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Digital Transformation, Operating Capacity and Firm Performance: Empirical Evidence from the Chinese Stock Market

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Abstract
In the context of the digital economy, digital technologies such as big data, artificial intelligence, cloud computing and so on continue to promote enterprise value creation. This paper takes the annual reports of listed companies in Shanghai and Shenzhen A-shares from 2015 to 2021 as the object, constructs digital transformation indexes based on Word2Vec machine learning technology, and empirically analyzes the relationship between digital transformation, enterprise operating capacity and company performance. The study finds that: the higher the degree of digital transformation, the stronger the operating capacity of enterprises; the improvement of enterprise operating capacity can significantly enhance company performance; digital transformation will strengthen the positive effect of operating capacity on company performance. The study's findings not only reveal the moderating role of digital transformation in the relationship between enterprise operating capacity and company performance but also provide theoretical and empirical evidence for a comprehensive and objective evaluation of the implementation effect of digital transformation.
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1. Introduction

With the development of computers, mathematics, and other disciplines in recent years, big data, cloud computing, artificial intelligence, and other related technologies have emerged as leaders of economic growth and boosters of national economic development. Related technologies based on digitalization have begun to be integrated into various fields of the real economy and traditional industries (Peukert & Reimers 2022), further giving rise to a new concept: digital transformation (Sandberg 2020). In 2021, the State Council released the "14th Five-Year Plan for the Development of Digital Economy", which clearly defined the overall requirements, key areas and safeguards for digital transformation, and the report of the 20th Party Congress also proposed to accelerate the development of digital economy and strengthen the construction of digital China, thus elevating digital transformation to the level of a national strategy (Benner & Waldfogel 2023). With the deep integration of modern information technology and the real economy, digital transformation has entered and rapidly changed various fields of China's economy, society and consumer life, empowering the transformation and upgrading of traditional industries and giving rise to new industries, new business models and new modes (Nadkarni & Prügl 2021). In the context of the gradual disappearance of China's demographic dividend and the gradual weakening of the low-cost manufacturing advantage, digital transformation uses data and platform resources to promote traditional enterprises to create value, which is an important way to enhance the competitiveness of enterprises.

So far, among the studies on the positive economic consequences of digital transformation, although individual studies have explored the direct impact of digital transformation on performance (Tambe 2014; Benitez *et al.* 2022), they have not studied the mechanism of its impact, and are mostly limited to the description of the phenomenon or the analysis of the transformation process of an enterprise's business model, failing to reveal how the internal factors of an organization affect the relationship between digital transformation and corporate performance. At the same time, research on the relationship between operational capability and corporate performance is relatively mature. Still, there are relatively few empirical studies on the mechanism of the effect of digital transformation on operational capability and corporate performance. To this end, this paper focuses on integrating digital transformation into the research framework of the relationship between operating capability and firm performance. It establishes a theoretical model of the relationship between digital transformation, firm operating capability and firm performance. Specifically, first, this paper uses a Word2Vec-based machine learning approach to construct digital transformation indicators to form an unbalanced panel data of A-share listed companies in China's Shanghai and Shenzhen markets between 2015 and 2021 (Siano & Wysocki 2021; Geertsema & Lu 2023; Ma *et al.* 2023); then, it empirically tests the relationship between digital transformation, corporate operating capacity and firm performance. We find that: (1) the higher the degree of digital transformation, the stronger the firm's operating capacity. (2) The operational capability of a company can significantly improve its

performance. (3) Digital transformation strengthens the positive effect of operational capability on firm performance.

The contribution of this paper is to present and validate the role of digital transformation in the relationship between operational capability and firm performance. The paper integrates digital transformation, operational capability and firm performance into an analytical framework to identify whether digital transformation moderates the relationship between operational capability and firm performance. The findings of the study provide not only new ideas on how companies can improve their operating capabilities and reveal the boundaries of the role of digital transformation in the relationship between operating capabilities and firm performance but also provide theoretical and empirical evidence for a comprehensive and objective evaluation of the effectiveness of the implementation of digital transformation and firms' operating capabilities. The findings of the study will help the state and government to optimize the development environment of the "digital economy" and promote digital transformation as a national strategy while promoting the deep integration of digital technologies such as big data, artificial intelligence and cloud computing with traditional enterprises; enterprises should be actively guided to develop digital thinking to promote the improvement of operational capabilities, this will ultimately enhance corporate performance.

