. and Gastaldi, L. (2020), "The digitalization of the innovation process: Challenges and opportunities from a management perspective", *European Journal of Innovation Management*, Vol. 23 No. 1, pp. 1-12, doi: 10.1108/EJIM-11-2019-0330.

Autio, E., Mudambi, R. and Yoo, Y. (2021), "Digitalization and globalization in a turbulent world: Centrifugal and centripetal forces", *Global Strategy Journal*, doi: 10.1002/gsj.1396.

Bai, X.J., Song, P., Ai, Y. and Li, L. (2022), "The theoretical logic and practical path of constructing an independent and controllable modern industrial system in China", *Economist*, No. 6, pp. 48-57, doi: 10.16158/j.cnki.51-1312/f.2022.06.008.

Bhilat, E.M.E., Jaouhari, A.E. and Saadia, H. (2024), "Assessing the influence of artificial intelligence on agri-food supply chain performance: the mediating effect of distribution network efficiency", *Technological Forecasting and Social Change*, Vol. 200, doi: 10.1016/j.techfore.2023.123149.

Bjrkdahl, J. (2020), "Strategies for Digitalization in Manufacturing Firms", *California Management Review*, Vol. 62 No. 4, doi: 10.1177/0008125620920349.

Central Government of the People's Republic of China. (2020), "Proposal of the Central Committee of the Communist Party of China on Formulating the 14th Five-Year Plan for National Economic and Social Development and the long-range Goals for the next five years", https://www.gov.cn/zhengce/2020-11/03/content_5556991.htm.

Chen, K.X. and Zhang, S.S. (2023), "How can industrial chain leaders empower the total factor productivity of local enterprises?", *Journal of Nanjing University of Finance and Economics*, No. 6, pp. 1-11.

Chen, Y.B., Lin, C. and Chen, X.L. (2019), "Artificial intelligence, ageing and economic growth", *Economic Research Journal*, Vol.54 No. 7, pp. 47-63.

Daneshvar, Maryam, R.H., Seyed, H., Laura, K. and Farkhondeh. (2020), "Effective factors of implementing efficient supply chain strategy on supply chain performance", *Technological and*

Economic Development of Economy, Vol. 26 No. 4, doi: 10.3846/tede.2020.12827.

Du, Z.Y., Peng, Y.Y. and Guo, M.N. (2024), "State-owned assets regulatory reform and supply chain efficiency of state-owned enterprises: Empirical evidence from the establishment of two types of companies", *Journal of Zhongnan University of Economics and Law*, pp. 1-13, doi: 10.19639/j.cnki.issn1003-5230.20241008.002.

Fang, M., Liu, F., Xiao, and S.(S)., Park, K. (2023), "Hedging the bet on digital transformation in strategic supply chain management: a theoretical integration and an empirical test", *International Journal of Physical Distribution & Logistics Management*, Vol. 53 No. 4, pp. 512-531, doi: 10.1108/IJPDLM-12-2021-0545.

Ferreira, J.J.M., Fernandes, C.I. and Ferreira, F.A.F. (2019), "To be or not to be digital, that is the question: Firm innovation and performance", *Journal of Business Research*, Vol. 101, pp. 583-590, doi: 10.1016/j.jbusres.2018.11.013.

Freeman, R.E., Dmytriyev, S.D. and Phillips, R.A. (2021), "Stakeholder Theory and the Resource-Based View of the Firm", *Journal of Management*, Vol. 47 No. 7, doi: 10.1177/0149206321993576.

Gao, Y., Yang, H.Y., Sun, X.J., Tian, X.Y. and Xu, J. (2024), "Corporate digital transformation and financing constraints: The moderating effect of institutional investors", *Heliyon*, Vol. 10 No. 12, doi: 10.1016/j.heliyon.2024.e33199.

Geng, Y., Xiang, X.J. and Xu, F. (2024), "Can Digital Transformation Break the Constraints of Geographical Distance? - Evidence from the geographical distribution of the company's supply chain", *Business and Management Journal*, Vol. 46 No. 3, pp. 165-185, doi: 10.19616/j.cnki.bmj.2024.03.009.

Giustiziero, G., Kretschmer, T., Somaya, D. and Wu, B. (2021), "Hyperspecialization and Hyperscaling: A Resource-based Theory of the Digital Firm", *SSRN Electronic Journal*, doi: 10.2139/ssrn.3531111.

Hamann-Lohmer, J., Bendig, M. and Lasch, R. (2023), "Does digital transformation restrain corporate financialization? Evidence from China", *International Journal of Production Economics*, doi: 10.1016/j.ijpe.2023.108932.

