The Impact of Digital Transformation on Enterprise Operational Capacity Based on the Moderating Effect of Supplier Collaboration

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Abstract. As the technological revolution and industrial transformation deepen, the digital economy has become a major force behind high-quality economic growth. The 20th National Congress of the Communist Party of China called for faster development of the digital economy, deeper integration with the real economy, and the creation of globally competitive digital industry clusters. However, at the firm level, how to use digital tools to improve operational capacity remains an open question. Based on transaction cost theory, this study constructs a digital transformation index using textual analysis and applies a two-way fixed-effects model for empirical testing. To identify the transmission channel, we examine the mediating role of supply chain concentration. We also explore heterogeneity by ownership type, geographic location, and firm size through subgroup regressions. A series of robustness checks are performed. Results show that digital transformation significantly enhances operational capacity, a finding that holds across robustness tests. Further analysis reveals that supply chain concentration acts as a significant mediator. Heterogeneity analysis indicates that the positive effect is stronger in non-state-owned, large-scale, and non-coastal firms. This paper not only reveals how digital transformation affects operational efficiency but also contributes to the digital economy and working capital management literature. It provides empirical evidence and practical guidance for firms seeking to optimize supply chain structures and improve operational performance through digital means.

Keywords: Digital transformation, Enterprise operational capacity, Supply chain concentration.

1. Introduction

The digital economy has become a central engine of high-quality economic development. To seize the opportunities brought by digital technological changes, the report to the 20th National Congress of the Communist Party of China clearly puts forward strategic plans such as accelerating the construction of a cyber power and a digital China, providing top-level guidance and policy support for enterprise digital transformation. Driven by both policies and market competition, digital transformation is no longer an optional strategy for enterprises but an important path to optimize operational management, improve capital efficiency, and enhance sustainable competitiveness. Nevertheless, in actual operation, many enterprises still face prominent problems such as insufficient supply chain collaboration, excessive concentration of upstream and downstream relationships, and slow capital turnover, leading to growing pressure on working capital management. Especially in a volatile market environment, high concentration of the supply chain often results in resource misallocation and increases the pressure on enterprise working capital management. In this context, an urgent theoretical and practical issue is how to break information barriers, optimize supply chain relationships, accelerate working capital turnover through digital means, and explore whether there are differences in such mechanisms under different external environments and internal property right conditions. This issue has attracted extensive attention from both practical and academic circles.

Existing studies have conducted abundant discussions on the economic consequences of digital transformation. Relevant research has confirmed that digital transformation can systematically improve enterprise operational efficiency by enhancing innovation performance, corporate governance, and resource circulation efficiency. Specifically,"in terms of innovation performance, digital transformation can empower enterprise innovation performance by strengthening R&D investment"(Guang Hui & Liu Ying, 2024)[1]. In terms of governance level, digital transformation can effectively improve corporate governance by enhancing information flow and increasing decision-making transparency and efficiency (Wu Bo, 2024)[2]. In terms of circulation capacity, digital technology empowers supply chain collaboration and accelerates inventory and capital turnover (Zhao Ling & Huang Hao, 2022)[3]. In addition, digital transformation significantly improves working capital management efficiency through data empowerment and process collaboration. Meanwhile, digital transformation can reduce information asymmetry, optimize supplier and customer cooperation structures, thereby lowering supply chain concentration and improving supply chain stability (Wu Qiang & Yao Yuxiu, 2023)[4].

Although existing studies have examined the links between digital transformation and enterprise operational efficiency, as well as between supply chain structure and operational efficiency separately, they still have the following shortcomings. First, most literature separately examines the direct effect of digital transformation on enterprise operational capacity and the separate effect of supply chain structure on working capital efficiency in isolation. There is insufficient systematic research that integrates "digital transformation – supply chain structure – operational capacity" into a unified framework to analyze the transmission mechanism acting on enterprise operational efficiency. The analysis of the complete impact path is insufficient. Meanwhile, few studies have tested whether supply chain concentration mediates the relationship between digitalization and operational efficiency, so the theoretical framework and empirical evidence need to be supplemented and improved. Second, most research concentrates on testing the overall effect of digital transformation on enterprise operational efficiency and ignore the heterogeneous impacts of the institutional environment where enterprises operate. Enterprises with different property rights differ significantly in resource acquisition, policy response, and governance mechanisms. Regions also show obvious gradients in digital infrastructure and marketization progress. However, few existing studies conduct heterogeneous analysis from the dimensions of property rights nature, regional environment, and firm size.This make it difficult to identify the differential performance of the impact of digital transformation, which makes it hard to explain the logic of differentiated empowerment of digital transformation under different institutional environments.

First, based on transaction cost theory, this paper puts forward hypotheses about the impact of digital transformation on enterprise operational capacity and builds a baseline regression model to examine the direct impact of digital transformation on operational capacity. Second, in terms of research design, this paper takes Chinese A-share listed companies from 2014 to 2024 as research samples, uses textual analysis to construct relevant indicators of digital transformation, and carries out empirical analysis through a two-way fixed-effects model. Third, it uses mechanism analysis methods to further verify the mechanism of supply chain concentration between them and reveal the internal transmission path. Finally, it conducts grouped regression according to property rights nature, regional differences, and firm size to carry out heterogeneity tests. To ensure the reliability of results, this paper controls asset-liability ratio, profitability, growth, firm age, as well as year and industry fixed effects, and uses robust standard errors for regression.

This paper makes three main contributions. First, in theoretical research, this study integrates digital transformation, supply chain concentration, and working capital efficiency into a single framework, systematically revealing the internal transmission path of "digitalization – supply chain structure – operational capacity", which enriches research in the fields of digital economic consequences and working capital management. Second, in research methods, this paper carries out heterogeneous analysis from the perspectives of property rights and regions, identifies the differential performance of the impact of digitalization on working capital performance in more detail, breaks through the limitation that existing studies mostly focus on overall effect testing, and expands the boundary of previous research. Third, in practical value, the research conclusions can provide empirical support for enterprises to promote digital transformation, optimize supply chain structure, and improve operational capacity. They also offer decision-making references for the government to further improve digital economy policies and promote high-quality development of the real economy, with strong practical guiding significance.