2. Theoretical Analysis and Research Hypothesis

Digital transformation refers to the deep integration of digital technology and the real economy in various aspects, such as production and operation management, based on digital technology. It builds a platform between suppliers and consumers for enterprises with the help of emerging technologies such as big data, artificial intelligence, blockchain and cloud computing, reshapes the organizational structure and industrial modules, drives enterprise innovation and cross-border integration, and forms a new operational system that can span time and space. Drawing on the research of relevant scholars and taking into account the actual situation of listed companies in China, this paper defines the level of digital transformation as the extent to which digital-based information technologies such as big data, artificial intelligence and cloud computing can be applied in conjunction with listed companies.

2.1 Digital Transformation and Business Operating Capability

Digital transformation is beneficial for enterprises to improve operational efficiency. Firstly, big data systems can provide enterprises with more valuable information based on the theory of transaction costs and information asymmetry. Enterprises can easily and inexpensively obtain information from upstream and downstream feedback, thus increasing the transparency of enterprise information, reducing information asymmetry (Sussan & Acs 2017), and better meeting the needs of upstream and downstream enterprises and customers (Loebbecke &Picot 2015), making comprehensive arrangements for various resources in the operation process from time and space, reasonably decomposing The company's operational objectives and resources can be rationalized to improve operational efficiency and quality.

Secondly, traditional manufacturing companies invest heavily in plant and equipment, distribution channels and other dedicated assets, showing heavy and low mobility. In the digital economy, enterprises are transformed into network-based enterprises. On the one hand, through high-speed connection and two-way interaction with network partners, enterprises can integrate external resources for their use more flexibly and efficiently, thus reducing the investment in fixed assets and realizing asset-light operations, supporting business operations of the same scale with smaller asset investment (Li *et al.* 2018). On the other hand, enterprises can use digital technology to accelerate the turnover of cash, inventory, accounts receivable and other current assets to generate more revenue with fewer existing assets in the same business cycle and achieve operational goals (Vial 2019).

Finally, digital transformation pushes traditional industries to change through technology spillover effects. In applying digital technology to enterprises, the degree of digital transformation varies among enterprises due to their different innate resource endowments, making the development of enterprises have a technological spillover effect (Hess *et al.* 2016). As the first enterprises to implement digital transformation will have a more obvious competitive advantage, it puts the lagging enterprises into a situation of tension and crisis, forcing these enterprises to start catching up with the advanced enterprises and actively implement digital transformation, taking the initiative to absorb various new technologies based on digitalization. Therefore, in recent years, traditional industries have begun to gradually draw on information technologies such as big data, cloud computing and blockchain to achieve digital transformation, to encourage the real economy to form new technologies, standards and forms through digital transformation, bringing significant positive technological spillover effects to traditional industries and promoting recent changes to the operating and profit models of the real economy (Nambisan *et al.* 2019), thereby enhancing the operational This will improve business operations.

Based on the above analysis, this paper proposes hypothesis H1:

H1: The higher the degree of digital transformation, the stronger the operational capacity of the enterprise.

2.2 Business Operating Capacity and Corporate Performance

The purpose of the study of operating capacity is to analyze its impact on a company's performance and to provide direction on improving its business performance. Operating capacity refers to a company's ability to use its assets to earn profits and is one of the most important elements of corporate financial management. Foreign scholars believe that factors such as the size of fixed assets and the total asset turnover rate will have an impact on the profitability of an enterprise and that the ratio indicator of operating capacity can effectively measure the efficiency of asset management (Agiomirgianakis & Voulgaris 2006). By analyzing the relationship between working capacity and profitability in different industries, domestic scholars generally believe that the efficiency of working capital management can significantly affect a company's profitability and that total asset turnover is significantly related to return on net assets.

