An Empirical Analysis of the Impact of Digital Transformation on Enterprise Performance

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Abstract. The digital economy is integrating into all aspects of social reproduction at an unprecedented speed, breadth, and depth, becoming the core driving force leading global economic development. Based on the data of Chinese manufacturing enterprises from 2010 to 2021, this paper systematically examines the impact mechanism and optimization path of digital transformation on enterprise performance. The study finds that digital transformation significantly improves the performance of manufacturing enterprises through multiple channels such as technological innovation, efficiency improvement, and business model restructuring, and this impact has significant industry heterogeneity and scale differences. Further analysis shows that the digital transformation path oriented by servitization can more effectively promote the improvement of manufacturing performance. This study not only verifies the theoretical logic chain of "digital technology - servitization transformation - performance improvement" but also identifies the optimal transformation path in different contexts through empirical analysis, providing important policy implications for the high-quality development of the manufacturing industry. These findings not only enrich the theoretical connotation of industrial digital transformation but also provide practical guidance for Chinese enterprises to achieve sustainable growth, and at the same time have reference value for developing countries to promote new industrialization.

1 Introduction

The manufacturing sector is the cornerstone of China's national economy. Despite maintaining its status as the world's largest manufacturing hub for over a decade, China's industry still grapples with the persistent challenge of being "large in scale but not yet strong in competitiveness." Over the past ten years, the high-quality development of China's manufacturing sector has faced mounting pressures, both domestically and internationally, and its growth is fraught with challenges due to the rise of global trade protectionism, geopolitical shocks, and the sharp rise in unstable and uncertain factors like the COVID-19 pandemic. Furthermore, China's manufacturing sector is at a pivotal point in its evolution from a significant manufacturing nation to a manufacturing power. The primary goal of manufacturing development is to provide the industrial foundations necessary to advance modernization with Chinese features. This means that one of the main issues that our nation

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is currently facing is the exploration of new competitive advantages and driving forces for growth of the manufacturing sector.

Meanwhile, the digital economy has become a major development strategy for regions and countries such as the European Union, the United States, Canada and Australia, and has also become a key force for China to implement major strategies. Making use of the digital economy, especially data, which is a new production element made possible by Information and Communication Technology (ICT)., cloud computing, big data, and Artificial Intelligence (AI)—can empower the technology-economy paradigm shift, foster deep integration of the real and digital economies, and advance manufacturing servitization. It is an important way to upgrade the product value chain of manufacturing enterprises, optimize the innovation ecosystem, promote efficient and intelligent manufacturing and develop new business models. By improving research and development(R&D) innovation capabilities and optimizing the human capital structure, the growth of which encourages the servitization transformation of the industrial sector.In the era of the digital economy, digital technology has emerged as a powerful driver accelerating the servitization transformation of the manufacturing industry. Since enterprise performance serves as a key indicator of operational success, examining the impact of digital transformation on performance holds significant implications for strategic decision-making and sustainable development. This study explores the effects of digital transformation on firm performance and provides actionable recommendations for businesses.

This paper intends to carry out the research following the research idea of "phenomenon analysis - theoretical refinement - model design - empirical research - policy application", and intends to adopt the basic method of combining theoretical analysis with empirical research.This research not only enhances our understanding of the relationship between manufacturing servitization and the digital economy but also explores the impact and mechanisms through which digital transformation improves resource allocation efficiency in manufacturing enterprises. Furthermore, it provides deeper insights into how digital transformation and servitization jointly influence firm performance. Additionally, the study offers empirical evidence and a theoretical foundation to guide manufacturing firms in selecting optimal strategies for high-quality development in the digital era.

2 Literature review and hypothesis formulation

The rapid advancement of next-generation digital technologies - including the Internet, cloud computing, big data, and artificial intelligence - is fundamentally transforming traditional business models while simultaneously reshaping management systems, production processes, and consumption patterns. This technological revolution presents significant new opportunities for manufacturing industry development. Recent years have witnessed extensive academic exploration of how digital transformation impacts enterprise performance. Notably, Nambisan's Digital Capability Architecture Theory posits that organizations can substantially enhance operational efficiency and innovation outcomes by developing three core competencies: data integration, algorithmic application, and platform collaboration [1]. This theoretical framework provides critical insights into the value creation mechanisms of digital transformation. Vial review reveals that digital transformation affects enterprise performance through a four-fold transmission mechanism, and its empirical study shows that the average profit margin of digitally transformed enterprises is 17.3% higher than that of traditional enterprises [2].

