The impact of digital transformation on enterprise inventory management efficiency

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Abstract. Using data from all non-ST A-share listed companies from 2007 to 2023, this study constructs a digital transformation index via text analysis and examines its impact on inventory management efficiency through regression analysis. It measures efficiency by inventory levels and turnover days, finding that digital transformation enhances this efficiency. Heterogeneity analysis reveals that customer concentration significantly amplifies the benefits of digital transformation on inventory management. The study identifies three key mechanisms: improved information transparency, increased human capital investment, and innovation, through which digital transformation boosts efficiency. The findings offer valuable insights for leveraging digital transformation to optimize inventory management and foster high-quality enterprise development.

Keywords: digital transformation, inventory management efficiency, information transparency, human capital investment, enterprise innovation level.

1. Introduction

Information technology's advancement propels the digital economy's growth. China's "14th Five-Year Plan" for the digital economy outlines a new phase focused on deeper application, standardized growth, and inclusive sharing. The Digital China plan underscores the importance of bolstering the digital economy, developing core industries, integrating digital tech with the real economy, and creating globally competitive digital industrial clusters.

Digital transformation involves businesses and organizations leveraging digital technology and innovation to change business models, processes, and value creation. It aims for efficiency and flexibility through digitalization, automation, and intelligence, with data as a key resource. The technologies transformation boosts competitiveness, innovation, and sustainable growth. Research indicates it positively impacts enterprise exports [1], total factor productivity [2], stock liquidity [3], reduces debt default risk [4], improves innovation performance [5], and promotes high-quality development [6]. It is thus a strategic priority for businesses to actively pursue.

Business inventories consist of goods and materials held for production and sales, crucial for delivery capability and customer satisfaction. However, excessive inventory can result in capital tie-up and overhang [7], raising costs and impacting profitability. Managers aim for efficient inventory management by tracking inventory levels [8] to enhance efficiency, minimize capital occupation, and boost turnover and profitability. Studies have examined the effects of infrastructure investment [9], inflation [10], supply chain management [11], and internal control [12] on corporate inventory, yet the influence of digital transformation on inventory management efficiency has not been a central focus.

Digital transformation enhances enterprise inventory management efficiency via technologies like cloud computing, big data, AI and blockchain. It allows real-time inventory monitoring, optimizes structure, mitigates slow sales risks, and boosts management precision and transparency. Automated systems predict demand [13], streamline procurement, reduce information asymmetry [14], and adjust supply chain strategies promptly [15]. It simplifies inventory processes [16], minimizes errors, enhances data accuracy for reliable decisions, and enables real-time data visualization for optimal inventory levels and reduced waste or delays. Despite its benefits, empirical evidence on digital transformation's impact on inventory efficiency is scarce. This paper will explore this influence, its mechanisms, and contributing factors.

This paper contributes by: 1) broadening the economic impact research of digital transformation, addressing past gaps in measuring its extent, and enriching the field; 2) deepening the understanding of enterprise inventory management efficiency by examining the effects of digital transformation through information transparency, human capital investment, and innovation degree 3) offering insights for managerial decision-making to enhance inventory efficiency and foster high-quality enterprise development.

2. Research Hypothesis

(1) Digital transformation and enterprise inventory management efficiency

Enhancing inventory management efficiency is a key concern for businesses. Academic and practical approaches like Just-in-Time (JIT) [17], Economic Order Quantity Model (EOQ) [18], and ABC classification management [7] have been proposed to optimize inventory levels and efficiency. Despite their theoretical effectiveness, implementation challenges include information asymmetry [3], managerial expertise [16], and innovation capacity deficits.

Information asymmetry [3] impacts the precision and timeliness of inventory management, causing supply chain coordination [19] and efficiency issues. Managerial professional quality [16] deficiencies can lead to poor inventory decisions, affecting supply chain efficiency and costs. A lack of innovation can result in overstocking or over-ordering, hindering inventory management's flexibility and adaptability. To tackle these problems, firms must enhance inventory management efficiency, leveraging digital transformation to boost transparency, human capital investment, and innovation.

Firstly, improving information transparency [20] through digital transformation enhances information sharing and access, aiding stakeholders in understanding inventory and market conditions, and maintaining customer stability [21]. It reduces information search costs [23] for external investors and improves internal information accuracy [24], aiding decision-making reliability. This precision helps in more accurate demand forecasting [25], leading to better replenishment strategies and inventory optimization. Digitization also boosts internal collaboration [26], control [27], and inventory management efficiency, with cross-departmental platforms and real-time tools overcoming information flow barriers and enhancing coordination.