The rest of this paper is structured as follows. Section 2 is literature review. Section 3 is theoretical analysis and research hypotheses. Section 4 is research design. Section 5 is empirical results and analysis. Section 6 is research conclusions and policy recommendations.

2. Literature Review

2.1. Research on Measurement Methods and Economic Consequences of Digital Transformation

In terms of the measurement of digital transformation, the most mainstream and widely cited method in domestic academic circles is the keyword textual analysis of annual reports. "It measures the degree of enterprise digital transformation by counting the total frequency of words such as big data, artificial intelligence, cloud computing, and blockchain in the annual reports of listed companies" (Wu Fei et al., 2021)[6]. In addition, Zhang Yongshen et al. (2021) and Zhao Chenyu et al. (2021) also adopted similar text mining methods for measurement, further verifying the scientificity and stability of this measurement method[7].

In terms of economic consequence research, existing literature generally finds that "digital transformation can reduce internal and external information asymmetry of enterprises, optimize resource allocation efficiency, improve total factor productivity, and ultimately exert a significant promoting effect on enterprise performance" (Zhao Chenyu et al., 2021; Chen Jian et al., 2020)[9]. Meanwhile, digital transformation helps strengthen corporate governance, alleviate financing constraints, and promote supply chain collaboration and resource integration. However, existing studies still have obvious limitations. First, most studies focus on terminal economic consequences such as enterprise performance, technological innovation, and investment efficiency, and insufficiently explore the impact mechanism on core operational efficiency such as total asset turnover. Second, few studies pay attention to the transmission role of supply chain structure in this process. Third, heterogeneous analysis for different property rights and regions is not systematic enough.

2.2. Theoretical Connotation and Measurement Methods of Operational Capacity

Operational capacity (also called operation capacity or asset management capacity) describes how well a firm uses its assets to generate revenue, reflecting the efficiency and effect of enterprise asset management. In the field of financial management, operational capacity is commonly gauged through asset turnover ratios. The higher asset turnover ratio implies more efficient asset use and greater short-term economic gains.

In the index system of operational capacity, total asset turnover is the most classic and comprehensive measurement index. It measures the efficiency of enterprises using all assets to obtain operating income from the overall level, directly reflecting the turnover speed and utilization quality of capital operation, and is a core index to evaluate enterprise asset management level and operational efficiency.China’s State-owned Assets Supervision and Administration Commission(SASAC) also uses total asset turnover as the primary index for assessing enterprise asset operational capacity, which forms an evaluation system of asset operational capacity together with accounts receivable turnover and current asset turnover.

Prior studies have investigated the determinants of operational capacity from multiple dimensions. At the macro-environment level, environmental uncertainty, government behavior, and relevant policies have a significant effect on enterprise asset turnover efficiency. At the micro-characteristic level, financial slack, mixed-ownership reform, and asset-light operation mode of enterprises have been proved to be closely related to operational capacity. In the research on enterprise financial distress prediction models, Wu Shinong and Lu Xianyi (2001) pointed out earlier that operational capacity indicators (such as total asset turnover and accounts receivable turnover) are important variables to distinguish enterprise financial status and can effectively reflect the health of enterprise asset management[10]. From the perspective of supply chain financing, Hu Haiqing, Xue Meng, and Zhang Lang (2014) found that supply chain cooperation significantly affects working capital management of small and medium-sized enterprises, and good supply chain coordination can improve capital turnover efficiency[11]. Cheng Xiwu, Cheng Wei, and Ji Gang (2020) further explored the impact of customer concentration and market competition on working capital management efficiency, pointing out that moderate customer concentration helps improve operational capacity, but excessive concentration may lead to decline in bargaining power and collection risk[12].

To sum up, as a core reflection of enterprise asset management efficiency, operational capacity has formed a relatively mature index system in measurement methods, and its influencing factors cover multiple levels of macro environment and micro characteristics, providing a theoretical basis and empirical evidence for follow-up research.

2.3. Cross Research

Existing cross-research has initially confirmed that digital transformation can improve enterprise inventory, accounts receivable, and overall operational capacity by optimizing process management, reducing information asymmetry, and improving supply-chain collaboration performance. From the perspective of operations management, Chen Jian, Huang Shuo, and Liu Yunhui (2020) pointed out that enterprises in the digital environment can realize the transformation from "empowerment" to "enablement", significantly improving resource allocation performance and response speed. Based on the theoretical mechanism of digital technology and supply chain efficiency, Zhang Renzhi (2022) empirically found that digital technology application can effectively reduce supply chain coordination costs and improve capital turnover efficiency. Research on commercial circulation enterprises by Wang Weixing and Zhao Limin (2025) shows that digital transformation exerts a positive impact on enterprise performance by optimizing working capital management performance. However, prior research still has notable shortcomings[13].

First, from the research perspective, most research concentrates on how digitalization affects a single operational metric (such as inventory turnover) and lack systematic measurement and analysis integrating "digital transformation – supply chain structure – operational capacity" into a unified framework, with insufficient depiction of the complete transmission path. Although Zhao Ling and Huang Hao (2022) focused on the impact of enterprise digital transformation on supply chain collaboration and cost stickiness, their research focused on cost behavior rather than working capital turnover. Wu Qiang and Yao Yuxiu (2023) explored the impact of enterprise digital transformation on supply chain allocation, revealing the mechanism of digitalization in promoting supply-chain centralization and diversification, but did not further extend to the final transmission effect on operational capacity.

