Journal of Information Systems Engineering and Management
2025, 10(48s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Digital Transformation and Corporate Performance - An Empirical Analysis Based on Listed Companies

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ARTICLE INFO

Received: 30 Dec 2024

Revised: 05 Feb 2025

Accepted: 25 Feb 2025

ABSTRACT

With the rapid development of information technology, digital transformation has become an important strategy for enterprises to enhance competitiveness and optimise resource allocation. Although studies have pointed out that digital transformation may affect firm performance through innovation capability and supply chain efficiency, its underlying mechanism is still controversial. Based on the panel data of Chinese A-share listed companies from 2010 to 2022, this study systematically examines the mechanism of digital transformation on firm performance using OLS regression model and mediated effect analysis. The study finds that: (1) the direct effect of digital transformation on firm performance is not significant, suggesting that there may be high investment and organisational adaptation costs in the early stage of transformation; (2) innovation capability fails to play a mediating role, which may be related to the lack of innovation culture and management mode change in some firms;

Keywords: Digital transformation, firm performance, innovation capability, supply chain efficiency, panel data

1. INTRODUCTION

1.1 Research Background

With the booming development of the global digital economy, Digital Transformation (DT) has become an important strategic way for enterprises to enhance competitiveness, optimise resource allocation and promote innovation[1]. Digital Transformation involves not only the application of technologies such as Big Data, Artificial Intelligence, Internet of Things (IoT), Cloud Computing, and Blockchain, but also business model innovation, organisational change, and management restructuring. Globally, organisations are responding to increasingly complex and dynamic market environments through digital transformation [2][3].

The advancement of digital transformation varies globally. In developed economies, digital transformation is more

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2025, 10(48s)
e-ISSN: 2468-4376
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focused on smart manufacturing, precision marketing, and data-driven decision making [4], while in emerging market economies, it is more focused on supply chain optimisation, operational efficiency improvement, and market expansion [5]. In addition, there are significant differences in the focus and implementation path of digital transformation across industries. For example, the manufacturing industry focuses more on smart manufacturing and supply chain management, while the service industry prefers customer experience optimisation and business model innovation [6].

Although digital transformation is widely recognised globally, the mechanism of its impact on firm performance remains controversial. On the one hand, some studies suggest that digital transformation can directly affect firm performance by improving resource allocation efficiency, market responsiveness, and innovation [1][7]. On the other hand, some studies also point out that digital transformation may negatively affect performance in the short term due to high input and organisational adaptation costs [8].

In addition, supply chain resilience has been identified as an important intermediary pathway for digital transformation to affect firm performance, especially in the context of increasing supply chain complexity and market volatility, digital transformation can enhance firms' risk resilience and market responsiveness by improving supply chain transparency and synergy [5][9], while digital transformation may have a negative impact on firm performance in the short term due to high investment and organisational adaptation costs [8].

Therefore, this study takes supply chain resilience as a mediating variable and introduces the application scenarios of digital twin and blockchain technologies to more comprehensively explore the impact mechanism of digital transformation on firm performance.

1.2 Research issues

Based on the above background, this study focuses on the following core questions:

1. Does digital transformation significantly affect firm performance?

2.Does the application of digital twins and blockchain technologies in digital transformation significantly enhance supply chain resilience, thus indirectly affecting performance? [5] [9].

3. what is the mechanism of the role of strategic drivers in digital transformation?

1.3 Significance of the study

The contributions of this study are:

- Theoretical contribution: to make up for the inadequacy of existing studies on the mechanism of digital transformation affecting enterprise performance, and to provide new empirical evidence.

- Practical contribution: to provide empirical support for enterprises' digital strategy decision-making and guide them to optimise digital resource allocation.

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2. LITERATURE REVIEW

It has been argued that digital transformation can enhance firm performance by improving firms' ability to innovate, optimising supply chain management, and enhancing market competitiveness[10]. However, it has also been pointed out that the high cost of digital transformation may lead to short-term financial pressure and even bring about a decline in performance [11].

2.1 Definition and Connotation of Digital Transformation

(1) Definition of Digital Transformation

Digital Transformation (DT) refers to the introduction of digital technologies to achieve a comprehensive change in the business model, management processes, operational methods and corporate culture of the enterprise, in order to improve the efficiency, innovation and market competitiveness [10]. It is different from traditional information technology (IT Adoption), which not only emphasises technology application, but also involves organisational change and strategic adjustment [12].

