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A Mechanistic Examination of the Impact of Digital Transformation on the Performance of Chinese Manufacturing Firms: An Analysis of the Mediating Role of Firm Innovation

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Abstract

This study explores the interactive mechanisms and transmission pathways between corporate innovation, digital transformation, and corporate performance in Chinese manufacturing enterprises. This study conducts theoretical research through a literature review and proposes research hypotheses. A multiple regression model is constructed to test the hypotheses in the empirical research. Through descriptive, regression, and correlation analyses, the relationship between enterprise digital transformation and enterprise performance, and the mediating role of enterprise innovation, is determined. Finally, robustness analysis is used to validate the research results. The study finds that enterprise digital transformation can significantly improve enterprise performance: enterprise innovation plays an intermediary role between enterprise digital transformation and enterprise performance. In addition, the Szfix regression coefficient of non-state-owned enterprises is much lower than that of state-owned enterprises, and the impact of enterprise digital transformation on the performance of state-owned enterprises is more significant. Compared with existing literature, the innovation and contribution of this study lie in introducing the concept of corporate innovation, which not only further expands the scope of research on the impact of corporate digitalisation on corporate performance but also provides strong empirical evidence. In addition, the study considers different types of corporate property rights.

Keywords: digital transformation, business performance, business innovation, manufacturing companies.

JEL Classification: D24, D22, L60

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1. Introduction

Emerging clusters of next-generation information technologies are redefining industry landscapes, including the fields of the Internet, big data analytics, cloud computing infrastructures, and artificial intelligence methodologies, are achieving technological breakthroughs and innovative applications at an unprecedented rate, prompting traditional industries to accelerate their evolution and upgrade towards digitalisation, networking and intelligence in terms of production models, organisational structures and value creation. Statistics from the China Academy of Information and Communications Technology indicate that as of 2020, the total value of the global digital economy had exceeded the 32.6 trillion US dollar mark, and its role as an engine in the world economic structure is becoming increasingly prominent. In the global economic recovery led by digital technology, countries worldwide are actively optimising their policy systems, focusing on strategic deployments such as promoting digital upgrading and digital-driven green development, so that the digital economy has gradually developed into a core driver leading the global economic recovery. Against this backdrop, China's share of the global digital economy continues to rise. As the core pillar of China's real economy and the lifeblood of its national economy, the depth and breadth of the manufacturing industry's digital transformation directly determine the quality of China's digital economy and the level of cultivation of its industrial core competitiveness. Therefore, under the dual influence of policy guidance and practical promotion, the digital transformation of Chinese manufacturing enterprises has become the core path for promoting the high-quality development of China's digital economy, and it is an important research topic in academia.

As the basic unit of the macroeconomic system, the digital transformation and upgrading of enterprises are strategically significant in promoting the overall development of the digital economy and stimulating new drivers of economic growth. A fundamental question is how enterprises can be motivated to embark on a digital transformation process. The central issue is whether enterprises' digitalization can enhance their performance. The ‘IT paradox’ endorsed by Hajli et al. (2015) and Mikalef et al. (2017) points out that digitisation does not necessarily improve corporate performance. Still, Qi et al. (2020) point out that the mechanism of digitisation's impact on enterprise performance is multiple, and that the positive and negative effects of various impacts may be why performance is not significant, given the issues above. This research investigates the dynamic interplay between digital transformation and firm performance, examining how integrating digital technologies can drive enhanced operational efficiency and innovation, and ultimately boost overall business outcomes. Using data from listed companies, the study delves into whether digitalisation can promote firm performance and, if so, the mechanism behind this effect.

2. Literature Review and Hypothesis Development

2.1 Impact of digital transformation on business performance

The digital economy was first a concept of Tapscott (1996), but it has recently become the focus of attention. In 2008, with the advent of the mobile Internet wave, digital technology was an opportunity and a challenge. For enterprises, before the digital era, adding brick and mortar was crucial for the rapid development of enterprises. Now, digitalisation has become an inevitable trend in business development. Scholars generally debate the relationship between enterprise digital (information technology) transformation and firm performance from two perspectives. One of these perspectives is the information value-added theory, one of the productivity paradoxes. As the economy evolves, many empirical studies increasingly support the "information value-added theory." This perspective suggests that digital transformation enhances firm performance by improving the processing, utilization, and overall value generation from information. Scholars supporting the first view argue that strategic investments in information technology substantially enhance firm performance. Ji Anqi et al.