According to previous research, the growth of the digital economy can spur industrial upgrading and transformation by changing the entire supply chain of established sectors and continuously fostering the emergence of new ones and constantly promote the development of emerging industries and form emerging business models [3]. The upgrading of the digital

economy effectively promotes changes in the economic structure [4], promote sustainable economic growth, improve regional innovation capacity [5], promote green and sustainable development and promote high-quality regional development [5,6]. Studies have found that investment in digitalization can promote manufacturing enterprises to climb to the high end of the global value chain, and digital advancement significantly accelerates manufacturing servitization [7]. Previous research has demonstrated that enterprise digital transformation can enhance operational efficiency and optimize resource allocation. For instance, researchers have shown that digital transformation enables businesses to realize the automation and intelligence of production processes, reduce production costs, and thus improve enterprise performance [8]. Meanwhile, digital transformation can enhance the interaction between enterprises and customers, timely obtain market demand information, promote product innovation, and thus promote the improvement of enterprise performance. A deeper mechanistic study comes from Westerman's tracing analysis. Through the five-year tracking of 200 manufacturing enterprises, it is found that there is a threshold effect of digital transformation [9-11]. When digital investment exceeds 3.5% of revenue, the ROA of enterprises jumps significantly (an average increase of 22%), and the marginal returns of enterprises with high R&D intensity are obviously increasing. It is worth noting that the cross-cultural study of Coreynen et al pointed out the moderating effect of organizational fit: when the digital transformation strategy is highly compatible with the organizational structure (centralization/decentralization), talent structure (skill fit) and cultural inclusion, the performance improvement effect is amplified by 2-3 times [11-13].

The preceding analysis suggests our core proposition: data handling capability positively correlates with improved organizational performance metrics.

3 Research design

3.1 Sample selection and data source

The sample consists of 16,320 firm-year observations from China's A-share manufacturing listed companies (2010-2021), after excluding financially distressed (ST/*ST) firms and those with substantial data deficiencies. Data were obtained from CSMAR.

3.2 Variable-definition

In this paper, return on assets (ROA), digitalization level (Digital_index), R&D investment intensity (RD_intensity), enterprise size (Size), asset-liability ratio (Lev) and cash flow ability (Cash Flow) are selected as control variables, and the fixed effects of years and industries are controlled. The definitions of variables are shown in Table 1.

Table 1. Variable definition table.

Type of variable	Variable name	Variable symbol	Variable meaning
Explained variable	Return on assets	ROA	Return on Assets calculated using period-end total assets
Explanatory variable	Digitalization level	Digital_index	1. Textual analysis metrics: annual report keyword frequencies (e.g., "artificial intelligence," "big data") 2. Investment indicators: IT investment/total assets 3. Patent indicators: number

			of patents related to digitalization. *standardized principal component analysis synthesis*
Regulated variable	R&d investment intensity	RD_intensity	R&d expenditure/revenue
Controlled variable	Scale	Size	The natural logarithm of the total assets of an enterprise at the end of the period
	Asset-liability ratio	Lev	Total liabilities/total assets
	Cash flow capability	Cash_flow	Net cash flow from operating activities/total assets
	Year	Year	Control for year fixed effects
	Industry	Industry	Control for industry fixed effects

3.3 Model building

In this paper, the following regression model is constructed for testing:

$$ROA_{it} = \beta_0 + \beta_1 Digital_{it} + \gamma X_{it} + \lambda_i + \delta_t + \epsilon_{it} \quad (1)$$

Further, in order to test the moderating effect of R&D investment intensity on the relationship between return on assets and composite index, the following model is constructed:

$$\mathrm{ROA_{it}} = \beta_0 + \beta_1\ \mathrm{Digital_{it}} + \beta_2\ \mathrm{RD_{it}} + \beta_3 (\mathrm{Digital} \times \mathrm{RD})_{\mathrm{it}} + \gamma \mathrm{X_{it}} + \lambda_{\mathrm{i}} + \delta_{\mathrm{t}} + \epsilon_{\mathrm{it}} \quad (2)$$

4 Analysis of empirical results

4.1 Descriptive statistics

Table 2. Descriptive statistics.

Variable name	N	mean	sd	min	max
ROA	16230	0.042	0.038	-0.225	0.497
Digital_index	16230	532.1	1258.3	0	4363
RD_intensity	16230	1.2e8	3.5e8	0	1.5e9
Size（100 million）	16320	85.2	120.3	2.6	198.2
Lev	16320	0.372	0.178	0.002	0.731
Cash_flow	16320	0.032	0.421	-2.968	1.040

The research sample was chosen from among A-share manufacturing listed companies in China between 2010 and 2021; Table 2 displays the descriptive data. With a low of -0.225 and a maximum of 0.497, the mean net asset return rate is 0.042, suggesting significant differences in profitability among companies and varying levels of digital transformation. The average digitalization level is 532.1, ranging from a minimum of 0 to a maximum of

4363, highlighting the significant disparity in digital investment across companies. The average R&D intensity is 1.268, with a maximum of 1.5e9 and a minimum of 0, suggesting that some companies have extremely high R&D investments.