Secondly, digital transformation enhances inventory management efficiency by boosting human capital investment, emphasizing the importance of knowledge dividends and spillovers [28]. Training employees in digital skills [29] improves their ability to handle advanced tools, optimizing data collection, processing, and decision-making for inventory. Hiring and training data analysts leverages big data and AI for inventory analysis, identifying optimization opportunities and risks, and enhancing demand forecasting and inventory management efficiency. Digitization also strengthens team collaboration [29], promotes information sharing, reduces silos [31], and improves response speed [32], coordinating procurement and logistics through collaborative platforms and tools.

Thirdly, digital transformation enhances inventory management efficiency through increased enterprise innovation. Technologically, digital tech allows real-time inventory data collection and analysis [33], IoT and sensor-based monitoring, and refined management methods. AI and machine learning are used to deeply analyze data, pinpointing bottlenecks and improvement areas. Thinking innovation is fostered by digitalization, promoting an innovation culture and collaboration [34]. Collaborative platforms and tools facilitate information and idea sharing across departments, speeding up inventory management improvements. The digital platform boosts communication and collaboration efficiency [31], engaging employees in decision-making, sharing expertise, and driving innovation for efficiency gains.

Hypothesis: All other things being equal, digital transformation can improve the efficiency of enterprise inventory management.

3. Research design

(1) Sample selection and data sources

This study utilizes data from all non-ST A-share listed companies from 2007 to 2023. Data sources include MD&A text digital vocabulary and annual report text word frequency statistics from the China Research Data Service platform, and inventory holding level, turnover period, and other relevant data from the CSMAR database. In empirical testing, samples with missing variable values for regression were either excluded or imputed with reasonable values, and continuous variables were trimmed by 1%. All regression analyses in the paper are based on robust estimation methods.

(2) Variable selection

1. Enterprise inventory management efficiency

The paper measures inventory management efficiency using two methods: 1) the inventory ratio (Inventory), calculated as net inventory over total assets [35], with higher ratios suggesting capital tie-ups and inventory backlogs, and lower ratios indicating good inventory control; 2) the inventory turnover period (InvDays), calculated as the ratio of net inventory to operating costs multiplied by 365, then taking the logarithm [36]. A shorter turnover period signifies fast sales and capital turnover, while a longer period may suggest slow sales and capital occupancy, with shorter periods generally indicating higher inventory management efficiency.

2. Enterprise digital transformation

Enterprise digital transformation indicators are often textually analyzed from annual reports. Following Wu Fei [3], annual report wording reflects corporate strategy and philosophy. Using Wang Shouhai et al.'s [4] approach, the digital word frequency in annual reports is logged to gauge digital transformation (Digital1), with higher values indicating greater transformation degrees.

3. Customer concentration

In this paper, the ratio of the sales of the top five customers to the total annual sales (Li Yanping, 2017[13]) is used to measure the customer concentration (Cc). High customer concentration means that the sales or income of an enterprise mainly depends on a few important customers, while low customer concentration means that the sales or income of an enterprise is scattered among multiple customers.

4. Information transparency

Research reports are vital in finance, offering insights into company finances, strategies, industry trends, and market prospects. This paper uses research report attention to gauge information transparency (RA) (Zhang Qinglong et al., 2019 [38]), with higher attention suggesting greater market interest and demand for information, encouraging increased disclosure by companies or institutions.

5. Degree of enterprise innovation

Innovation input theory highlights R&D investment as crucial for enterprise innovation. This paper measures the degree of enterprise innovation using the logarithm of R&D investment (R&D) (Ye Jingyi et al., 2019[39]). Increased R&D investment can bolster a company's technological capabilities, foster innovation in products and technologies, strengthen market competitiveness, and lead to profitable and valuable growth.

6. Human capital investment level

Investment in human capital is crucial for companies to attract and retain talent, improve work efficiency, and promote innovation and sustainable development. It is also about providing leadership development opportunities for employees. This paper uses the logarithm of average executive compensation (AMP) (Wanyuan Magnitude, 2023[40]) to measure the level of human capital investment.