(2025) proposed that by leveraging advanced IT systems, companies can optimize their operations, boost productivity, and gain a competitive edge, ultimately leading to significant improvements in overall performance. In today's competitive environment, digital technology improves the responsiveness and sensitivity of enterprises. Throughout digital transformation, enterprises use data elements as the core means of production and the object of labour to establish a data-driven production and operation system. Compared with traditional enterprises, this new model can significantly improve the scientific nature of decision-making and the agility of market response. Digital technology can optimise the flow of information within the enterprise. The role of data is to facilitate the internal circulation of the company, rendering it more straightforward, faster, and more complete. Furthermore, it has the potential to reduce the barriers of the hierarchy, improve the management's decision-making efficiency, optimise the overall efficiency of the allocation of resources, and streamline information processing and decision-making, enabling better allocation of tangible and intangible assets, leading to more efficient use of resources and enhanced competitive advantage. Furthermore, digital technology can leverage its inherent advantages to convert data into information, providing practical assistance to management in decision-making processes. It can refine the production methods employed by technicians, consequently enhancing the efficacy of internal information transfer. Concurrently, companies continually refine their production technologies to cut costs and boost efficiency. The capacity to leverage digital technologies is of paramount importance in the execution of an enterprise's digital transformation strategy, enterprises in the production, operation, management and sales, etc. need different digital technology to improve further and change, advanced digital enterprise must have advanced digital technology, enterprise digital technology generally need to go through the three stages of technology conversion, technology application, technology competition, etc. to transform the technical advantage into enterprise performance. From a comprehensive perspective, the application of digital technology and the extra cost that enterprises need to invest are complementary; that is, the stronger the ability of using digital technologies adopted by enterprises, the less the additional cost that enterprises need to invest, and the higher the performance level of enterprises. Based on this, the thesis posits the following hypothesis:

H1: Digital transformation by manufacturing firms can positively contribute to the improvement of firm performance.

2.2 The mediating role of corporate innovation on digital transformation and firm performance

Innovation is the core driving force behind sustainable corporate development. It is not only the key to maintaining market vitality and competitive advantage, but also the internal engine that drives the improvement of core competitiveness and the continuous growth of operating performance. It is irrefutable that continuous innovation improves a company's competitiveness; furthermore, as Fan (2020) believes, this kind of innovation can also bring about sustained improvements in business performance. Enterprise innovation can bring new products for the enterprise, enterprise digital can use data and data into information, for the management or relevant technical staff to provide more targeted decision-making advice, while refining the technical level of technical staff, and thus promote the enhancement of enterprise output capacity. Digital transformation mainly from the following three aspects to foster enterprise innovation: Firstly, as Chen et al. (2019) argue, it is clear that the digital economy can motivate manufacturing enterprises to undertake a series of innovations, including, but not limited to, product innovation, system innovation and model innovation, etc., to encourage the manufacturing industry to continue to innovate; Secondly, the efficiency, reliability, and high productivity of digital technology can assist manufacturing enterprises in their innovation development. Thirdly, the digital economic environment can substantially influence consumer

demand. The digital economy fosters continuous growth in innovation investment while enhancing efficiency. Enterprises are pressured to improve information transparency and foster competitive environments in the expanding digital economy. They need to invest more in innovation to facilitate the development of new products. The correlation between innovation and firm performance has shown significant changes driven by the digital economy. As the digital economy expands, the significance of innovation is increasing, with the resultant output becoming a contributing factor in this growth. The correlation is indisputable: The evolution of the digital economy shows a significant intrinsic correlation with changes in innovation factors. Furthermore, the extent to which enterprises undergo digital transformation is positively correlated with innovation input performance. Consequently, Improvements in firm performance may stem from the facilitating effect on innovation outputs during digital transformation. The digital transformation of enterprises significantly enhances their innovation capabilities, mediates, and indirectly improves overall firm performance. Drawing upon these findings, the thesis posits the following hypothesis:

H2a: Firm innovation output serves as a critical mediator linking digital transformation to firm performance.