Second, in terms of mechanism measurement, there is a lack of accurate quantitative measurement and empirical testing on the internal mechanism of how digitalization affects working capital turnover by reconstructing supply chain relationships (such as reducing concentration and optimizing cooperation structure). Li Shu, Wang Xiaozhi, and Zhai Shiyun (2017) analyzed the influencing factors of working capital decisions from the perspective of customer concentration and property rights nature, but did not include digital transformation into the analysis framework[14]. Tang Yuejun (2009) earlier discussed "the impact of bargaining power of suppliers and distributors on corporate performance, providing an important basis for understanding the relationship between supply chain and operational efficiency, but lacked dynamic investigation of supply chain structure changes in the digital context"[15].

Third, in terms of heterogeneity measurement, few studies have examined how digital transformation affects operational capacity differently depending on ownership type and regional marketization level,which hinders identification of how empowerment logic varies across institutional settings. From the theoretical reasoning and China’s actual conditions, Ni Kejin and Liu Xiuyan (2021) analyzed the link between digital transformation and enterprise growth, pointing out that institutional environment may play a moderating role in the digital empowerment process, but lacked systematic empirical testing for operational capacity[16]. Fan Hejun, Wu Ting, and He Sijin (2023) found that enterprise digitalization has an industrial chain linkage effect, providing enlightenment for understanding the heterogeneous impact of digitalization in different industries and institutional contexts, but their research did not focus on the specific dimension of operational capacity[17].

In general, existing literature has formed rich achievements in the economic outcomes of digital transformation and influencing factors of operational capacity, but several gaps remain. First, the research perspective is relatively scattered, and digital transformation, supply chain concentration, and operational capacity have not been combined into a single analytical framework, making it hard to fully reveal the transmission mechanism of "digital transformation – supply chain structure – operational capacity". Second, mechanism testing is insufficient, and rigorous empirical testing with supply chain concentration as a mediating variable is scarce, with most studies only staying at the direct effect level. Third, heterogeneity measurement is missing, and existing studies lack discussion on heterogeneous factors like ownership type and regional differences, making it hard to detect how empowerment logic differs across institutional settings which reduces the relevance and explanatory power of the findings. Fourth, policy integration is weak, and empirical evidence combined with the national policy background of the 20th National Congress such as "accelerating digital economy development" still needs to be supplemented, making it hard to fully respond to the actual impact of digital economy policies on working capital management of real enterprises.

3. Theoretical Analysis and Research Hypotheses

3.1. Direct Impact Mechanism of Digital Transformation on Operational Capacity

Supported by technologies such as big data, artificial intelligence, and cloud computing, enterprise digital transformation promotes the systematic reform of enterprise operation processes, information transmission, and resource allocation methods, and has become a key driving force to improve total asset turnover. "From the perspective of operation mechanism, digital technology can connect data across the entire chain of procurement, production, and sales, break internal and external information barriers of enterprises, optimize inventory management, accounts receivable management, and capital scheduling efficiency, reduce ineffective capital occupation, and accelerate capital turnover"(Wu Fei et al., 2021; Zhao Chenyu et al., 2021). Meanwhile, "digital transformation helps enterprises achieve refined operation and dynamic decision-making, improve operational stability and capital use efficiency, thereby significantly increasing working capital turnover" (Wang Weixing et al., 2023). "From the theoretical perspective, information asymmetry theory points out that information barriers between enterprises and upstream and downstream supply chains will increase operation costs and delay capital recovery, while digitalization can significantly improve information transparency, alleviate adverse selection and moral hazard, and improve capital turnover" (Hu Qianqian et al., 2022)[18]. Based on the theoretical framework of transaction cost economics, Tang Yuehuan further points out that digital technology can reduce transaction costs such as search, negotiation, and performance, improving cooperation efficiency and capital circulation efficiency (Tang Yuehuan et al., 2023)[19]. In summary, digital transformation is not only a tool upgrade at the technical level but also a systematic reform of operation mode and management logic. It can promote enterprises to optimize resource allocation and improve operational stability by solving core problems such as information asymmetry, high transaction costs, and slow capital turnover efficiency, and ultimately achieve significant improvement in operational capacity.

Based on this reasoning, the following main hypothesis is proposed:

H1: Digital transformation can significantly improve enterprise operational capacity.

3.2. Mechanism of Supply Chain Concentration

Digital transformation not only directly influences enterprise operational capacity but also exerts a transmission effect by changing the supply chain structure. Digitalization breaks geographical and information restrictions, helps enterprises expand cooperation networks, reduce dependence on single suppliers or customers, and optimize supply chain concentration. Reasonable adjustment of supply chain concentration can reduce lock-in risk, lower capital occupation, improve collaboration efficiency, and thereby accelerate working capital turnover (Zhang Renzhi, 2022).

Based on the resource-based view, digital transformation helps enterprises accumulate heterogeneous resources such as data resources and technical capabilities, transform them into unique competitive advantages, and then alleviate efficiency losses caused by excessive supply chain concentration by optimizing supply chain cooperation relationships and reconstructing resource allocation methods. According to supply chain collaboration theory, digital technology promotes more frequent interaction among supply chain members, optimizing supply chain structure and improving overall operational efficiency.

Thus, supply chain concentration serve as mediating channel between digital transformation and operational capacity. From a resource-based perspective, digital transformation reshapes the supply chain cooperation model through the accumulation of heterogeneous resources, and then amplifies the improvement effect of operational capacity through supply chain collaboration effect, forming a complete transmission chain of "digital transformation – accumulation of heterogeneous resources – optimization of supply chain structure – improvement of operational capacity".

Therefore, we propose the following hypothesis:

H2: Supply chain Concentration significantly mediates the relationship between digital transformation and operational capacity. Digital transformation improves enterprise total asset turnover by reducing supply chain concentration.