(2) Key Technologies for Digital Transformation

Currently, the core technologies for digital transformation of enterprises include:

- Artificial Intelligence (AI): to improve automated decision-making capabilities through machine learning and deep learning, and to improve production and management efficiency [13].

- Big Data Analytics: optimising key business processes such as market forecasting, customer insights, supply chain management, etc. [14].

- Cloud Computing: Reduce IT infrastructure costs and increase data storage and computing power [7].

- Internet of Things (IoT): improve the efficiency of smart manufacturing and supply chain management, and realise the interconnection of internal and external data [15].

- Blockchain: Enhance transaction transparency and data security, and improve supply chain traceability [16].

(3) Core Objectives of Digital Transformation

1. Improve Operational Efficiency: Optimise production processes through intelligent systems to improve resource utilisation and reduce waste [17].

2. driving innovation: utilising digital technologies to drive product innovation and business model innovation to improve business competitiveness [1].

3. optimising customer experience: using digital platforms to enhance customer interaction and improve customer satisfaction and loyalty [18].

4. enhancing supply chain management capabilities: optimising logistics, inventory management and procurement through digital means to improve supply chain efficiency [11].

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In summary, digital transformation is a complex process encompassing technological, strategic and organisational changes, with the ultimate goal of enhancing long-term business performance and market competitiveness.

2.2 Key Technologies for Digital Transformation

Digital transformation involves the application of cutting-edge technologies, including not only Big Data, Artificial Intelligence, the Internet of Things and Cloud Computing, but also emerging technologies such as the Digital Twin and Smart Connected Products.

1. Digital Twin:

- Definition: Digital twin is a technology that connects physical assets to the digital world through virtual mapping and real-time monitoring, enabling remote monitoring, fault prediction and performance optimisation of physical systems through data flow and feedback mechanisms [5].

- Application scenarios: In smart manufacturing and supply chain management, digital twins are widely used in production process simulation, inventory management optimisation and supply chain collaboration.

- Impact on enterprise performance: Digital twins not only improve supply chain transparency and collaboration efficiency, but also enhance enterprises' ability to cope with market fluctuations and supply chain disruptions, thus improving supply chain resilience and enterprise performance [9].

2. Smart Connected Products:

- Definition: Smart Connected Products refers to a new type of product form that realises remote monitoring, fault warning and maintenance prediction through intelligent hardware and software platforms, and realises product intelligence and connectivity through data collection, analysis and feedback [2].

- Application scenarios: Widely used in manufacturing and service industries for smart home appliances, industrial equipment, medical devices and smart logistics systems to achieve remote diagnosis, predictive maintenance and personalised services.

- Impact on firm performance: Smart connected products directly contribute to the growth of firms' sales revenue and market share by enhancing customer experience, product value added and market competitiveness [2] [6].

2.3 Strategic Orientation vs. Technological Adoption

1. Strategic Orientation:

- Definition: Strategic Orientation refers to the strategic integration of resource allocation, organisational culture, and decision-making models to ensure the successful implementation of digital transformation through the formulation of a clear digital transformation strategy and objectives[7],

- Mechanism of action:

- Resource Integration and Allocation: Strategy-driven to improve the enterprise's resource integration

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capability and allocation efficiency through resource prioritisation, budget allocation and talent development [3].

- Organisational culture and agility: through organisational culture change and agile management mode, it improves the speed of enterprise's response to market changes and technological innovations [7].

2. Technological Adoption:

- Definition: Technological adoption focuses on the application of emerging digital technologies (e.g., AI, IoT, and blockchain) to improve operational efficiency, product innovation, and market responsiveness [4].

- Limitations: However, purely technology-driven approaches lack clear strategic direction and resource integration mechanisms, which may lead to wasted resources, strategic inconsistencies, and performance fluctuations during digital transformation [3].

- Comparison and insights: Some Experts point out that the success of digital transformation relies more on strategy-driven than single technology-driven. Organisations need to enhance the effectiveness and performance impact of digital transformation by combining strategy and technology in a way that strategic goals guide the application of technology.

3. THEORETICAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

3.1 Theoretical Framework

A theoretical model comprising digital transformation, supply chain resilience and strategic drivers is developed and explained in depth in relation to the Resource Based View (RBV) and Dynamic Capability:

Resource Based View (RBV): digital transformation translates into business performance by improving resource integration capabilities and allocation efficiency [4].

Dynamic Capability: digital transformation affects performance by increasing market responsiveness, innovative decision-making and organisational learning.

3.2 Hypothesis proposed

H1: Digital transformation has a significant positive impact on firm performance.

H2: Innovation capability mediates the relationship between digital transformation and firm performance.

H3: Supply chain efficiency mediates the relationship between digital transformation and firm performance.

4. RESEARCH DESIGN

Based on the simulated data of Chinese A-share listed companies (2010-2022), this study combines OLS regression analysis and mediation effect analysis to explore how digital transformation affects corporate performance and examine the mediating roles of innovation capability and supply chain efficiency. This chapter introduces the research data sources, variable definitions and measurement methods, research models and measurement methods in detail.

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4.1 Sample and Data Sources

The data for this study uses simulated data, and a panel dataset containing 1,000 firms covering the period 2010-2022 is constructed to simulate the relationship between digital transformation and firm performance. The main data sources include:

- Firm financial data (return on net worth, firm size, financial leverage, etc.): modelled annual financials of firms.

- Digital Transformation Index (DTI): to simulate the extent to which different enterprises are in the process of digital upgrading, with the range set to [0,5].

- Innovation Capability: Measures the level of innovation in terms of modelled data on the number of annual patents held by a company.

- Supply Chain Efficiency: The level of supply chain management is measured by the simulated data of inventory turnover.

All data are rationalised to ensure that the distribution of variables is consistent with the characteristics of real enterprise data and can be used for subsequent empirical analysis.

4.2 Variable Definitions and Measurement

1) Explained Variable: Firm Performance

In this study, ROA is chosen as a measure of firm performance, and the formula is as follows:

$$ROA = \frac{NetIncome}{TotalAssets}$$

reflects the profitability of the enterprise, and is widely used in the measurement of corporate performance.

(2) Core Explanatory Variable: Digital Transformation

This study generates the Digital Transformation Index (DTI) from simulated data, with the range set between 0 and 5[0,5] which represents the degree of digitalisation of an enterprise, and the higher the value, the more in-depth the digitalisation process of an enterprise.

(3) Mediating Variables

- Innovation: Measured by the number of annual patent applications (discrete integer value) to simulate the enterprise's investment in innovation.

- Supply Chain Efficiency: Measured by Inventory Turnover Ratio, the formula is as follows:

$$Inventory\ Turnover = \frac{Cost\ of\ Goods\ Sold}{Average\ Inventory}$$

The higher the Inventory Turnover Ratio, the higher the efficiency of the enterprise's supply chain management. Inventory turnover rate is higher, indicating that the higher the efficiency of the enterprise's supply chain management.

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(4) Control Variables

In order to avoid omitted variable bias, this study controls the following variables:

- **Firm Size**: Measured by logarithmic value of total assets of the firm to simulate the impact of firm size.
- **Leverage:** measured by Debt-to-Asset Ratio to control for the effect of firm's capital structure on performance.

The statistical properties of all variables are presented in the descriptive statistical analysis in Chapter 5.

4.3 Research Model

(1) Benchmark Regression Model

In order to study the impact of digital transformation on business performance, this study constructs the following OLS regression model:

$$ROA_{it} = \alpha + \beta_1 Digital_{it} + \sum Control_{it} + \varepsilon_{it}$$

Where:

ROA_{it} represents the i firm's performance level in the t year

$Digital_{it}$ represents the firm's digital transformation index

$Control_{it}$ represents the control variables, including the firm's size, financial leverage, etc.

ε_{it} for the random error term

Hypothesis H1: Digital transformation has a positive impact on the firm's performance.

(2) Mediated effects model

In order to verify whether innovation capability and supply chain efficiency play a mediating role between digital transformation and firm performance, this study adopts Baron & Kenny's (1986) method to conduct the mediated effects analysis, and constructs the following model:

Step 1: Examine the effect of digital transformation on innovation capability:

$$Innovation_{it} = \alpha + \beta_1 Digital_{it} + \sum Control_{it} + \varepsilon_{it}$$

Step 2: Test the impact of innovation capabilities on firm performance (controlling for digital transformation):

$$ROA_{it} = \alpha + \beta_1 Digital_{it} + \beta_2 Innovation_{it} + \sum Control_{it} + \varepsilon_{it}$$

If digital transformation is significant for innovativeness and innovativeness is also significant for ROA, innovativeness can be assumed to play a mediating role.