H2b: Firm innovation investment functions as a significant mediator in the relationship between digital transformation and firm performance.

2.3 The impact of the nature of business ownership on performance

The advent of digital technology has engendered a plethora of benefits for manufacturing enterprises. However, given the disparate nature of property rights, the impact will differ in distinct ways. This paper will analyse the respective effects on state-owned enterprises and enterprises not owned by the state.

In contradistinction to enterprises not owned by the state, the merits of enterprises owned by the state are more pronounced, and these potential advantages permeate the enterprises' production technology, helping them break through more efficiently. This is indicative of the two primary advantages of enterprises owned by the state. Zhao Fang et al. (2023) argue that, first, state-owned enterprises have unique advantages in innovation, and second, state-owned enterprises have responsibilities and missions. Firstly, about the characteristics of enterprises owned by the state, it is evident that the innovation of such enterprises is predominantly oriented towards long-term, socially valuable innovation. This is analogous to the concept of digital transformation. Enterprises owned by the state have a longer-term view of digital innovation, rather than short-term improvements in innovation efficiency. The benchmark for technological innovation is enterprises not owned by the state. While improving innovation efficiency, enterprises owned by the state also combine digitalisation with traditional industries, thereby breaking through existing boundaries and developing new technological products. YANG et al. (2023) argue that the government often plays the role of a ‘mentor’ in state-owned enterprises, providing corresponding policy support, making it easier for enterprises owned by the state to innovate in high-end industries that enterprises not owned by the state cannot. Secondly, enterprises owned by the state, in the national strategic security and other fields, are charged with the responsibility of undertaking more major scientific and technological innovation missions, and are closely associated with the government, enabling enterprises owned by the state to access resources for breakthroughs in high-precision technology more quickly. Conversely, enterprises not owned by the state are characterised by a paucity of relevant resources and government support and protection and tend to adopt a more conservative approach when making digital investments. HUAN JIN et al. (2024) argue that state-owned enterprises generate a significant ‘siphoning effect’ compared to non-state-owned enterprises. This is evidenced by the denser

population of highly educated R&D personnel in state-owned enterprises, and their more substantial investment in R&D personnel compared to private enterprises. The available data demonstrates that, compared to enterprises not owned by the state, enterprises owned by the state are characterised by a consistently increasing degree of digital investment, albeit at a relatively stable rate. The increase in enterprises owned by the state is greater than that in enterprises not owned by the state, indicating that enterprises owned by the state have more resources, greater advantages, and greater responsibility in the national digital strategy orientation, thus making the enterprises owned by the state devote themselves to digital infrastructure. This observation gives rise to the following hypothesis:

H3: Digital transformation improves firm performance more significantly in state-owned enterprises than in non-state-owned enterprises.

3. Data and Methodology

3.1 Sample selection and data sources

This study takes listed companies in the manufacturing industry in China's A-share market as the sample body, and conducts empirical analyses based on panel data for 2014-2021. To ensure the reliability of the research findings, strict screening criteria were applied during data processing. Only samples from companies listed continuously for eight consecutive years were included, ensuring consistency and robustness in the analysis.

(1) Companies designated with ST status were excluded from the study to prevent potential distortions in the performance data;

(2) Companies that have been delisted due to unusual financial circumstances have been excluded;

(3) Firms listed for a shorter period, after 2014, were excluded from the study.

In this study, Winsor's deflation method is adopted to deal with the extreme values of continuous variables at the upper and lower 1%, effectively controlling the influence of extreme values on the research results. After screening, 7,210 balanced data observations from 1,030 listed companies are finally obtained. The pertinent financial indicators and patent data employed in this study were derived from the CSMAR database, CNRDS database, and Stata 16.0 statistical software was used for subsequent empirical analyses.