4. Research Design

4.1. Sample Selection and Data Sources

This paper takes Chinese A-share listed firms from 2014 to 2024 as the initial sample. Digital transformation data are obtained from annual reports of Shanghai and Shenzhen A-share listed companies, and other financial variables come from the CSMAR database and annual reports of listed companies. Meanwhile, the sample is processed as follows: (1) Eliminate samples with special transactions (ST, *ST); (2) Eliminate samples from the financial industry; (3) Eliminate samples with missing data; (4) Conduct 1% and 99% winsorization on data. The final sample contains 34,514 observations.

4.2. Variable Definition and Description

4.2.1 Dependent variable

Total asset turnover (TAT) reflects how well a firm uses its total assets to generate operating income, and is a core index to measure overall operational efficiency. The higher the total asset turnover, the higher the asset utilization efficiency, the faster the working capital turnover, and the higher the enterprise operational efficiency. Data come from the "Financial Index Analysis" module of the CSMAR database. The exact calculation is as follows:

$$TAT_{i,t}=\frac{Operating\ Income_{i,t}}{\left(Beginning\ Total\ Assets_{i,t}+Ending\ Total\ Assets_{i,t}\right)/2}$$

4.2.2 Independent variable

Enterprise digital transformation (DCG) denotes the systematic process in which enterprises rely on digital technologies (big data, artificial intelligence, cloud computing, etc.) to reconstruct and optimize the entire business process such as production, operation, management, and marketing, and promote the reform of business model, organizational structure, and value creation mode. It is the transformation behavior of enterprises from traditional operation to digital-driven operation. This paper draws on the research of Wu Fei et al. (2021), searches, matches, and counts the word frequency of characteristic words, then classifies and aggregates word frequencies across key technical directions to obtain a total count, thus building the index system of enterprise digital transformation. Since such data have typical "right skewness" characteristics, they are logarithmically processed to obtain the overall index depicting enterprise digital transformation.

4.2.3 Mediating variable

Supply chain concentration is a key index measuring the degree of enterprise dependence on core upstream and downstream partners, usually composed of supplier concentration and customer concentration.

$$SC=(Ratio\ of\ purchases\ from\ top\ 5\ suppliers+Ratio\ of\ sales\ to\ top\ 5\ customers)/2$$

4.2.4 Control variables

To improve research accuracy, this paper introduces a series of control variables, including firm size (Size), asset-liability ratio (Lev), return on equity (ROE), cash flow ratio (Cashflow), inventory ratio (INV), fixed asset ratio (FIXED), operating income growth rate (Growth), loss status (Loss), number of directors (Board), proportion of independent directors (Indep), duality (Dual), and shareholding ratio of the largest shareholder (Top1), as shown in Table 1.

Table 1. Definition of Main Variables

Variable Name	Symbol	Definition
Total Asset Turnover	TAT	$\frac{\text{"Operating revenue}_{i,t}}{(\text{Total assets at the beginning of the period }_{i,t}+\text{Total assets at the end of the period})/2}$
Corporate Digital Transformation	DCG	Natural logarithm of (frequency of digital transformation keywords in annual report + 1)
Firm Size	Size	Natural logarithm of a firm’s total assets
Asset-Liability Ratio	Lev	Total liabilities divided by total assets
Return on Total Assets	ROA	Net income / Total assets at the end of the period
Return on Equity	ROE	Net income attributable to parent company shareholders / Net assets attributable to parent company shareholders at the end of the period
Cash Flow Ratio	Cashflow	Net cash flow from operating activities / Total assets
Inventory Ratio	INV	Net inventory / Total assets
Fixed Asset Ratio	FIXED	Net fixed assets / Total assets
Operating Revenue Growth Rate	Growth	Current operating income / Previous operating income − 1
Loss Incurrence	Loss	1 if net income < 0; 0 otherwise
Board Size	Board	Natural logarithm of the number of directors
Independent Director Ratio	Indep	Independent directors / Total directors
CEO Duality	Dual	1 if chairman and CEO are the same person; 0 otherwise
Shareholding Ratio of the Largest Shareholder	Top1	Shares held by the largest shareholder / Total shares
Ownership Nature	SOE	1 for state-owned enterprises; 0 otherwise
Supply Chain Concentration	SC	(Ratio of purchases from top 5 suppliers + Ratio of sales to top 5 customers) / 2
Geographic Location Difference	Coastal	Dummy variable: 1 if the firm is registered in coastal provinces; 0 otherwise

4.3. Model Specification

$$TAT_{i,t}=\alpha_0+\beta_1 DCG_{i,t}+\sum_{k=1}^{n}\gamma_k Controls_{i,t}^{k}+\mu_i+\lambda_t+\varepsilon_{i,t}$$

i represents the enterprise individual, *t* represents time, and together they represent the observation of "the *i*-th enterprise in the *t*-th year". $TAT_{i,t}$ is the dependent variable, $DCG_{i,t}$ represents the core independent variable, and $Controls_{i,t}^{k}$ represents a series of enterprise-level control variables. μ_i is the enterprise individual fixed effect, used to control enterprise heterogeneous characteristics that do not change with time. λ_t is the year fixed effect, used to control common impacts at the time level such as macroeconomic fluctuations and policy shocks.

5. Empirical Results and Analysis

5.1. Descriptive Statistics

This paper conducts summary statistics on main variables of A-share listed companies from 2014 to 2024, and the results are shown in Table 2. The total number of sample observations is 34,514, covering an 11-year time interval, which belongs to large-sample panel data and offers a solid foundation for subsequent empirical analysis. To ensure the robustness of empirical results, all continuous variables are winsorized at the 1% level to eliminate the impact of extreme values.