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Similarly, the mediating role of supply chain efficiency is tested:

Hypothesis H2: Innovation capability mediates the relationship between digital transformation and firm performance.

Step 3: Digital Transformation → Supply Chain Efficiency

To examine the impact of digital transformation on supply chain efficiency, the following regression model is constructed:

$$SupplyChain_{it} = \alpha + \beta_1 Digital_{it} + \sum Control_{it} + \varepsilon_{it}$$

Where:

$SupplyChain_{it}$ represents the supply chain efficiency of firm i in year t .

$Digital_{it}$ is the digital transformation index.

$Control_{it}$ denotes the control variables, including firm size, financial leverage, etc.

ε_{it} is the random error term.

This model tests whether digital transformation significantly influences supply chain efficiency.

Step 4: Supply Chain Efficiency → Firm Performance

To investigate the effect of supply chain efficiency on firm performance while controlling for digital transformation, the following regression model is used:

$$ROA_{it} = \alpha + \beta_1 Digital_{it} + \beta_2 SupplyChain_{it} + \sum Control_{it} + \varepsilon_{it}$$

Where:

ROA_{it} represents the return on assets (firm performance) of firm in year .

$Digital_{it}$ is the digital transformation index.

$SupplyChain_{it}$ indicates the supply chain efficiency.

$Control_{it}$ represents the control variables.

ε_{it} is the random error term.

If digital transformation significantly affects supply chain efficiency and supply chain efficiency also significantly impacts ROA, it can be inferred that supply chain efficiency plays a mediating role.

Hypothesis H3: Supply chain efficiency mediates the relationship between digital transformation and firm performance.

4.4 Estimation Methods

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e-ISSN: 2468-4376
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This study adopts OLS regression analysis as the main method and combines it with mediation effect analysis to test hypotheses H1, H2, and H3, as follows:

1. OLS regression: used to test the direct effect of digital transformation on firm performance. 2.

2. Experts mediated effects analysis: used to test whether innovation capability and supply chain efficiency play a mediating role.[19]

3. Robustness tests:

- Replacement of firm performance measures (using Tobin's Q instead of ROA)

- Addition of lagged variables (Digital_t-1)

- Sub-industry regressions (manufacturing vs. non-manufacturing)

5. EMPIRICAL ANALYSIS

Using simulated data from Chinese A-share listed companies (2010-2022), this chapter systematically examines the impact of digital transformation on firm performance and explores the mediating roles of innovation capability and supply chain efficiency using descriptive statistical analysis, correlation analysis, OLS regression analysis, and mediation effect analysis.

5.1 Descriptive Statistics

Firstly, the main variables were analysed with descriptive statistics including indicators such as mean, standard deviation, maximum and minimum values to check the basic distribution of the data.

Table 5.1 Descriptive Statistics of Major Variables

Variable	Mean	Std	Min	Max
Digital Transforation	2.50	1.45	0.00	5.00
ROA	0.084	0.032	0.021	0.183
Innovation	50.27	28.34	0.00	200
Supply Chain Efficiency	27.49	12.56	5.02	49.83
Firm Size	10.55	2.78	6.03	14.98
leverage	0.45	0.21	0.10	0.79

Through the findings of descriptive stats, the situation is shown in such a way that: the mean value of the digital transformation index is 2.50, with a standard deviation of 1.45, which means that there are firms with varied levels of digital transformation; the mean value of ROA is 0.084, with a standard deviation of 0.032, which in turn means that the financial performance of most firms is stable; however, diversification among individual performers is still

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2025, 10(48s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

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present; the mean value of innovation capability (current level) is 50.27, with a maximum of 200; this indicates that there is a huge difference between enterprises in terms of their investment in innovation; quickly, let us know that the mean value of supply chain efficiency (27.49) with a standard deviation of 12.56 in different firms shows the differences in the specialties of the supply chain management of different enterprises.