3.2 Research variables

Table 1 provides a comprehensive overview of the key variables used in this study, including their definitions, measurement methods, and data sources. Firstly, regarding the dependent variables, enterprise performance is selected as the explanatory variable in this study. In contrast, enterprise financial performance is quantified by the return on net assets (Roe) indicator. The innovative performance of an enterprise is evaluated based on the number of invention patent filings it submits. Second, regarding the independent variables, this study focuses on enterprise digital transformation. Given the absence of a unified standard for measuring digital transformation, this study employs a text analysis approach informed by Yuan et al. (2021). Data is extracted from the annual reports of A-share listed companies using Python, and a statistical model is built to quantify digital transformation through word frequency analysis with the Jieba thesaurus, whose keywords are primarily based on the research by Wu Fei et al. (2021) and Ren et al. (2017). Again, in terms of mediating variables, this study selected enterprise innovation as a mediating variable. Enterprise innovation is operationalized using

two indicators: innovation input (the ratio of R&D expenditure to operating revenue) and innovation output (the number of patent applications). Finally, to mitigate the effects of potential confounders, this study controls for firm-level characteristics—including firm size, total asset growth rate, gearing ratio, major shareholder ownership, board independence, operating cash flow, and cost of goods sold ratio—along with year and industry factors, as supported by existing literature.

Table 1. Definition of variables

Variable category	Variable name	Variable symbol	Calculation method
Explanatory variable	Corporate financial performance	Roe	Net profit / 0. 5 (Net assets at the beginning of the year + Net assets at the end of the year)
Explanatory variable	Digital Transformation	Dig	Frequency obtained by text mining
Intermediary variable	Enterprise investment in innovation	Rd	R&D investment as a percentage of operating revenue
	Enterprise innovation outputs	Innovation	Natural logarithm of the total number of patents granted to enterprises+ 1
Control variable	Enterprise size	Size	Natural logarithms of total assets
	Total asset growth rate	Growth	The difference between assets at the end of the period and assets at the beginning of the period divided by assets at the beginning of the period
	Gearing	Leverage	Total liabilities divided by total assets at the end of the year
	Shareholding ratio of major shareholders	Sharehoder	Number of shares held by the largest shareholder divided by total share capital
	Board independence	Indirecter	Number of independent directors divided by the number of board members
	Operating cash flow	NC	Natural logarithm of the net operating cash flow of the enterprise
	Cost of goods sold ratio	Cos	Business operating costs divided by operating revenue
	Vintages	Year	virtual variable
	Sector	Ind	By industry classification standards issued by the Securities and Futures Commission in 2012

3.3 Modelling

This study constructs the subsequent econometric model, drawing upon the work of Wen Zhonglin et al. (2014), to assess the influence of digital transformation on business performance and elucidate its underlying mechanisms.

To test Hypothesis 1, which examines the effect of digital transformation on business performance, a multiple regression model was developed as outlined below:

$Roe=\alpha 0+\alpha_1 Szfix+\alpha_2 \Sigma Controls+\Sigma Year+\Sigma Ind+\varepsilon 1$ (1)

The model is adapted from Qi Yudong, which examines the multifaceted effects of digitalisation on manufacturing enterprise performance and its underlying mechanisms.

To evaluate the mediating role of corporate innovation in linking digital transformation to corporate performance (Hypothesis 2), we construct the following multiple regression model:

$Roe = \omega 6+ \omega 7\ Szfix + \omega 8\ Rd + \omega 9\ \Sigma Controls + \Sigma Year + \Sigma Ind + \theta_3$ (2)

$Roe = \omega 10+ \omega 11 Szfix+\omega 12 Innovation+\omega 13 \Sigma Controls+\Sigma Year+\Sigma Ind$ (3)

The above model is from Wen Zhonglin, who discusses the impact of mediating effects.

To investigate how variations in enterprise property rights influence the relationship between digital transformation and firm performance, the following multiple regression models are established to test Hypothesis 3. Model (4) pertains to state-owned enterprises, while Model (5) applies to non-state-owned enterprises.

$Roe=\alpha 0+\alpha_1 Szfix+\alpha_2 \Sigma Contrlos+\Sigma Year+\Sigma Ind+\varepsilon 3$ (4)

$Roe = \alpha 0 + \alpha_1 Szfix + \alpha_2 \Sigma Controls + \Sigma Year + \Sigma Ind + \varepsilon 4$ (5)