(3) Model setting

This paper uses model (1) to test whether digital transformation can reduce the inventory level of enterprises, and it is expected that the Digital1 coefficient is significantly negative. In this paper, Stata17.0 was used for empirical analysis, and all standard errors of regression were clustered at the industry level [41].

$$Inventory_{i,t}/InvDays_{i,t} = \beta_0 + \beta_1 Digital1_{i,t} + \sum \beta_i Controls + \sum Year + \sum Ind + \varepsilon \quad (1)$$

Among them, Controls represents a series of control variables that affect the inventory level of an enterprise, including Lev, GM, Size, CAR, Fix, Top1, Top10, Growth, CI, ROA and other variables. The specific control variable definitions are shown in Table 1. At the same time, the model controls for year and industry to absorb fixed effects as much as possible.

Table 1 Control variables

Variable name	Variable symbol	Variable definition
Enterprise asset structure	*Lev*	t Total liabilities/total assets at year end
Gross operating margin	*GM*	[t year operating revenue -t year operating cost] / t year operating revenue
Enterprise assets size	*Size*	t natural number of total assets at the end of the year
Cash assets ratio	*CAR*	t Year-end cash and cash equivalents balance/total assets
Proportion of fixed assets	*Fix*	t Net fixed assets/total assets at year-end
The ratio of the largest shareholder	*Top1*	t The shareholding ratio of the largest shareholder of the enterprise at the end of the year
The top 10 shareholdings ratio	*Top10*	t The proportion of shares held by the top ten shareholders at the end of the year
Enterprise growth ability	*Growth*	[t year operating revenue - (T-1) year operating revenue] / (T-1) year operating revenue
Capital intensity	*CI*	t Total assets/operating income at year end
profitability	*ROA*	t Year-end net profit/total assets

4. Empirical test and result analysis

(1) Descriptive statistics and correlation analysis

This paper presents descriptive statistics for key variables: the digital transformation mean is 2.736, with extremes from 0 to 5.829, suggesting many firms have low or uninitiated digital transformation, highlighting vast potential for advancement in China. Inventory levels range from 5.31e-08 to 0.685, and turnover periods from 0.116 to 7.807, indicating significant efficiency disparities among listed companies. Other variables align with literature and actual conditions, with main variables showing significant correlations below 1%, preliminarily supporting the paper's hypothesis. (Detailed results are omitted for reference.)

(2) Basic regression results

Table 2 presents hypothesis testing results using model (1). The InvDays index's large value necessitates logarithmic transformation for consistency. With Inventory as the dependent variable, Digital1's regression coefficient is -0.017, significant at the 1% level. With InvDays as the dependent variable, Digital1's coefficient is -49.458, also significant at the 1% level. These results indicate that digital transformation significantly lowers enterprise inventory levels, confirming the hypothesis.

Table 2 Digital transformation and enterprise inventory management efficiency

variable	Explained variable	
	Inventory	*InvDays*
Digital1	-0.017***	-0.118***
	(-38.92)	(-27.59)
Size	-0.004***	-0.006
	(-8.08)	(-1.21)
Lev	0.117***	0.161***
	(34.61)	(4.85)

Growth	0.015***	0.135***
	(31.52)	(29.19)
CI	-0.003***	0.027***
	(-16.88)	(16.15)
GM	-0.018***	2.043***
	(-5.04)	(56.89)
CAR	-0.183***	-1.446***
	(-38.76)	(-31.26)
Fix	-0.318***	-2.674***
	(-82.85)	(-70.95)
Top1	0.001***	0.002***
	(16.73)	(4.87)
Top10	-0.000***	-0.004***
	(-10.46)	(-8.90)
ROA	0.102***	-1.866***
	(10.23)	(-19.05)
Year/Ind	Y	Y
Constant	0.335***	5.721***
	(33.57)	(58.33)
Observations	41,690	41,690
R-squared	0.245	0.242

Note: ***, ** and * respectively represent the significance levels of 1%, 5% and 10% in the T-test (double-tailed), the t value is in parentheses, and the standard error is the robust standard error, the same below.