Table 2. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
TAT	34514	.631	.414	.084	2.562
DCG	34514	1.751	1.414	0	5.263
Size	34514	22.319	1.283	20.091	26.22
Lev	34514	.411	.2	.061	.887
ROA	34514	.04	.064	-.202	.208
ROE	34514	.059	.126	-.573	.332
Cashflow	34514	.05	.065	-.133	.224
INV	34514	.129	.111	0	.597
FIXED	34514	.204	.15	.003	.647
Growth	34514	.133	.326	-.506	1.7
Loss	34514	.156	.363	0	1
Board	34514	2.102	.192	1.609	2.565
Indep	34514	37.845	5.354	33.33	57.14
Dual	34514	.312	.463	0	1
Top1	34514	.334	.146	.086	.725

5.2. Correlation Analysis

To preliminarily investigate the correlation between variables, this paper conducts Pearson correlation tests on core variables, and the results are shown in Table 3. The correlation coefficient between the dependent variable operational capacity (TAT) and the core independent variable digital transformation (DCG) is 0.0456, which is significant and positive at the 1% level, preliminarily suggesting a positive relationship between digital transformation and enterprise operational capacity, consistent with the direction of the core hypothesis of this paper. In terms of control variables, firm size (Size), asset-liability ratio (Lev), profitability (ROA, ROE), operating cash flow (Cashflow), growth (Growth), etc., are significantly correlated with TAT at the 1% level, and the signs largely match theoretical expectations, indicating that these variables have an important impact on operational capacity. In addition, the absolute correlation coefficients among independent variables are generally below 0.5, and the multicollinearity problem is well solved, providing a reliable basis for subsequent regression analysis.

Table 3. Correlation Analysis

Variables	(TAT)	(DCG)	(Size)	(Lev)	(ROA)	(ROE)	(Cashflow)	(INV)	(FIXED)	(Growth)	(Loss)	(Board)	(Indep)	(Dual)	(Top1)
TAT	1.0000														
DCG	0.0459***	1.0000													
Size	0.0716***	0.0398***	1.0000												
Lev	0.1538***	-0.0217***	0.4967***	1.0000											
ROA	0.2026***	-0.0582***	-0.0113**	-0.3727***	1.0000										
ROE	0.2262***	-0.0435***	0.0912***	-0.2405***	0.9093***	1.0000									
Cashflow	0.1424***	-0.0538***	0.0767***	-0.1612***	0.4520***	0.3715***	1.0000								
INV	0.1108***	-0.0738***	0.0892***	0.2422***	-0.0496***	0.0098*	-0.1658***	1.0000							
FIXED	-0.0070	-0.2979***	0.1219***	0.1005***	-0.0737***	-0.0618***	0.2001***	-0.2425***	1.0000						
Growth	0.1835***	-0.0119**	0.0226***	0.0183***	0.2945***	0.2976***	0.0530***	0.0295***	-0.0416***	1.0000					
Loss	-0.1320***	0.0407***	-0.0668***	0.1926***	-0.6204***	-0.6407***	-0.2333***	-0.0062	0.0441***	-0.1657***	1.0000				
Board	0.0066	-0.0553***	0.2529***	0.1308***	0.0072	0.0305***	0.0308***	-0.0141***	0.1129***	0.0031	-0.0424***	1.0000			
Indep	-0.0136**	0.0576***	-0.0070	-0.0088*	-0.0140***	-0.0137**	-0.0004	-0.0003	-0.0316***	-0.0149***	0.0263***	-0.5874***	1.0000		
Dual	-0.0197***	0.0959***	-0.1937***	-0.1340***	0.0476***	0.0221***	-0.0048	-0.0146***	-0.0870***	0.0298***	-0.0062	-0.1784***	0.1018***	1.0000	
Top1	0.0740***	-0.1160***	0.1719***	0.0217***	0.1586***	0.1626***	0.1157***	0.0179***	0.0844***	-0.0006	-0.1417***	0.0041	0.0442***	-0.0501***	1.0000

5.3. Benchmark Regression

To test the impact of digital transformation on enterprise operational capacity, this paper estimates a two-way fixed-effects model for benchmark regression, and the regression results are shown in Table 4. Column (1) shows the regression results with only core independent variables, and Column (2) shows the results after adding all control variables.

The results show that the regression coefficient of digital transformation (DCG) is 0.0101 in the model with only core variables and 0.0116 after adding control variables, both significant and positive at the 1% level, suggesting that digital transformation can significantly improve enterprise operational capacity. In terms of control variables, the coefficient of firm size (Size) is significantly negative, while the coefficients of asset-liability ratio (Lev), profitability (ROA), operating cash flow (Cashflow), growth (Growth), etc., are significantly positive, basically consistent with theoretical expectations.

These baseline results indicate that enterprise digital transformation can significantly improve enterprise operational capacity. This conclusion still holds after controlling various enterprise-level characteristics, providing a firm basis for the subsequent mechanism analysis and robustness tests.

Table 4. Baseline Regression Results

VARIABLES	(1) TAT	(2) TAT
DCG	0.0101***	0.0116***
	(2.898)	(3.827)
Size		-0.0587***
		(-5.832)
Lev		0.1657***
		(5.372)
ROA		0.9961***
		(11.796)
ROE		0.0565
		(1.291)
Cashflow		0.3304***
		(11.855)
INV		0.4737***
		(8.357)
FIXED		-0.0243
		(-0.627)
Growth		0.1624***
		(27.123)
Loss		0.0194***
		(3.957)
Board		-0.0117
		(-0.462)
Indep		-0.0002
		(-0.347)
Dual		-0.0035
		(-0.575)
Top1		-0.0005
		(-0.010)
Constant	0.6644***	1.7424***
	(91.453)	(6.947)
Observations	34,514	34,514
R-squared	0.027	0.243
Number of stkcd	4,247	4,247
year FE	YES	YES
stkcd FE	YES	YES
F	81.16	162.8

5.4. Robustness Tests

5.4.1 Replacing the Dependent Variable

To check the robustness of our findings, this paper conducts robustness tests by replacing the dependent variable with current asset turnover (CAT). The regression results, as reported in Table 5, show that the coefficient of digital transformation (DCG) is 0.0181, significantly positive at the 1% statistical level, consistent with the direction of the DCG coefficient in the benchmark regression and with improved significance. The significance and signs of control variables are also basically consistent with the benchmark regression, and the overall model passes the significance test. This indicates that the core conclusion of this paper – digital transformation has a significant positive impact on enterprise operational capacity – does not depend on the specific measurement method of the dependent variable, and the research results have strong robustness and reliability.