3.4 Descriptive statistical analyses

Table 2 summarizes the descriptive statistics derived from 7,210 observations of A-share listed companies. Enterprise performance ranges from -0.526 to 0.349, indicating notable variability among manufacturing firms. However, a standard deviation of 0.117 suggests that most performance values are clustered toward the lower end. Values in the digital transformation dimension range from 0 to 3.363, with a standard deviation of 0.543, indicating moderate firm dispersion. The data suggests that only 33% of enterprises have initiated digital transformation, while more than half remain inactive. Additionally, among those that have begun the process, there are considerable differences in the extent of transformation. Regarding innovation investment (Rd), the mean is 4.550, with values ranging from 0 to 20.01. This wide dispersion indicates substantial heterogeneity among firms and suggests significant potential for many enterprises to enhance their innovative investment. The standard deviation of 3.446 suggests that, despite some variation, the overall level of innovation investment across enterprises remains relatively low. Regarding innovation, the average is 2.097 with a standard deviation of 2.250, ranging from 0 to 7.192. This indicates substantial variability in patent applications among companies.

Table 2. Descriptive statistics

Variant	Sample size	Average value	Median	(Statistics) Standard deviation	Minimum value	Maximum values
Roe	7161	0.060	0.061	0.117	-0.526	0.349
Szfix	7210	0.330	0.146	0.543	0	3.363
Innovation	7210	2.097	1.609	2.250	0	7.192

Source: Authors' calculations using CSMAR data, CNRDS data and textual mining of annual reports (SSE/SZSE A-share manufacturers).

Continuation of Table 2. Descriptive statistics

Variant	Sample size	Average value	Median	(Statistics) Standard deviation	Minimum value	Maximum values
Rd	7210	4.550	3.870	3.446	0	20.01
Soe	7210	0.689	1	0.463	0	1
Size	7210	22.27	22.12	1.118	20.23	25.56
Growth	7170	0.144	0.0800	0.283	-0.299	1.725
Lev	7210	0.401	0.394	0.186	0.0570	0.865
Sharehoder	7210	0.321	0.301	0.134	0.0900	0.687
Indirecter	7209	0.375	0.333	0.0530	0.333	0.571
Nc	7210	5.718e+08	1.610e+08	1.402e+09	1.052e+09	9.522e+09
Cos	7210	0.711	0.747	0.167	0.188	0.982

Note. In order to ensure the sample size and the "eight-year continuity" data, only companies with serious vacancies were excluded from the data processing process, so the above sample values in the table are slightly different.

Source: Authors' calculations using CSMAR data, CNRDS data, and textual mining of annual reports (SSE/SZSE A-share manufacturers).

3.5 Correlation analysis

Table 3 reveals that the absolute correlation coefficients among the key variables are all below 0.6, suggesting that multicollinearity is not a significant concern. Additionally, the variance inflation factor (VIF) test results presented in Table 4 further confirm that the VIF values for all variables are below 2, a series of statistical indicators that fully prove that the research model does not have a significant multicollinearity problem. The correlation coefficients suggest a statistically significant positive association between digital transformation and enhancements in enterprise performance. This finding not only supports Hypothesis H1 but also offers robust empirical evidence for the subsequent analysis. Implementing a digital transformation strategy by enterprises positively contributes to their performance improvement, laying a solid empirical foundation for future in-depth studies.

Table 3. Correlation analysis

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Roe	1										
(2) Szfix	0.0154	1									
(3) Innovation	0.0567	-0.0289	1								
(4)Rd	-0.0326	0.275	0.0577	1							
(5) Soe	0.0424	0.0412	0.0359	-0.173	1						

Source: Authors' calculations using CSMAR data, CNRDS data and textual mining of annual reports (SSE/SZSE A-share manufacturers).

Continuation of Table 3. Correlation analysis

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(6) Size	0.0692	0.0953	0.126	-0.234	0.348	1					
(7) Growth	0.125	0.0612	0.00010	0.0334	-0.0851	0.0187	1				
(8) Leverage	-0.149	-0.0982	0.0240	-0.294	0.320	0.564	-0.0244	1			
(9) Sharehode	0.0607	-0.0989	0.0639	-0.162	0.236	0.237	-0.0487	0.122	1		
(10) Indirecte	-0.0343	0.0195	0.0149	0.0676	-0.0187	0.0318	0.0270	-0.003	0.0481	1	
(11) Nc	0.148	-0.0578	0.0567	-0.0586	0.0274	0.205	-0.0338	-0.0240	0.0770	-0.0057	1
(12) Cos	-0.259	-0.163	0.00560	-0.369	0.246	0.221	-0.0987	0.473	0.0917	-0.0239	-0.138

Source: Authors' calculations using CSMAR data, CNRDS data, and textual mining of annual reports (SSE/SZSE A-share manufacturers).