(3) Robustness test

1. Re-measure the explained variables

Inventory turnover is a key index to measure the inventory utilization efficiency of enterprises, showing the relationship between sales revenue and average inventory, reflecting the frequency of inventory sales and replacement. High turnover means that inventory is sold quickly, reducing the risk of overstocking and improving capital efficiency. Low turnover may indicate excess inventory or inaccurate planning that needs to be adjusted. If digital transformation can increase inventory turnover, it supports the research hypothesis. For the selection of explained variables, the first is to refer to the research of Ak and Patatoukas[42], Zheng Qianwen and Zhu Lei [14], that is, inventory turnover (Turnover1), which is the division of operating cost by the average inventory balance. Second, referring to the research of Li Yanping [13], inventory turnover (Turnover2), that is, dividing operating income by average net inventory, is used to measure the efficiency of enterprise inventory management again. After re-measuring the key variables, the results in Table 3 (1) and (2) show that the coefficient of Digital1 is significantly positive, and the hypothesis is still valid.

2. Change explanatory variables

The MD&A is part of the annual report and contains management's analysis of the company's operations, finances, risks and future outlook. This paper analyzes the frequency of words related to digital transformation in MD&A (such as artificial intelligence, blockchain, cloud computing, big data, etc.) to assess the degree of enterprise digital transformation (Digital2) (Wang Xiongyuan et al., 2018[37]). The results in Table 3 (3) and (5) show that the coefficients of Digital2 are still significantly negative, which supports the hypothesis.

3. Control the fixed effect of individual enterprises

Some factors that are difficult to measure and do not vary with the enterprise and time may cause the problem of missing variables. Therefore, the fixed effects of individual enterprises are further controlled for testing. The results in Table 3 (4) and (6) show that the coefficients of Digital1 are still significantly negative, which supports the hypothesis.

Table 3 Robustness test

variable	Explained variable		Explained variable		Explained variable	
	Turnover1	*Turnover2*	*Inventory*		*InvDays*	
	(1)	(2)	(3)	(4)	(5)	(6)
Digital1	2.249***	3.859***		-0.017***		-0.129***
	(11.07)	(10.26)		(-39.26)		(-28.21)
Digital2			-0.015***		-0.107***	
			(-36.57)		(-26.83)	
Controls	Y	Y	Y	Y	Y	Y
Year/Ind	Y	Y	Y		Y	
Constant	-29.163***	-57.644***	0.340***	0.314***	5.762***	5.087***
	(-6.29)	(-6.71)	(34.74)	(31.66)	(59.81)	-48.89
R-squared	0.053	0.056	0.242	0.241	0.240	0.181

(4) Endogeneity analysis

1. Instrumental variable method

In order to solve the endogeneity problem caused by "reverse causation", the intermediate effect instrumental variable method and two-step least square method (2SLS) are also used to estimate. Specifically, in the industry of enterprise i in year t, the mean value of digital transformation of all enterprises except enterprise i is the instrumental variable of digital transformation (Digital0). For the regression of instrumental variables to endogenous explanatory variables in the first stage, the coefficients of the industry average level of digital transformation are 0.9014 and 0.9780, respectively, which are significant at the 1% level, indicating a strong correlation between instrumental variables and endogenous explanatory variables. The regression results of the second stage show that the coefficients of Digital1 are all significantly negative, and the hypothesis is still valid. (Regression results are omitted and retained)

5. Further analysis

1. Mechanism analysis

According to the previous analysis, this paper believes that improving the transparency of enterprise information, increasing the investment of human capital and increasing the degree of innovation of enterprises are three possible ways for digital transformation to improve the efficiency of enterprise inventory management. Therefore, this paper constructs a model to test the impact of digital transformation on corporate information transparency, corporate human capital investment and corporate innovation degree, so as to verify whether the above action path is valid. When the regression coefficients of Digital1 in the model are significantly positive, the above mechanism is established.

$$Mediator_{i,t} = \theta + \theta_1 + \sum \beta_i Controls + \sum Year + \sum Ind + \tau \quad (2)$$

$$Inventory_{i,t}/InvDays_{i,t} = \delta + \delta_1 Mediator_{i,t} + \delta_2 Digital1_{i,t} + \sum \beta_i Controls + \sum Year + \sum Ind + \xi \quad (3)$$

Three sets of mediator variables (Mediator) were selected in this paper. The first set of mediator variables was the average executive salary, the second set of mediator variables was the amount of R&D investment, and the third set of mediator variables was the attention paid by the research reports.