He, J., Du, X.D. and Tu, W. (2023), "Can corporate digital transformation alleviate financing constraints?", *Applied Economics*, Vol. 56 No. 20, pp. 2434-2450, doi: 10.1080/00036846.2023.2187037.

He, J.B., Fan, M. and Fan, Y.J. (2024), "Digital transformation and supply chain efficiency improvement: An empirical study from a-share listed companies in China", *Plos One*, Vol. 19 No. 4, doi: 10.1371/journal.pone.0302133.

Hendrik, B., Nils-Ole, H. and Sven, H. (2023), "How have digital technologies facilitated supply chain resilience in the COVID-19 pandemic? An exploratory case study", *Computers & Industrial Engineering*, Vol. 183, doi: 10.1016/j.cie.2023.109538.

Huiyang Zhou, H.Y., Wang, R.Z., Zhang, X.Y. and Chang, M.Y. (2024), "The impact of digital technology adoption on corporate supply chain concentration: Evidence from patent analysis", *Finance Research Letters*, Vol. 64, doi: 10.1016/j.frl.2024.105413.

Jamal, E. B. and Salomée, R. (2024), "Achieving social performance through digitalization and supply chain resilience in the COVID-19 disruption era: An empirical examination based on a stakeholder dynamic capabilities view", *Technological Forecasting and Social Change*, Vol. 201, doi: 10.1016/j.techfore.2024.123209.

Ji, Y.D., Zhao, M. and Zhao, W. (2024), "Evaluation of ecological dominance of industrial chain main enterprises based on rooted theory: a scale development", *Scientific and technological progress and countermeasures*, Vol. 41 No 6, pp. 86-96, doi: 10.6049/kjjbydc.H202308286.

Jiang, X.L. and Hu, D. (2024), "Research on the Evolutionary Game of Government Participation in Industrial Chain Collaborative Innovation in the Context of Digitalization: Based on the Perspective of "Chain Length System"", *Journal of China University of Geosciences(Social Sciences Edition)*, pp. 1-15, doi: 10.16493/ j.cnki.42-1627/c.20240718.002.

Lei, S.J. (2023), "Does Digital Transformation Drive Industrial Innovation? Based on the micro evidence of listed companies", Jiangxi Social Sciences, Vol. 43 No. 7, pp. 110-120.

Li, C.M., Huo, P., Wang, Z.Y., Zhang, W.G., Liang, F.Y. and Abbas M. (2023), "Digitalization generates equality? Enterprises' digital transformation, financing constraints, and labor share in China", *Journal of Business Research*, Vol. 163, doi: 10.1016/j.jbusres.2023.113924.

Li, C.M., Zhou, D. and Dong, Z.Y. (2023), "Has the opening of the capital market promoted the digital transformation of enterprises? ——Based on quasi-natural experiments and text analysis methods", *Statistical Research*, Vol. 40 No. 8, pp. 96-109, doi: 10.19343/j.cnki.11-1302/c.2023.08.008.

Li, L.X. (2022), "Digital transformation and sustainable performance: The moderating role of market turbulence", *Industrial Marketing Management*, Vol. 104, pp. 28-37, doi: 10.1016/j.indmarman.2022.04.007.

Li, W.L., Liu, H.C., Long, Z.N. and Tang, X.D. (2023), "Enterprise digital transformation and geographical distribution of supply chains", *Journal of Quantitative & Technological Economics*, Vol. 40 No. 8, pp. 90-110, doi: 10.13653/j.cnki.jqte.20230418.001.

Li, Z.C., Zimu, Xu, Z.M. and Sukumar, A. (2023), "Digital resilience and firm internationalization: a study of Chinese listed companies", *Journal of Enterprise Information Management*, doi: 10.1108/JEIM-02-2023-0095.

Liao, F.M., Hu, Y.Y., Chen, M.G. and Xu, S.L. (2024), "Digital transformation and corporate green supply chain efficiency: Evidence from China", *Economic Analysis and Policy*, Vol. 81, pp. 195-207, doi: 10.1016/j.eap.2023.11.033.

Liao, K.C., Liu, H.Y. and Liu, F. (2023), "Digital transformation and enterprise inefficient investment: Under the view of financing constraints and earnings management", *Journal of Digital Economy*, Vol. 2, pp. 289-302, doi: 10.1016/j.jdec.2023.12.001.

Lin, B.Q. and Xie, Y.J. (2023), "Does digital transformation improve the operational efficiency of Chinese power enterprises?", *Utilities Policy*, Vol. 82, doi: 10.1016/j.jup.2023.101542.