Table 4. Variance inflation factor test

Variables	Szfix	Rd	Innovation	Lev	Size	Cos	Soe	Share	Nc	Growth	Indirecter	Mean VIF
VIF	1.140	1.480	1.030	1.880	1.750	1.570	1.240	1.110	1.110	1.060	1.010	1.310

Source: Authors' calculations using CSMAR data, CNRDS data, and textual mining of annual reports (SSE/SZSE A-share manufacturers).

3.6 Benchmark regression

The fixed effects model regression results from Model 1 (see Table 5) indicate that for manufacturing firms, the digital transformation variable (Szfix) exhibits a coefficient of 0.008 with a t-value of 2.27, achieving significance at the 5 percent level, and this result verifies Research Hypothesis 1. These results suggest that digital transformation plays a significant role in enhancing the performance of manufacturing enterprises, thereby effectively driving the economic development of the manufacturing sector. Moreover, the regression outcomes for the control variables are in line with established research, further substantiating that digital transformation contributes positively to the

performance of manufacturing enterprises. Therefore, with the arrival of the digital wave in enterprises, enterprises can seize digital technology platforms to create many opportunities for innovation and inject new vitality into the enterprise. In addition, through the promotion of digital transformation, enterprise resources can be effectively integrated. This dynamic improvement in capabilities enables enterprises to quickly coordinate their production and operation activities, thereby reducing enterprise costs, improving enterprise efficiency, and enabling enterprises to grow rapidly.

Table 5. Baseline regression

Variant	Roe	T-value
Szfix	0.008**	2.27
Size	0.013***	3.42
Growth	0.092***	21.62
Lev	-0.214***	-15.61
Sharehoder	0.082***	3.65
Indirecter	-0.096***	-2.83
Nc	0.000***	9.25
Cos	-0.482***	-25.17
Constant	0.203**	2.44
Company FE	YES	
Year FE	YES	
R-squared	0.142	

Note: ***p<0.01,**p<0.05,*p<0.1. T-values in parentheses.
Source: Authors' calculations using CSMAR data and textual mining of annual reports (SSE/SZSE A-share manufacturers).

3.7 Robustness Tests

To enhance the robustness of the empirical analysis, this study adopts the variable substitution method to conduct the robustness test, i.e., the explanatory variable was recalibrated by replacing return on net assets (Roe) with return on assets (Roa) for re-measurement. In Table 6, Model 1—where ROE is replaced with ROA—the regression coefficient for digital transformation is 0.003 and is significant at the 10% level. This outcome demonstrates that a digital transformation strategy significantly boosts the return on net assets, underscoring its positive effect on enhancing firm performance. This finding corroborates the validity of Hypothesis H1; this additional measure further reinforces the robustness of the study's findings.

Table 6. Robustness Tests

Variables	Roa
Szfix	0.003* (1.82)
Size	0.006*** (3.48)
Growth	0.047*** (23.36)
Lev	-0.121*** (-18.97)

Note. ***p<0.01,**p<0.05,*p<0.1. T-values in parentheses.
Source: Authors' calculations using CSMAR data and textual mining of annual reports (SSE/SZSE A-share manufacturers).

Continuation of Table 6. Robustness Tests

Variables	Roa
Sharehoder	0.025**
	(2.44)
Indirecter	-0.018
	(-1.11)
Nc	0.000***
	(8.34)
Cos	-0.262***
	(-29.44)
Constant	0.137***
	(3.54)
Company FE	YES
Year FE	YES
R-squared	0.202

Note. ***p<0.01,**p<0.05,*p<0.1. T-values in parentheses.
Source: Authors' calculations using CSMAR data and textual mining of annual reports (SSE/SZSE A-share manufacturers).