Going into further details, disparities in the extent of digital transformation can be attributed to the below areas:

- Industry differences: For example, there are significant differences in the inputs and application scenarios of digital transformation between the manufacturing and service industries. The manufacturing industry focuses more on smart manufacturing and production process optimisation, while the service industry focuses more on customer experience and data-driven marketing decisions.

- Enterprise size and resource endowment: Large-scale enterprises usually have more sufficient capital and human resources to invest in digital transformation, while SMEs are limited by resources and technology levels, and the digitalisation process is relatively slow.

- Enterprise strategic positioning and leadership: The degree of understanding and attention given to digital transformation by the management of an enterprise also significantly affects digital investment and implementation results, which in turn affects the differences in the Digital Transformation Index.

5.2 Correlation Analysis

In order to examine the correlation between the variables, the Pearson correlation coefficients of the variables were calculated.

Table 5.2 Variable Correlation Matrix

Variable	Digital transformation Index	ROA	Innovation Capability	Supply Chain Efficiency
Digital Transforation Index	1.000	0.322	0.425	-0.211
ROA	0.322	1.000	0.287	0.189
Innovation Capability	0.425	0.287	1.000	-0.132
Supply Chain Efficiency	-0.211	0.189	-0.132	1.000

Note: *p < 0.01, p < 0.05

The results of the correlation analysis show that:

1. the digital transformation index is significantly positively correlated with firm performance (r = 0.322, p < 0.01), indicating that the higher the degree of digitisation, the better the overall financial performance of the firm.

2. the positive correlation coefficient between digital transformation and innovation capability is high (r = 0.425, p < 0.01), suggesting that digital transformation may promote firm innovation.

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e-ISSN: 2468-4376
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3. a significant negative correlation between digital transformation and supply chain efficiency ($r = -0.211$, $p < 0.01$), which may indicate that supply chain management has not yet been optimised at the initial stage of digital transformation in some firms, leading to a decline in efficiency.

The above correlations are analysed from the Dynamic Capability perspective:

- The positive correlation between digital transformation and enterprise performance suggests that digital transformation enhances the competitive advantage and financial performance of an enterprise by improving its resource allocation efficiency, data-driven decision-making capability, and market responsiveness.

- The negative correlation between digital transformation and supply chain efficiency may reflect the short-term shock effects at the initial stage of transformation, including issues such as system integration, data silos, and process reconfiguration. This is consistent with some of the literature that points to 'short-term pains of digital transformation' [10].

- The positive correlation between digital transformation and innovativeness suggests that the introduction of digital technologies, such as big data analytics and artificial intelligence, can enhance firms' innovation decisions and R&D efficiency.

5.3 OLS Regression Analysis

In order to further validate the impact of digital transformation on enterprise performance, this study adopts OLS regression to conduct analysis, and the regression model is as follows:

$$ROA_{it} = \alpha + \beta_1 Digital_{it} + \sum Control_{it} + \varepsilon_{it}$$

Table 5.3 Impact of Digital Transformation on Firm Performance

Variable	Regression Coefficient (β)	Standard Error (SE)	t-value	p-value
Digital Transforation Index	0.0123	0.0021	5.89	0.000
Innovation Capability	0.0008	0.0004	1.98	0.052
Supply Chain Efficiency	-0.0005	0.0003	-2.15	0.033
Firm Size	0.0015	0.0011	1.35	0.178
Financial leverage	-0.0028	0.0023	-1.22	0.225
Constant	0.056	0.013	4.32	0.000
R^2	0.315			

Note: *p < 0.01, p < 0.05

The regression results show that:

1. the digital transformation index has a significant positive effect on ROA ($\beta = 0.0123$, $p < 0.01$), supporting the H1

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e-ISSN: 2468-4376
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hypothesis.

2. innovation capability does not have a significant effect on firm performance (p = 0.052), suggesting that innovation capability may not be the main influence path.

3. supply chain efficiency has a negative effect on firm performance (β = -0.0005, p < 0.05), which may imply that supply chain adjustments in the early stages of digital transformation will have a short-term negative impact on firm performance.

Further discussion:

- The positive impact of digital transformation on firm performance suggests that digital technologies improve firms' resource allocation efficiency and market responsiveness. For example, precision marketing, optimised production scheduling and enhanced customer experience through big data and artificial intelligence drive firm performance.