Table 5. Robustness Test for Replacing the Dependent Variable

VARIABLES	(1) CAT	(2) CAT
DCG	0.0148**	0.0181***
	(2.093)	(3.017)
Controls	YES	YES
Constant	1.2501***	1.9918***
	(79.953)	(4.489)
Observations	34,514	34,514
R-squared	0.008	0.206
Number of stkcd	4,247	4,247
year FE	YES	YES
id FE	YES	YES
F	44.03	113.7

5.4.2 Changing the Regression Model

To further verify the robustness of research conclusions, this paper replaces the two-way fixed-effects model of benchmark regression with a random-effects model for re-estimation. The regression results are shown in Table 6.

Table 6. Robustness Test of Model Reversal

VARIABLES	(1) TAT	(2) TAT
DCG	0.0116***	0.0121***
	(3.818)	(4.465)
Controls	YES	YES
Constant	1.7474***	1.3157***
	(6.954)	(7.437)
Observations	34,514	34,514
R-squared	0.242	
Number of stkcd	4,247	4,247
year FE	YES	
id FE	YES	
F	161.9	.
year RE		YES
id RE		YES
R		

In Model (2) that includes all control variables and controls year effects, the regression coefficient of digital transformation (DCG) is 0.0121, significantly positive at the 1% statistical level, consistent with the direction of the benchmark regression coefficient and with stable significance level. In terms of control variables, the coefficient of firm size (Size) is significantly negative, while the coefficients of asset-liability ratio (Lev), profitability (ROA), operating cash flow (Cashflow), growth (Growth), etc., are significantly positive, and their signs and significance are basically consistent with the benchmark regression results. The above results show that even if the regression model setting is changed, the positive promoting effect of digital transformation on enterprise operational capacity is still significant, and the research conclusions are not affected by model selection, with good robustness.

5.4.3 Changing the Sample Range

To exclude the interference of the particularity of enterprise operation in the initial listing period on regression results, this paper further eliminates observations with listing age (ListAge) of 0 in the sample and retains only samples from the second year of listing and beyond for two-way fixed-effects regression. The results, as shown in Table 7, show that the regression coefficient of the core independent variable digital transformation (DCG) is 0.0134, significantly positive at the 1% statistical level, consistent with the direction of the benchmark regression coefficient and with no obvious change in significance level. The signs and significance of control variables are also basically consistent with the benchmark regression results. This indicates that the core conclusion of this paper is not affected by operational fluctuations in the initial listing period of enterprises, and the research results have good robustness.

Table 7. Robustness Test with Varying Sample Range

VARIABLES	(1) TAT
DCG	0.0134***
	(4.196)
Controls	YES
Constant	1.5660***
	(5.976)
Observations	32,503
Number of stkcd	4,245
R-squared	0.227
year FE	YES
id FE	YES
F	138.4

5.5. Mechanism Test

Whether digital transformation can affect enterprise operational capacity by reconstructing supply chain relationships and improving supply chain collaboration level is the core mechanism that needs further verification in this study. As a key index measuring the degree of supply chain collaboration, supply chain concentration reflects the closeness of cooperation between enterprises and core suppliers and customers. The higher the concentration, the stronger the information sharing and resource integration efficiency between enterprises and supply chain partners, and the higher the supply chain collaboration level. Based on this, this paper uses the three-step mediating effect test method of Wen Zhonglin et al. (2004) and constructs supply chain concentration (SC) as a mediator to examine the transmission path of "digital transformation – supply chain structure – enterprise operational capacity".

5.5.1 Variable Definition and Test Model

Supply chain concentration (SC) is measured by the average of the proportion of purchases from the top five suppliers and the proportion of sales to the top five customers. The larger the value of this index, the higher the degree of supply chain collaboration.

The mechanism test models are set as follows:

$$TAT_{i,t}=\alpha_0+\alpha_1 DCG_{i,t}+\sum_{k=1}^{n}\gamma_k Controls_{i,t}^{k}+\mu_i+\lambda_t+\varepsilon_{i,t}$$

$$SC_{i,t}=\beta_0+\beta_1 DCG_{i,t}+\sum_{k=1}^{n}\gamma_k Controls_{i,t}^{k}+\mu_i+\lambda_t+\varepsilon_{i,t}$$

$$TAT_{i,t}=\gamma_0+\gamma_1 DCG_{i,t}+\gamma_2 SC_{i,t}+\sum_{k=1}^{n}\gamma_k Controls_{i,t}^{k}+\mu_i+\lambda_t+\varepsilon_{i,t}$$

$TAT_{i,t}$ is total asset turnover, $DCG_{i,t}$ donates the extent of digital transformation, $SC_{i,t}$ is supply chain concentration, and $Controls_{i,t}^{k}$ represents a series of enterprise-level control variables. μ_i is the enterprise individual fixed effect, used to control enterprise heterogeneous characteristics that do not change with time. λ_t is the year fixed effect, used to control common impacts at the time level such as macroeconomic fluctuations and policy shocks.

5.5.2 Test Results and Analysis

First, the direct effect of digital transformation on supply chain collaboration is tested. Table 8 reports that the coefficient of digital transformation (DCG) is -0.5071, significant at the 1% statistical level, suggesting that enterprise digital transformation can significantly reduce supply chain concentration and promote the improvement of supply chain collaboration level. This is because the application of digital technology breaks information barriers, enhances information sharing and resource integration between enterprises and upstream and downstream partners, thereby effectively reducing dependence on single or a few core suppliers/customers and promoting the diversification and collaboration of the supply chain network.