3.8 Analysis of mechanisms

Table 7, column (1) presents the test results without including the mediating factor. In Model 1, the coefficient α1 of Szfix is significantly positive at the 5% level. As illustrated in column (2) of Table 7, the coefficient η4 for Szfix in Model 2 is statistically significant. As illustrated in (3), the regression coefficient ω11 for digital transformation (Szfix) is significantly positive at 5%, while the coefficient ω12 for Innovation is significantly positive at 1%. The above experimental results satisfy the three conditions mentioned above. α1、ω11、ω12 are all significant, indicating the existence of partial mediation effects. η4、ω12 are both significant, so there is no need to perform the Sobel test. Hypothesis H2a is therefore verified.

Table 7. Tests for mediating effects of innovation output

Variables	(1)	(2)	(3)
	Roe	$Innovatio_{t-2}$	Roe
Szfix	0.008**	0.290***	0.008**
	(2.27)	(5.07)	(2.25)
Innovation			0.003***
			(4.51)
Indirecter	-0.096***	0.764	-0.097***
	(-2.83)	(1.31)	(-2.86)
Shareholder	0.082***	0.007***	0.078***
	(3.65)	(2.71)	(3.49)
Size	0.013***	0.025	0.013***
	(3.42)	(0.13)	(3.46)
Growth	0.092***	0.328***	0.092***
	(21.62)	(7.50)	(21.54)

Note. ***p<0.01,**p<0.05,*p<0.1. T-values in parentheses.
Source: Authors' calculations using CSMAR data， CNRDS data, and textual mining of annual reports (SSE/SZSE A-share manufacturers).

Continuation of Table 7. Tests for mediating effects of innovation output

Variables	**(1)**	**(2)**	**(3)**
	Roe	**Innovatio$_{t-2}$**	**Roe**
Lev	-0.214***	0.358***	-0.213***
	(-15.61)	(3.22)	(-15.55)
Nc	0.000***	-0.647***	0.000***
	(9.25)	(-3.17)	(9.11)
Cos	-0.482***	-0.000	-0.018***
	(-25.17)	(-0.96)	(-3.85)
Constant	0.203**	-5.603***	0.195**
	(2.44)	(-5.77)	(2.36)
CompanyFE	YES	YES	YES
YearFE	YES	YES	YES
R-squared	0.265	0.029	0.267

Note. ***p<0.01,**p<0.05,*p<0.1. T-values in parentheses.
Source: Authors' calculations using CSMAR data, CNRDS data, and textual mining of annual reports (SSE/SZSE A-share manufacturers).

As seen from Table 8, column (1) shows the test results without including the mediating factor. In Model 1, the coefficient α1 corresponding to Szfix is significantly positive at the 5 percent level. As illustrated in column (2), the coefficient η1 of Szfix in Model 2 is significant. As illustrated in column (3), in Model 3, the coefficient ω7 corresponding to Szfix is significantly positive at the 5 percent level, whilst the coefficient ω8 for Innovation is significantly positive at the 1 percent level. The above experimental results satisfy the three conditions mentioned above, and α1, ω7, and ω8 are significant, indicating partial mediation effects. Since η1 and ω8 are both critical, there is no need to perform the Sobel test, and Hypothesis H2 b is verified.

Table 8. Mediation effect test for innovation inputs

Variables	**(1)**	**(2)**	**(3)**
	Roe	**Rd**	**Roe**
Szfix	0.008**	0.242***	0.004**
	(2.27)	(4.96)	(1.28)
Rd			0.002***
			(5.59)
Indirecter	-0.096***	0.391	-0.109***
	(-2.83)	(0.77)	(-3.25)
Shareholder	0.082***	0.010***	0.001***
	(3.65)	(4.98)	(6.12)
Growth	0.092***	0.270***	0.033***
	(21.62)	(7.28)	(7.90)
Lev	-0.214***	0.329***	0.026***
	(-15.61)	(3.33)	(4.07)
Nc	0.000***	-0.679***	-0.242***
	(9.25)	(-3.93)	(-6.62)

Note. ***p<0.01,**p<0.05,. *p<0.1 T-values in parentheses.
Source: Authors' calculations using CSMAR data, CNRDS data, and textual mining of annual reports (SSE/SZSE A-share manufacturers).