Based on the above analysis, this paper proposes hypothesis H2:

H2: Increasing a firm's working capacity can significantly enhance its performance.

2.3 Digital Transformation, Operating Capacity and Corporate Performance

Digital transformation can help enterprises improve operational efficiency and performance in three ways: digitalization of operations, information transparency, and decision-making flexibility. Firstly, in the context of digital transformation, the most obvious manifestation of the in-depth integration of traditional enterprises with digital technology is the extensive use of advanced technology, software and information systems in operations (Li *et al.* 2019), finance and user management, which can make use of big data and artificial intelligence to accurately analyze market demand and provide specific quantitative data analysis for operational planning, enabling enterprises to make more effective matches between procurement, production and sales to utilize the value of their assets fully. This enables enterprises to match different markets and demands more effectively in the procurement, production and sales processes, giving full play to the value of their assets and ultimately promoting improved business performance. Secondly, based on the transaction cost theory, the connectivity features of digitalization directly lead to changes in the structure of transactions, breaking the constraints of time and space and expanding the spatial scope of transactions, which can greatly improve the efficiency of business management and enhance business performance through the innovation of transaction structures and the reduction of unnecessary intermediary channels. Finally, the use of digital technology can help reduce the disadvantages of information asymmetry(Banalieva & Dhanaraj 2019), reduce the risks caused by poor information, provide immediate data and information services for business decisions, improve the efficiency of asset utilization, which in turn improves the efficiency of business decisions and the turnover rate of various assets(Kang & Suh 2022), and ultimately enhances the performance of the company.

Based on the above analysis, this paper proposes hypothesis H3:

H3: Digital transformation will strengthen the positive effect of corporate operating capabilities on firm performance.

3. Research Design

3.1 Data Source and Sample Selection

This paper selects A-share listed companies in China's Shanghai and Shenzhen markets from 2014 to 2020 as the original research sample. The enterprise digital transformation text data are from the WinGo financial text data platform, and other financial data and indicators are from the CSMAR database. In this paper, the processing of the sample is as follows. (1) To avoid interfering with the estimation results, listed companies that are naturally related to digital technology, such as those in the high-tech sector, are excluded, mainly including information transmission, the software and information technology service industry and China's GEM listed companies. (2) Samples from the financial industry, ST and *ST companies are excluded. (3) Samples with missing relevant data are excluded. Finally, we get 13043 effective observations. At the same time, to eliminate the potential impact of sample outliers and heteroscedasticity, sequence correlation and other issues, all continuous variables are Winsor processed according to the 1% standard.

3.2 Definition and Measurement of Variables

(1) Digital Transformation

DT, the independent variable in Hypotheses H1 and H3, expresses digital transformation. This paper adopts the Word2Vec technology method based on text analysis and machine learning on the expression information of keywords in annual statistical reports, which can better accommodate the text context environment according to the context content of the vocabulary, realize the expansion of similar words based on the particular corpus of finance and economics, and avoid the subjectivity of manual judgment. This method has been proven feasible in empirical research based on text analysis (Siano & Wysocki 2021; Geertsema & Lu 2023).

(2) Operating capacity

Operating capacity refers to the ability of a company to use its assets to earn profits. It is reflected in management's

ability to manage the company and the efficiency of its use of resources. It is the explanatory variable in Hypothesis H1 and both Hypotheses H2 and H3. The analysis of operating ability includes the estimation of current asset turnover, the analysis of fixed asset turnover and the analysis of total asset turnover. In this paper, the fixed asset turnover ratio (*TAT*) is chosen to measure the operating ability of enterprises, which can reflect the use of assets of enterprises more comprehensively.

(3) Financial Performance

In hypotheses H2 and H3, financial performance is the explanatory variable measured using return on net assets (*ROE*).

(4) Control variables

To control the possible impact of other company-level characteristics on the relationship between research variables, this paper controls other factors that affect financial performance, including two levels of (1) company financial characteristics variables: company size (*SIZE*), company growth (*GROWTH*), asset-liability ratio (*LEVER*), company property rights (*SOE*); (2) Corporate governance variables: whether the CEO and the Chairman are in one position(*DUAL*), the shareholding ratio of senior executives (*MANAGE*), the concentration of equity (*CONCEN*), the size of the board of directors (*BOARD*), the proportion of independent directors (*INDEP*). The specific definition and description of variables are shown in Table 1.