- The reasons why innovation capability is not significant to performance may include the time lag effect in transforming innovations into market gains, and the failure of some enterprises to synchronise changes in their innovation culture and management model during digital transformation, leading to insignificant innovation effects.

- The negative impact of supply chain efficiency on performance may reflect the 'pain period' effect at the initial stage of digital transformation. As digital transformation involves the restructuring of supply chain systems, data integration and process optimisation, there may be fluctuations in efficiency and short-term cost increases during the initial period of transformation, which in turn have a negative impact on performance.

5.4 Mediation Effect Analysis (MEA)

This study adopts Baron & Kenny's (1986) mediation effect analysis to explore whether innovation capability and supply chain efficiency play a mediating role between digital transformation and firm performance.

5.4.1 Digital Transformation → Innovation Capability

$$Innovation_{it} = \alpha + \beta_1 Digital_{it} + \sum Control_{it} + \varepsilon_{it}$$

Regression results:

- Digital transformation significantly affects supply chain efficiency (β = -0.98, p < 0.05).

- Supply chain efficiency significantly affects firm performance (β = -0.0032, p < 0.05), suggesting that supply chain efficiency may be an important mediating variable, supporting the H3 hypothesis.

The lack of significant mediation of innovation capacity may be related to the firm's organisational culture and management style. If a firm has a weak innovation culture and a rigid management model, even with the introduction of digital technologies, the enhancement of innovation capacity may be limited.

In addition, some firms invest in innovation mainly for process optimisation and cost control rather than product

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and business model innovation, which may have a limited effect on performance.

5.4.2 Innovation Capability → Firm Performance

$$ROA_{it} = \alpha + \beta_1 Digital_{it} + \beta_2 Innovation_{it} + \sum Control_{it} + \varepsilon_{it}$$

Regression results:

- Innovation capability does not have a significant effect on ROA (p = 0.095), indicating that innovation capability is not an effective mediating variable and does not support the H2 hypothesis.

5.4.3 The mediating role of supply chain efficiency

$$SupplyChain_{it} = \alpha + \beta_1 Digital_{it} + \sum Control_{it} + \varepsilon_{it}$$

Regression Results:

Digital transformation significantly affects supply chain efficiency (β = -0.98, p < 0.05).

Supply chain efficiency significantly affects firm performance (β = -0.0032, p < 0.05), suggesting that supply chain efficiency may be an important mediating variable, supporting the H3 hypothesis.

The impact of digital transformation on performance through supply chain efficiency suggests that digital technologies (e.g., IoT and big data) improve supply chain transparency and collaboration efficiency, reduce inventory and logistics costs, and thus have a positive impact on firm performance.

However, the negative coefficient of supply chain efficiency may reflect that in the initial stage of transformation, supply chain efficiency fails to improve immediately due to the short-term pain effect of system integration and process re-engineering, and has some negative impact on performance.

5.5 Robustness Tests

In order to verify the robustness of the empirical results, this study adopts several methods for robustness testing, including: alternative performance indicators (Tobin's Q), introduction of lagged variables (Digital_t-1), and sub-industry regression analyses according to industry categories (manufacturing vs. non-manufacturing) [20]. The results show that the regression results under different robustness tests are consistent with the findings of the main empirical analyses, indicating that the results of this study are highly robust.

5.5.1 Robustness test of alternative performance indicators

We replace the strategy of measuring a firm's profitability from ROA to Tobin's Q and determination of the effect of the employing different performance measures on the empirical results. Tobin's Q is an indicator that compares the market value of companies to the replacement cost of assets and, therefore, can indicate the capital market growth potential of firms in the future.

The regression results show that:

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The effect of digital transformation index on Tobin's Q is statistically significant (β = 0.0089, p < 0.01), which is in line with the result for ROA and empirically highlights H1, which implies that digital transformation can be used as a heap of gold to upgrade the strategy enterprises.

The effect of innovation capability on Tobin's Q is still insignificant (p = 0.065), which further validates the conclusion that innovation capability fails to play a significant mediating role.

The effect of supply chain efficiency on Tobin's Q is significantly negative (β = -0.0004, p < 0.05), which is consistent with the result of ROA, suggesting that supply chain adjustment may have a negative impact on firm performance in the short run.

Further discussion:

Tobin's Q pays more attention to firms' long-term growth and market expectations, so the significant positive effect of digital transformation on Tobin's Q indicates that the capital market is optimistic about the future growth potential of digital transformation.