Liu, J. and Zhang, Y.K. (2023), "Can digital transformation improve the efficiency of enterprise supply chains? evidence from the text analysis of the annual reports of listed companies in China's manufacturing industry", *Industrial Economics Research*, No. 6, pp. 73-86, doi: 10.13269/j.cnki.ier.2023.06.009.

Ma, Z. and Lu, Y.L. (2024), "How can the "chain master" enterprises drive the improvement of the total factor productivity of enterprises on the chain?", *Journal of Guangdong University of Finance & Economics*, Vol. 39 No. 3, pp. 52-65.

Michael, E.P. (1991), "Towards a dynamic theory of strategy", *Strategic management journal*, doi: 10.1002/SMJ.4250121008.

Ministry of Industry and Information Technology General Office General Office of Finance. (2022), "Notice on the pilot work of financial support for the digital transformation of small and

medium-sized enterprises: The Department of Industry and Information Technology united enterprises", https://www.gov.cn/zhengce/zhengceku/2022-08/17/content_5705771.htm.

Mustafin, A. and Makhmutova, D.I. (2019), "Role of International Trade and Supply Chain Management in Economic Development of Countries", *International Journal of Supply Chain Management*, Vol. 8, pp. 512-516.

Pan, Y. and Zhang, J.C. (2023), "Digital Transformation and Enterprise Competitiveness: Opportunity or Crisis? Empirical Evidence from China's A-Share Listed Companies", *Industrial Economics Research*, No. 3, pp. 87-99, doi: 10.13269/j.cnki.ier.2023.03.004.

Qi, P. and Song, W.H. (2023), "The impact of chain leaders on the high-quality development of China's manufacturing industry chain", *South China Journal of Economics*, No. 5, pp. 84-106, doi: 10.19592/j.cnki.scje.401976.

Rastogi, C. and Arvis, J.F. (2014), "The Eurasian Connection : Supply-Chain Efficiency along the Modern Silk Route through Central Asia" , *Directions in Development – Trade*, doi: 10.1596/978-0-8213-9912-5.

Reza, P., Ahmad, D., Fatemeh, F., Javad, H., Sanaz, S. and Ali, R.G. (2024), "Unraveling the Potential of Blockchain Technology in Enhancing Supply Chain Traceability: A Systematic Literature Review and Modeling with ISM", *Blockchain: Research and Applications*, doi: 10.1016/j.bcra.2024.100240.

Sheng, C.X. (2022), "The international experience and Chinese path of cultivating leading enterprises in industrial ecology", *Reform*, No. 10, pp. 34-44.

Su, Z. and Hou, Y.L. (2019), "How industrial intelligence can reshape the employment structure of the labor force", *China Industrial Economics*, No. 5, pp. 61-79, doi: 10.19581/j.cnki.ciejournal.2019.05.004.

Sun, X. (2023), "Research on the Mechanism of Supply Chain Inventory Collaboration and Enterprise Performance: Based on the Data of Listed Companies in the Manufacturing Industry", *Shanghai University of Finance and Economics*, doi: 10.27296/d.cnki.gshcu.2023.000159.

Vu, K. and Asongu, S. (2023), "Patterns and drivers of financial sector growth in the digital age: insights from a study of industrialized economies", *Research in International Business and Finance*, Vol. 66, 102075, doi: 10.1016/j.ribaf.2023.102075.

Wang, J.M., Cui, L.G. and Xu, M.Z. (2022), "The Impact of Chain Leaders' Innovation Capability on Supply Chain Efficiency: Survey Evidence from Port-Hinterland Supply Chains", *China Business and Market*, Vol. 36 No. 8, pp. 16-28, doi: 10.14089/j.cnki.cn11-3664/f.2022.08.002.

Wang, L., Zeng, Y., Xu, Y.S., Chi, M. and Wu, H.T. (2025), "The effect of blockchain on construction supply chain resilience: A mediated moderation model", *Ain Shams Engineering Journal*, Vol. 16 No.2, doi: 10.1016/j.asej.2024.103253.

Wang, T.T., Jia, J.Y. and Zhang, F. (2023), "The Impact of Digital Transformation in Manufacturing on Green Technology Innovation: Evidence from A-share Listed Manufacturing Enterprises in Shanghai and Shenzhen", *Journal of Industrial Technological Economy*, Vol. 42 No. 4, pp. 91-99.

Wu, F., Hu, H.Z., Lin, H.Y. and Ren, X.Y. (2021), "Corporate Digital Transformation and Capital Market Performance: Empirical Evidence from Equity Liquidity", *Journal of Management World*, Vol. 37 No. 7, pp. 130-144, doi: 10.19744/j.cnki.11-1235/f.2021.0097.