Table 1. Summary of research variables

Variable	Name	Variable annotation
ROE	Financial performance	Net profit / net assets
TAT	Operating ability	Total sales revenue/average total assets
DT	Digital transformation	The proportion of total word frequency of digital transformation related words to total word frequency of annual report × 100
SIZE	Asset size	Ln (total assets)
GROWTH	Company growth	Annual revenue growth rate
LEVER	Financial risk	Asset-liability ratio
SOE	Nature of property rights	The value of state-owned enterprises is 1; the rest is 0
DUAL	Two-in-one	The value is 1 when the CEO and the chairman are concurrent; otherwise, 0
MANAGE	The shareholding ratio of executives	Total Executive Shareholding / total shares
CONCEN	Ownership concentration	Number of shares held by the largest shareholder / total number of shares
BOARD	Board size	Ln (number of board members)
INDEP	The proportion of independent directors	Number of independent directors/board of directors

3.3 Model Setting

To verify Hypothesis H1, this paper needs to construct a regression model between digital transformation and operating ability, as follows:

$$TAT_{i,t} = \alpha_0 + \alpha_1 DT_{i,t} + \alpha_2 SIZE_{i,t} + \alpha_3 GROWTH_{i,t} + \alpha_4 LEVER_{i,t} + \alpha_5 SOE_{i,t} + \alpha_6 DUAL_{i,t} + \alpha_7 MANAGE_{i,t} + \alpha_8 CONCEN_{i,t} + \alpha_9 BOARD_{i,t} + \alpha_{10} INDEP_{i,t} + \alpha_{11} Firm_i + \alpha_{12} Year_t + \varepsilon_{i,t} \quad (1)$$

To verify Hypothesis H2, this paper needs to construct a regression model between operating ability and financial performance, as follows:

$$ROE_{i,t} = \beta_0 + \beta_1 TAT_{i,t} + \lambda Controls_{i,t} + \varepsilon_{i,t} \quad (2)$$

To further test the moderating effect of digital transformation between operating ability and financial performance, i.e., H3, the following regression model was developed:

$$ROE_{i,t} = \gamma_0 + \gamma_1 DT_{i,t} + \gamma_2 TAT_{i,t} + \gamma_3 (DT_{i,t} * TAT_{i,t}) + \lambda Controls_{i,t} + \varepsilon_{i,t} \quad (3)$$

In Models (1), (2) and (3), the subscript *i* represents the enterprise and the subscript *t* represents the year. $Contorls_{it}$ in models (2) and (3) is a set of control variables. Consistent with the existing research (Chang *et al.* 2019), the above models all use the ordinary least squares regression method and add the firm fixed effect (*Firm*) and the annual fixed effect (*Year*). In this paper, we perform sequential tests according to the following steps. (i) If H1 holds, α_1 in the model (1) should be significantly positive. ②If H2 holds, then β_1 in model (2) should be significantly positive. (iii) If H3 holds, then the coefficient γ_3 of the cross-product term in model (3) should be significantly positive, indicating that implementing digital transformation in enterprises can strengthen the positive

effect of operating ability on financial performance.

4. Empirical Results and Analysis

4.1 Descriptive Statistical Analysis

Table 2 presents the results of descriptive statistics for the main variables. The mean and median of *ROE* are 0.064 and 0.070, respectively, and the difference between the two is small, indicating that the sample distribution presents strong normality. In addition, the standard deviation of *ROE* is 0.127, which is significantly larger than the mean and median of the variables, indicating a large difference in performance between different firms. The minimum value of the operating capacity (*TAT*) is 0.531, and the maximum value is 2.638, indicating large differences in the operating capacity of listed companies in terms of span. The sample mean of Digital Transformation (*DT*) is 0.142, indicating that the digital transformation of enterprises in China is still in the initial stage; the median of *DT* is 0.078, the standard deviation is 0.169, the minimum value is 0.003, and the maximum value is 0.919, which indicates that there is a large difference in the level of digital transformation of enterprises and that the digital transformation indicators have sufficient variability. The descriptive statistics of the control variables are consistent with existing studies.