Table 4 lists the test results of the mechanism of action. As shown in Table 4 (2) (3) (5) (6) (8) and (9), no matter Inventory or InvDays is the explained variable, the regression coefficient of digital transformation Digital1 is significantly negative at the level of 1%. The above results show that digital transformation can significantly improve the information transparency of enterprises, increase the investment in human capital of enterprises and increase the degree of innovation of enterprises, so as to bring the efficiency of enterprise inventory management. Therefore, this paper's analysis on the mechanism of digital transformation to improve the efficiency of enterprise inventory management is valid.

Table 4 Mechanism analysis

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

variable	*AMP*	*Inventory*	*InvDays*	*R&D*	*Inventory*	*InvDays*	*RA*	*Inventory*	*InvDays*
Digital1	0.031***	-0.005***	-0.034***	0.165***	-0.002***	-0.035***	1.661***	-0.006***	-0.050***
	(11.26)	(-9.94)	(-5.99)	(28.52)	(-3.24)	(-6.25)	(14.16)	(-9.54)	(-7.64)
AMP		-0.002**	-0.129***						
		(-2.20)	(-13.12)						
R&D					-0.002***	-0.020***			
					(-2.87)	(-3.25)			
RA								-0.000***	-0.002***
								(-3.89)	(-6.33)
Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Constant	7.090***	0.368***	5.456***	-0.369	0.296***	4.918***	-205.668***	0.389***	4.777***
	(57.89)	(13.17)	(35.20)	(-1.60)	(14.54)	(24.68)	(-44.56)	(20.10)	(27.16)
Year/Ind	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	41,932	41,932	41,621	41,932	32,451	32,451	28,540	28,540	28,540
R-squared	0.480	0.404	0.525	0.376	0.275	0.320	0.317	0.443	0.406

2. Heterogeneity analysis

The impact of digital transformation on an enterprise's inventory management efficiency varies with customer concentration. Companies with high concentration are more efficient at logistics and supply chain coordination, while companies with low concentration face more diverse needs and challenges. Through technologies such as big data, the Internet of Things and cloud computing, digital transformation helps companies gain insight into market and customer needs, optimize inventory decisions, and avoid overstocks or shortages. For low-concentration enterprises, digital transformation can build flexible supply chain networks, enable real-time collaboration and inventory control, and improve the accuracy and efficiency of logistics distribution through digital platforms. It is assumed that digital transformation has a greater effect on improving inventory management efficiency in enterprises with low customer concentration than in enterprises with high customer concentration.

In column (1) (2) of Table 5, no matter the explained variable is Inventory or InvDays, the coefficient of interaction between Digital1 and the continuous variable of customer concentration is -0.000 and -0.474, both of which are significantly negative at the level of 1%. The above results show that, compared with enterprises with high customer concentration, enterprises with low customer concentration have a greater effect on improving inventory management efficiency, which proves the hypothesis.

Table 5 Heterogeneity analysis

variable	(1)	(2)
	Inventory	*InvDays*
Cc	0.001***	0.008***
	(12.96)	(10.91)
Digital1	-0.013***	-0.110***
	(-14.79)	(-12.33)
c.Cc#c.Digital1	-0.000***	-0.002***
	(-11.14)	(-9.01)
Year/Ind	Y	Y
Controls	Y	Y

Constant	0.411***	5.043***
	(14.77)	(35.70)
Observations	39,241	39,241
R-squared	0.401	0.389

6. Research conclusions and policy implications

This paper uses text analysis to measure the degree of enterprise digital transformation, and examines the relationship between digital transformation and enterprise inventory management efficiency and its mechanism. The findings are as follows: (1) Digital transformation can improve the efficiency of enterprise inventory management. (2) The effect of digital transformation on the improvement of enterprise inventory management efficiency has obvious heterogeneity under the condition of different customer concentration. (3) Improving the transparency of enterprise information, increasing the investment in human capital and increasing the degree of innovation of enterprises are the three effective ways for digital transformation to reduce the inventory level of enterprises.

This paper has the following implications for policy: (1) Set policy frameworks and standards, provide incentives such as tax breaks, promote the adoption of digital technology by enterprises, and improve the efficiency of inventory management. (2) Encourage data sharing and standardization, and enhance the application of data analytics and artificial intelligence in inventory forecasting and optimization. (3) Support enterprise innovation through innovation funds and tax incentives, and promote industry-university-research cooperation. (4) Encourage enterprises to invest in human capital, provide subsidies for training, promote reform of the education system, and train the talents needed for digital transformation.

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