Xiong, Y.L. and Zhang, Y.F. (2024), "Study on the influence of cultivating "chain leading" of

industrial chain on the resilience of local enterprises", *Financial treatise*, pp. 1-13, doi: 10.13762/j.cnki.cjlc.20241028.002.

Ye, F., Liu, K., Li, L., Lai, K.H., Zhan, Y. and Kumar, A. (2022), "Digital supply chain management in the COVID-19 crisis: An asset orchestration perspective", *International Journal of Production Economics*, Vol. 245, doi: 10.1016/j.ijpe.2021.108396.

Ye, Z.Y. and Zhuang, Z.W. (2022), "The growth of industrial chain leading enterprises and local manufacturing enterprises: impetus or resistance", *Chinese industrial economy*, No. 7, pp. 141-158, doi: 10.19581/j.cnki.ciejournal.2022.07.013.

Yi, X.Z., Steven, A.B., Jin, X.Z., Pei, G.J., Shu, O., Xu, Q.Y., Hisako, O. and Cai, Y.H. (2023), "New Trends in the Global Industrial Chain: Opportunities and Challenges", *International Economic Review*, No. 6, pp. 9-32.

Yu, S., Yu, X.Y. and Wang, Z.Q. (2023), "Supply chain governance of "chain master" enterprises and total factor productivity of enterprises on the chain", *Business and Management Journal*, Vol. 45 No. 4, pp. 22-40, doi: 10.19616/j.cnki.bmj.2023.04.002.

Yuan, Y.H. and Sun, Y.P. (2024), "The impact and mechanism of digital transformation of core enterprises in the supply chain on the innovation of small and medium-sized enterprises", *Science Research Management*, Vol. 45 No. 6, pp. 12-21, doi: 10.19571/j.cnki.1000-2995.2024.06.002.

Yuan, Y.Q., Tan, H.Y. and Liu, L.L. (2023), "The effects of digital transformation on supply chain resilience: a moderated and mediated model", *Journal of Enterprise Information Management*, Vol. 37 No. 2, pp. 488-510, doi: 10.1108/JEIM-09-2022-0333.

Zahran, S.K. and Jaber, M.Y. (2017), "Investigation of a consignment stock and a traditional inventory policy in a three-level supply chain system with multiple-suppliers and multiple-buyers", *Applied Mathematical Modelling*, Vol. 44 No. 4, pp.390-408, doi: 10.1016/j.apm.2017.01.084.

Zhang, C.X. and Yu, P.P. (2022), "Domestic Market Segmentation and Supply Chain Efficiency: Based on the Perspective of Enterprise Inventory", *International Business*, No. 3, pp. 123-139, doi: 10.13509/j.cnki.ib.2022.03.009.

Zhang, P.P., Sun, M., Zhang, X.L. and Gao, C.X. (2017), "Who are leading the change? The impact of China's leading PV enterprises: A complex network analysis", *Applied Energy*, Vol. 207, pp. 477-493, doi: 10.1016/j.apenergy.2017.05.082.

Zhang, R.Z. (2022), "Digital Technology and Supply Chain Efficiency: Theoretical Mechanisms and Empirical Evidence", *Research on Economics and Management*, Vol. 43 No. 5, pp. 60-76, doi: 10.13502/j.cnki.issn1000-7636.2022.05.004.

Zhang, S.S., Zhang, P.W. and Gu, C. (2023), "Enterprise digital transformation and supply chain efficiency", *Statistics & Decision*, Vol. 39 No. 18, pp. 169-173, doi: 10.13546/j.cnki.tjyjc.2023.18.032.

Zhang, X.W. (2024), "Digital intelligence of the circulation industry, supply chain resilience and high-quality development of the regional economy", *Journal of Commercial Economics*, No. 12, pp. 35-38.

Zhang, Z.Q., Su, Z. and Tong, F. (2023), "Does digital transformation restrain corporate financialization? Evidence from China", *Finance Research Letters*, Vol. 56, 104152, doi: 10.1016/j.frl.2023.104152.

Zhao, C.Y., Wang, W.S. and Li, X.S. (2021), "How digital transformation affects the total factor

productivity of enterprises", *Finance & Trade Economics*, Vol. 42 No. 7, pp. 114-129, doi: 10.19795/j.cnki.cn11-1166/f.20210705.001.

Zhou, Z.S. and Li, Z. (2023), "Corporate digital transformation and trade credit financing", *Journal of Business Research*, Vol. 160, doi: 10.1016/j.jbusres.2023.113793.