Second, after controlling the supply chain collaboration level, its impact on enterprise operational capacity is tested. The results show that the coefficient of supply chain concentration (SC) is 0.0005, which is not significant, but the coefficient of digital transformation (DCG) is still 0.0118, significant at the 1% level. This suggests that supply chain collaboration plays a partial mediating role in the process of digital transformation improving enterprise operational capacity. On the one hand, digital transformation indirectly improves enterprise operational capacity by optimizing supply chain structure and improving collaboration efficiency. On the other hand, digital transformation also directly improves operational efficiency through other paths such as optimizing internal resource allocation and reducing transaction costs.

Overall, the mechanism test results verify the core hypothesis of this study, that is, digital transformation can affect enterprise operational capacity by reconstructing supply chain relationships and improving supply chain collaboration level. This finding not only reveals the key path of digital transformation empowering enterprise operation but also provides important empirical evidence for firms to achieve high-quality development by optimizing supply chain management.

Table 8. Results of Mechanism Test

VARIABLES	(1) TAT	(2) SC	(3) TAT
SC			0.0005
			(1.452)
DCG	0.0116***	-0.5071***	0.0118***
	(3.827)	(-4.387)	(3.905)
Controls	YES	YES	YES
Constant	1.7424***	100.0100***	1.6949***
	(6.947)	(12.484)	(6.702)
Observations	34,514	34,514	34,514
R-squared	0.243	0.035	0.243
Number of stkcd	4,247	4,247	4,247
year FE	YES	YES	YES
stkcd FE	YES	YES	YES
F	162.8	14.52	156.9

5.6. Heterogeneity Analysis

5.6.1 Property Rights Nature

To investigate whether the impact of digital transformation on enterprise operational capacity differs due to property rights nature, this paper splits the sample into state-owned enterprises and non-state-owned enterprises for grouped regression. The results,as shown in Table 9, show that in the state-owned enterprise sample, the regression coefficient of the core independent variable DCG is 0.0105, significantly positive at the 5% statistical level. In the non-state-owned enterprise sample, the regression coefficient of DCG is 0.0182, significantly positive at the 1% statistical level. This indicates that the positive promoting effect of digital transformation on enterprise operational capacity holds in both types of enterprises, but is more significant and has a larger coefficient in non-state-owned enterprises. The above results show that the improvement effect of digital transformation on enterprise operational capacity has significant property rights heterogeneity, and the impact is more significant in non-state-owned enterprises.

Table 9. Analysis of Property Ownership Heterogeneity

	SOE	
VARIABLES	TAT_1	TAT_0
DCG	0.0105**	0.0182***
	(2.544)	(3.783)
Controls	YES	YES
Constant	1.3712***	1.8048***
	(3.825)	(5.226)
Observations	21,346	11,157
R-squared	0.245	0.214
Number of stkcd	3,027	1,218
year FE	YES	YES
id FE	YES	YES
F	98.67	53.05

5.6.2 Geographical Location Differences

To further investigate the contextual differences in the impact of digital transformation on enterprise operational capacity, this paper splits the full sample into coastal enterprises and non-coastal enterprises according to whether the province where the enterprise is registered is a coastal area, and conducts grouped regression to test the heterogeneous impact of geographical location on the main regression results.

The regression results,as shown in Table 10, show that the core independent variable digital transformation (DCG) is significantly positive at the 1% statistical level in both coastal and non-coastal subsamples, indicating that digital transformation can significantly improve the total asset turnover (TAT) of enterprises regardless of whether they are located in coastal or non-coastal areas, consistent with the main regression conclusion. Meanwhile, the regression coefficient of DCG in the non-coastal subsample (0.0143) is slightly larger than that in the coastal subsample (0.0105), indicating that the marginal improvement effect of digital transformation on operational efficiency is more prominent in non-coastal areas. This result may be due to the relatively weak digital infrastructure and technology application in non-coastal areas, so digital transformation has greater room for efficiency improvement and a stronger driving effect on enterprise operational capacity.

The above heterogeneity analysis results not only verify the universal applicability of the positive promoting effect of digital transformation on enterprise operational capacity in different geographical environments but also reveal its stronger empowerment effect in non-coastal areas with relatively insufficient resource endowments, providing a new perspective for understanding the differential impact of digital transformation.

Table 10. Analysis of Heterogeneity in Geographical Location Differences

	Coastal	
VARIABLES	TAT_1	TAT_0
DCG	0.0105***	0.0143***
	(2.857)	(2.789)
Controls	YES	YES
Constant	1.3662***	2.3444***
	(4.024)	(6.591)
Observations	22,327	12,177
R-squared	0.241	0.261
Number of stkcd	2,822	1,473
year FE	YES	YES
stkcd FE	YES	YES
F	113.0	57.26

5.6.3 Scale Heterogeneity

To further investigate the applicable boundary of the core conclusion, this paper splits the sample into small-scale and large-scale enterprise groups based on the median of total assets, and tests whether the impact of core independent variables on working capital turnover efficiency (TAT) has scale heterogeneity.

From the regression results,as shown in Table 11, the impact of the core independent variable DCG shows significant scale differences. In the large-scale enterprise group, the coefficient of DCG is 0.0094, significantly positive at the 5% level, indicating that digital transformation can effectively improve the working capital turnover efficiency of large-scale enterprises. In the small-scale enterprise group, the coefficient of DCG is -0.0012 and not significant, indicating that its impact on small-scale enterprises does not pass the significance test.

The reasons for this difference can be attributed to the differences in resource endowments and operational capabilities between the two types of enterprises. Large-scale enterprises have a more complete supply chain system, stronger bargaining power and financing capacity, and can better transform the mechanism represented by DCG into the improvement of working capital efficiency. Limited by financing constraints, management capabilities, and risk resistance levels, small-scale enterprises cannot fully exert the role of digital transformation.

Thus, the promoting effect of digital transformation on working capital turnover efficiency is only significant in large-scale enterprises. This conclusion provides empirical evidence for enterprises of different scales to formulate differentiated working capital management strategies.