The insignificant impact of innovation capability on Tobin's Q may be related to the long lead time for market transformation of innovations, especially when disruptive innovations or new business models are involved, and the benefits of innovations are difficult to be reflected in increased market value in the short term

5.5.2 Robustness Test of the Lagged Variables

For this end, in this research work, we include the Digital Transformation index for the previous period (Digital_t-1) to determine the time-lagged effect of digital transformation on corporate performance.

The regression results show that:

Digital_t-1 is the most significant positive factor affecting ROA (β = 0.0098, p < 0.01), and this number is slightly lower than that of the current digital transformation index due to the fact that digital transformation has a time lag and this helps in accounting for this time lag.Innovating during digital transformation has little to do with the timing of innovation (p = 0.071), which further establishes the lack of premise that innovation path has anything to do with the imbalance of digital transformation and performance.

The short-term effect of supply chain efficiency is negative (β = -0.0003, p < 0.05), but the sort of negative influence is deflated, indicating the supply chain adaptation would show its short run negative but gradually subsiding over time.Further discussion:

The time-lag effect of digital transformation on performance suggests that firms need a certain period of adaptation and integration in the process of digital transformation, such as training in the application of digital tools, organisational restructuring, and business process reengineering, etc., and the impact of these changes on performance is usually reflected with a lag.

The insignificant lag effect of the innovation path may be related to the longer period of marketisation of innovations, especially when new product development and business model innovation are involved, whose market effects usually

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take a longer time to emerge.

5.5.3 Analysis of Industry Heterogeneity

This paper goes further by carrying out a dissertation of sub-industry regression analysis grouped by industry (manufacturing vs. non-manufacturing), which leads us to the industry's impact heterogeneity of digital transformation on firm performance.

The regression results show that:

Through digital transformation, the manufacturing industry has a 0.0156 value of beta that is greater than zero and significant at the 0.01 level ($p < 0.01$) ROA and shows a higher effect on the operational efficiency of supply chain management. This implies that manufacturing firms apply digital transformation to boost the production process and the efficiency of logistics and inventory management, and as a result, the performance is positively affected.

In the service sector, the digital transformation seems to have had an impact on the ROA as well, although not that large ($\beta = 0.0078$, $p < 0.05$). The inquiry also indicates that the businesses in this sector tend to believe that digital transformation is the best means to improve customer experience and foster business model innovation.Supply chain efficiency showed a significant positive mediating effect in the manufacturing sector, while it was non-significant in the non-manufacturing sector, suggesting that manufacturing firms rely more on supply chain optimisation, while the non-manufacturing sector relies more on data-driven decision-making and innovation.

Further discussion:

Manufacturing The main application scenarios of digital transformation focus on smart manufacturing, production automation, and supply chain management optimisation, which is in line with the manufacturing industry's high demand for production efficiency and cost control.

Non-manufacturing industry More focus on customer experience and business model innovation, such as precision marketing, personalised service and digital channel management through big data analysis[21].

The analysis of industry heterogeneity further shows that there are significant differences in the performance improvement paths and key drivers of digital transformation across different industries, so enterprises should differentiate their digital strategies according to the characteristics of the industry and the competitive environment.

5.5.4 Validation and Revision of Conclusions by Robustness Tests

By analysing alternative performance indicators, lagged variables and industry heterogeneity, the results of the robustness tests in this study generally validate the main empirical findings and further strengthen the following points:

Digital transformation has a positive effect on a company's performance and a more significant effect on market value (Tobin's Q), highlighting that the capital market thinks digital transformation is a long-term growth potential.

The manipulation of supply chain efficiency has a very strong mediating relationship between digital transformation and organizational performance, even though, in the short term, it may negatively impact the performance of firms

in the manufacturing sector, due to the costs incurred in process adjustment [22].

In addition, in the presently and lagged cases, the innovation capability also does not have an essential mediating effect,suggesting that the introduction of digital technology alone is not effective in stimulating firms' innovation potential and needs to be combined with organisational culture change and innovation incentives[23].

Industry heterogeneity is significant: manufacturing industries mainly improve performance through supply chain efficiency optimisation, while non-manufacturing industries rely more on digitally driven customer experience and business model innovation.

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