Table 2. Descriptive statistics of main variables

Variable	N	Mean	Std. Dev.	Minimum	Median	Maximum
ROE	13043	0.064	0.127	-0.638	0.070	0.354
TAT	13043	0.626	0.442	0.064	0.531	2.638
DT	13043	0.142	0.169	0.003	0.078	0.919
STRATEGY	13043	0.960	0.470	0.257	0.862	2.746
SIZE	13043	22.540	1.305	20.08	22.360	26.410
ROA	13043	0.035	0.058	-0.225	0.033	0.188
GROWTH	13043	0.152	0.476	-0.597	0.078	3.383
LEVER	13043	0.454	0.202	0.070	0.447	0.902
SOE	13043	0.416	0.493	0.000	0.000	1.000
DUAL	13043	0.016	0.124	0.000	0.000	1.000
MANAGE	13043	0.051	0.118	0.000	0.000	0.583
CONCEN	13043	35.420	14.910	9.390	33.380	75.050
BOARD	13043	2.139	0.194	1.609	2.197	2.708

4.2 Multiple Regression Analysis

Table 3 presents the results of the regression analysis for hypotheses H1, H2 and H3. Column (1) provides the regression results on how digital transformation affects firms' operating capacity. We can see that after controlling for a series of control variables such as firm fixed effects, year fixed effects, and firm size and firm growth, the regression coefficient of digital transformation (*DT*) is 0.225. The T-value is 4.41, which is significantly positive at the 1% level, indicating that the higher the degree of digital transformation, the more it improves the operating capacity of the firm, and Hypothesis H1 is supported. Column (2) provides the regression results on how operating capacity affects financial performance. We can see that the regression coefficient of operating capacity (*TAT*) is 0.070. The T-value is 5.54, which is significantly positive at the 1% level, indicating that improving operating capacity can significantly increase financial performance, and hypothesis H2 is supported. Column (3) provides the regression results of how digital transformation affects the relationship between corporate operating capacity and financial performance. We can see that the regression coefficient of *DT***TAT* is 0.106 and is significantly positive at the 1% confidence level, indicating that the positive effect of corporate operating capacity on financial performance is strengthened substantially as the integration of companies with digital technology deepens, and H3 is verified that digital transformation supports the positive effect of operating capacity on firm's financial performance.

Table 3. The regression results of digital transformation, operating capacity.and financial performance

	(1)	(2)	(3)
Variables	*TAT*	*ROE*	*ROE*
DT	0.225***		0.119***
	(4.41)		(4.05)
TAT		0.070***	0.088***
		(5.54)	(6.14)
*DT*TAT*			0.106***
			(2.78)
SIZE	-0.089***	0.058***	0.058***
	(-4.93)	(9.03)	(8.98)
GROWTH	0.099***	0.046***	0.045***
	(13.40)	(12.13)	(12.09)
LEVER	0.081	-0.406***	-0.402***
	(1.43)	(-15.98)	(-15.84)
SOE	-0.017	-0.016	-0.014
	(-0.68)	(-1.11)	(-0.97)
DUAL	-0.011	-0.012	-0.013
	(-0.68)	(-1.64)	(-1.64)
MANAGE	0.042	0.051**	0.052**
	(0.68)	(2.04)	(2.10)
CENT	0.000	0.001***	0.001***
	(0.59)	(3.45)	(3.46)
BOARD	0.080**	-0.020	-0.022
	(2.07)	(-1.00)	(-1.11)
INDEP	0.325***	-0.105*	-0.103*
	(2.95)	(-1.77)	(-1.75)
Controls	2.262***	-1.031***	-1.040***
	(5.43)	(-6.94)	(-7.00)
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	13043	13043	13043
Adjusted R^2	0.849	0.381	0.383

Note: The t value is in parentheses; ***, ** and * are significant at 1%, 5% and 10%, respectively. The following table is the same.