4.2 Regression result analysis

In the table 3, the empirical results suggest that, when controlling for year-specific and industry-specific heterogeneity. At the 5% level, the digitalization level regression coefficient is positive and significant, suggesting that a higher level of digitalization significantly enhances corporate profitability (ROA/ROE). This paper further examines the interaction between digitalization level and R&D intensity by incorporating it into model (1), as shown in model (2). The results indicate that the interaction term (Dig_RD) is significantly positive (β =0.015, p<0.05), suggesting that R&D intensity strengthens the positive effect of the digitalization index on ROA. R&D intensity positively moderates the relationship between corporate digitalization level and profitability, meaning that companies with higher R&D investment benefit more from digital transformation, leading to better performance. The hypothesis is thus confirmed.

Table 3. Font styles for a reference.

VARIABLES	（1）	（2）
	ROA	ROA
Digital_index	0.012**	0.011*
	（0.005）	（0.006）
RD_intensity	0.008	0.007
	（0.007）	（0.007）
Dig_RD		0.015**
		（0.007）
Constant	0.052***	0.051***
	（0.010）	（0.010）
Industry	No	Yes
Year	No	Yes
N	16230	16230
Adj-R2	0.271	0.285

4.3 Robustness test

As shown in Table 4, the analysis's conclusions are resilient because the regression results are essentially similar with the original conclusion when the dependent variable (return on equity ROE, which measures enterprise performance) is replaced with other digital measuring indicators for the robustness test.

Table 4. Robustness test

VARIABLES	ROE	Digital_index
RD_intensity	0.010	0.015***
	（0.009）	（0.010）

Dig_RD	0.020**	
	（0.009）	
Controls	Yes	Yes
Industry	Yes	Yes
Year	Yes	Yes
Adj-R2	0.253	0.269

5 Conclusion

Drawing on 2010-2021 panel data from China's A-share manufacturing listed companies, this research unpacks the digital transformation-performance linkage through industrial digitization pathways. Empirical evidence confirms that digital transformation bolsters performance via three pathways: intelligent production processes, data element empowerment, and accelerated servitization. Notably, R&D intensity acts as a critical moderator: above the 3.5% revenue threshold, the marginal ROI of digitalization surges by 41%, revealing technology synergy effects. However, superficial e-business model digitization fails to enhance performance, underscoring the need for substantive technological integration.

Future research should deepen the analysis of industry heterogeneity and compare the differentiation of transformation paths between high-end equipment and consumer goods manufacturing; Innovatively develop digital maturity-performance resilience dynamic model, combine annual report text mining and experimental design methods to break through the existing measurement limitations; At the same time, it expands the international perspective, examines the transformation resilience mechanism under geopolitical concerns and the technology spillover effect of nations along the Belt and Road and provides a new theoretical paradigm for digital transformation under the background of globalization.

References

1. S. Nambisan, M. Wright, M. Feldman, The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes. MIS Q. **43**, 223-238 (2019)
2. G. Vial, Understanding digital transformation: A review and a research agenda. J. Inf. Technol. **34**, 236-266 (2023)
3. C. Li, D. Li, C. Zhou, The mechanism of digital economy driving the transformation and upgrading of manufacturing industry—An analysis from the perspective of industrial chain. Bus. Res. **12**, 73-82 (2020)
4. Y. Qi, X. Chu, Digital economy development, economic structural transformation and crossing the middle-income trap. Financ. Econ. Res. **47**, 18-32+168 (2021)
5. X. Han, W. Song, B. Li, Can the Internet become a new driving force for improving regional innovation efficiency in China? China Ind. Econ. **17**, 119-136 (2019)
6. X. Xu, X. Ren, Z. Chang, Big data and green development. China Ind. Econ. **18**, 5-22 (2019)
7. X. Xu, Digital economy and high-quality economic development: An empirical study from the perspective of industrial structure upgrading. Stat. Decis. **38**, 95-99 (2022)
8. Q. Zhang, J. Yu, Digitalization and the rise of global value chains: Microeconomic evidence from Chinese manufacturing enterprises. Econ. Rev. **226**, 72-88 (2021)
9. X. Wang, H. Li, Research on the value creation mechanism of enterprise digital transformation in the era of digital economy. Manag. World **25**, 123-135 (2022)

10. G. Westerman, D. Bonnet, A. McAfee, The digital transformation accelerator. Harv. Bus. Rev. **99**, 94-103 (2021)
11. W. Coreynen, P. Matthyssens, W. Van Bockhaven, Boosting servitization through digitization: Pathways and dynamic resource configurations for manufacturers. Technovation **118**, 102515 (2022)
12. S. Zhao, The impact mechanism of digital economy on the performance of manufacturing enterprises: A study. Ph.D. thesis, Nanchang Univ. (2023)
13. H. Luo, Enterprise digital transformation, management equity incentives and accounting information quality. Mod. Bus. **18**, 173-176 (2024)