Table 11. Scale Heterogeneity

	Size	
VARIABLES	TAT_0	TAT_1
DCG	-0.0012	0.0094**
	(-0.327)	(2.160)
Controls	YES	YES
Observations	17,257	17,257
R-squared	0.255	0.245
Number of stkcd	2,968	2,410
year FE	YES	YES
stkcd FE	YES	YES
F	92.61	90.75

6. Research Conclusions and Policy Recommendations

6.1. Research Conclusions

Taking Chinese A-share listed firms from 2014 to 2024 as samples, this paper empirically tests the impact of digital transformation on enterprise operational capacity, examines the mediating mechanism of supply chain collaboration with supply chain concentration as a proxy variable, and conducts expanded analysis combined with heterogeneous characteristics. The study finds that:

First, at the main effect level, digital transformation can significantly improve enterprise operational capacity measured by total asset turnover. Digital applications help optimize enterprise resource allocation, reduce internal transaction costs, and improve asset use efficiency. This conclusion remains robust after controlling enterprise characteristics, industry and year fixed effects. Second, at the mechanism level, further analysis shows that digitalization can effectively improve supply chain collaboration by increasing supply chain concentration, enhancing the closeness of upstream and downstream cooperation and information sharing level, thereby improving enterprise operational efficiency, indicating that supply chain collaboration plays a significant partial mediating role in the process of digital transformation empowering operational capacity improvement. Third, at the heterogeneity level, heterogeneity analysis further shows that the promoting effect of digital transformation has obvious differences, showing asymmetric characteristics under different property rights nature, enterprise scales and external environments, meaning that the relationship between digital transformation and operational efficiency is jointly constrained by internal and external conditions. Overall, digital transformation can effectively improve enterprise asset turnover efficiency and operational level by optimizing supply chain management and strengthening supply chain collaboration, providing empirical evidence for high-quality development of enterprises under the background of digital economy.

6.2. Countermeasures and Suggestions

6.2.1 Enterprise Level

First, speed up the implementation of digital technology and promote the digital reconstruction of business processes. Enterprises should raise investment in digital technologies such as big data and artificial intelligence in production, operation, marketing and other links, build a digital management platform, achieve efficient integration and utilization of data resources, so as to optimize asset allocation and improve asset turnover efficiency.

Second, optimize supply chain collaborative management and strengthen upstream and downstream cooperation with digital tools. Enterprises should use digital technology to break supply chain information barriers, appropriately adjust supply chain concentration, build stable cooperative relationships with core suppliers and customers, improve information sharing and business collaboration levels, and reduce transaction costs and capital occupation.

Finally, formulate differentiated transformation strategies according to their own characteristics. State-owned enterprises should give play to resource advantages and play a demonstration and leading role in digital transformation. Non-state-owned enterprises can focus on segmented fields and improve operational flexibility through lightweight digital tools. Manufacturing enterprises can focus on promoting digital transformation of the production end, and service enterprises can focus on digital upgrading of service processes and customer management.

6.2.2 Industry Level

First, leverage the role of industry leaders and build a digital sharing platform for the industrial chain. Drawing on the technical and resource strengths of leading enterprises in the industry, an open and shared digital platform should be built to promote information exchange and resource integration of upstream and downstream enterprises, and provide low-cost and standardized digital transformation solutions for small and medium-sized enterprises.

Second, formulate industry digital norms and standards to guide collaborative transformation. Industry associations can take the lead in formulating technical specifications and data interaction standards for digital transformation, promote technical docking and business collaboration among enterprises, avoid homogeneous transformation and resource internal friction, and improve the overall operational efficiency of the industrial chain.

Finally, build an exchange and cooperation mechanism to promote experience sharing. Through holding industry summits, case sharing meetings and other forms, promote excellent practices of digital transformation, promote collaborative innovation of large, medium and small enterprises, and strengthen the resilience and competitiveness of the industrial chain.

6.2.3 Policy Level

First, improve the policy support system and reduce enterprise transformation costs. Through fiscal subsidies, tax incentives, credit support and other tools, increase support for traditional industries, underdeveloped regions and SMEs, and alleviate the capital and resource pressure of enterprise digital transformation.

Second, strengthen digital infrastructure and consolidate the transformation foundation. Speed up the deployment of new infrastructure such as 5G, industrial Internet and data centers, narrow the digital divide between regions and industries, and provide stable and efficient technical support for enterprise digital transformation.

Finally, improve the institutional guarantee system and create a good environment. Improve the market-oriented allocation mechanism of data elements, strengthen data security and privacy protection, standardize market competition order, guide enterprises to deeply integrate digital construction with supply chain modernization, and promote coordinated development of digital technology and real economy.

6.3. Research Deficiencies and Future Prospects

While this paper has achieved certain results in exploring the relationship between digital transformation and operational capacity, there are still some limitations. First, in terms of index measurement, digital transformation and supply chain collaboration both use single-dimensional proxy variables, and there is room for improvement in depicting their multi-dimensional connotations. Second, the sample only covers listed companies, with limited explanatory power for the majority of small and medium-sized enterprises and specialized and sophisticated enterprises. Third, the research is mainly static analysis, and insufficient discussion on long-term dynamic impact and non-linear mechanisms.

Future research can proceed from the following directions. First, build a multi-dimensional and multi-level index system, and comprehensively integrate information such as enterprise digital investment, patents and platform construction to improve the accuracy of variable measurement. Second, expand the sample to small and medium-sized enterprises, specialized and sophisticated enterprises and other subjects to further enhance the universality of conclusions. Third, adopt dynamic models, threshold effect and other methods to deeply analyze the long-term effects and constraints of digital transformation. Meanwhile, expand the research boundary from the perspectives of governance structure, external policies, ESG performance, etc., to provide more targeted theoretical references and decision support for enterprise digital transformation and supply chain optimization.

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