4.3 Robustness Test

To ensure the robustness of the model and results, this paper uses current asset turnover (ratio of operating income to average total existing assets, denoted by *LIQ*) as a proxy variable for operating capacity; the empirical results are shown in columns (1), (2), and (3) of Table 5, and the conclusions are similar to those of the main regression. Second, firm performance uses return on total assets (ratio of net profit to total assets, denoted by *ROA*) and earnings per share (ratio of net profit to total shares, represented by *EPS*) as proxy variables. The empirical results are shown in columns (4) and (5) of Table 4, indicating that the coefficients of the cross-multiplier terms of Digital Transformation (*DT*) and Operational Ability (*TAT*) are still significantly positive. The conclusions are similar to the main regression results, and the research hypotheses H1, H2, and H3 are again validated.

Table 4. Robustness test

	Adoption of proxy variables for operating capacity			Adoption of proxy variables for firm performance	
	(1) *LIQ*	(2) *ROE*	(3) *ROE*	(4) *ROA*	(5) *EPS*
DT	0.353***		0.084***	0.044***	0.204**
	(3.44)		(2.98)	(3.60)	(2.28)
LIQ		0.014***	0.016***		
		(3.29)	(3.32)		
*DT*LIQ*			0.022*		
			(1.76)		
TAT				0.041***	0.274***
				(7.87)	(6.67)
*DT*TAT*				0.042***	0.195**
				(2.88)	(2.02)
Constant	4.381***	-0.941***	-0.912***	-0.378***	-4.502***
	(4.71)	(-6.46)	(-6.16)	(-6.86)	(-9.32)
Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
N	13043	13043	13043	13043	13043
Adjusted R^2	0.808	0.374	0.375	0.555	0.641

5 Conclusion and Discussion

This paper empirically examines the relationship between operational capability and enterprise performance in digital transformation by combining textual and empirical analysis and using the "seed word set + Word2Vec similar word expansion" method of word frequency analysis to construct digital transformation indicators. The results show that: (1) the higher the degree of digital transformation, the stronger the operational capability of enterprises. (2) Operational capability can significantly improve enterprise performance. (3) Digital transformation enhances the positive effect of operational capability on firm performance.

5.1 Theoretical Contributions

Existing research has not yet explored the role of digital transformation in the relationship between operational capability and firm performance. Based on this, this paper incorporates digital transformation, operating capacity and firm performance into an analytical framework to identify whether digital transformation moderates the relationship between operating capability and firm performance. The study finds that the higher the degree of digital transformation, the stronger the firm's operating capability and that digital transformation enhances the positive effect of the firm's operating capability on firm performance. The findings of the study not only provide new ideas on how to improve operating capabilities and reveal the boundaries of the role of digital transformation in the relationship between operating capabilities and corporate performance but also provide theoretical and empirical evidence for a comprehensive and objective evaluation of the effectiveness of the implementation of digital transformation and the efficacy of corporate operating capabilities.

5.2 Managerial Contributions

Firstly, the economic consequences of the digital transformation of enterprises provide reference values for the practical activities of listed companies, help to gain insights and clarify the economic effects of the digital transformation of enterprises, promote the digital transformation to play its real role as a national strategy and enrich the relevant policy recommendations on the digital transformation, operational capacity and corporate performance of listed companies in China. Secondly, the findings of this paper help the state and government to optimize the development environment of the "digital economy", improve the level and quality of "digitalization", and promote the deep integration of digital technologies such as big data, artificial intelligence and blockchain with traditional enterprises. More importantly, in addition to promoting the deep integration of digital technologies such as big data, artificial intelligence and blockchain with traditional enterprises, it is more important to create a new ecosystem, optimize industrial institutions and promote the sustainable development of enterprises. Finally, in terms of the factors influencing operational capability, digital transformation is an important factor in operational capability, and enterprises should be actively guided to cultivate digital thinking to promote operational capability. For example, enterprises should use new technologies such as big data to reduce transaction costs and mitigate information asymmetries, thereby significantly improving the efficiency of their operational decisions and thus enhancing their performance.

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