Continuation of Table 8. Mediation effect test for innovation inputs

Variables	(1) Roe	(2) Rd	(3) Roe
Cos	-0.482*** (-25.17)	0.000 (0.54)	0.000*** (3.60)
Constant	0.203** (2.44)	-4.291*** (-5.23)	-0.459*** (-5.37)
CompanyFE	YES	YES	YES
YearFE	YES	YES	YES
R-squared	0.265	0.027	0.139

Note. ***p<0.01,**p<0.05,. *p<0.1 T-values in parentheses.

Source: Authors' calculations using CSMAR data, CNRDS data, and textual mining of annual reports (SSE/SZSE A-share manufacturers).

3.9 Analysing the heterogeneity of business ownership

Based on the regression findings for the whole sample grouping in columns (1) and (2) in Table 9, the research sample is partitioned into two distinct groups, state-owned and non-state-owned enterprises, and models 4 and 5 are empirically tested, respectively. The research data for state-owned enterprises indicate that the regression coefficient for the Szfix variable is 0.027, accompanied by a T-value of 4.72, and is statistically significant at the 1 percent level. Additionally, the regression outcomes for the other control variables align with the conclusions of previous literature, further supporting the robustness of the findings. In contrast, the regression coefficient of Szfix for non-state-owned enterprises is only 0.003, significant at the 10% level—substantially lower than the 0.027 observed for state-owned enterprises, which is significant at the 1% level. This empirical evidence unequivocally corroborates Hypothesis 5, indicating that digital transformation exerts a significantly more pronounced positive influence on the performance of state-owned enterprises than non-state-owned ones.

Empirical regression analysis indicates that property rights' characteristics significantly influence the degree of digital transformation. Although digital transformation yields positive outcomes for state-owned and non-state-owned enterprises, its effect is markedly more pronounced within state-owned firms. Specifically, digital transformation exerts a more pronounced impact on the performance of state-owned enterprises. This phenomenon can be attributed to the unique advantages of SOEs regarding resource endowment, national strategic mission, and policy support. As the pillars of the national economy, SOEs bear the great responsibility of promoting the construction of 'Digital China', and their continuous investment in digital infrastructure and technological innovation gives them a competitive advantage over non-SOEs in high-end industrial innovation, thus taking the lead in the process of digital transformation.

Table 9. Grouped Regression Analysis

Variables	State-owned Enterprise Group Roe	Non-state-owned Enterprise Group Roe
Szfix	0.027*** (4.72)	0.003* (1.65)
Size	0.007 (0.94)	0.016*** (3.56)

Note. ***p<0.01,**p<0.05,*p<0.1. T-values in parentheses.

Source: Authors' calculations using CSMAR data and textual mining of annual reports (SSE/SZSE A-share manufacturers).

Continuation of Table 9. Grouped Regression Analysis

Variables	State-owned Enterprise Group Roe	Non-state-owned Enterprise Group Roe
Growth	0.080***	0.097***
	(9.68)	(19.40)
Lev	-0.214***	-0.201***
	(-8.21)	(-12.41)
Share	0.099***	0.053*
	(2.68)	(1.75)
Indirecter	-0.182***	-0.064
	(-3.14)	(-1.50)
Nc	0.000***	0.000***
	(5.08)	(7.94)
Cos	-0.607***	-0.428***
	(-16.00)	(-19.45)
Constant	0.469***	0.094
	(2.85)	(0.98)
Company FE	YES	YES
Year FE	YES	YES
R-squared	0.146	0.156

Note. ***p<0.01,**p<0.05,*p<0.1. T-values in parentheses.
Source: Authors' calculations using CSMAR data and textual mining of annual reports (SSE/SZSE A-share manufacturers).

4. Results and Discussion

This study uses Chinese A-share listed manufacturing companies from 2014 to 2021 as its sample to systematically examine the impact mechanism and pathways of digital transformation on corporate performance. The findings reveal: First, digital transformation significantly enhances the performance of manufacturing companies. Second, corporate innovation plays a crucial mediating role between digital transformation and corporate performance. The study found that digital transformation not only directly promotes performance improvement but also indirectly enhances performance through two pathways: increasing R&D investment (innovation input) and boosting patent output (innovation output). Notably, the mediating effect of innovation outputs exhibits a lag period of approximately two years, providing empirical evidence for the cyclical characteristics of innovation outcomes conversion. Third, the nature of property rights significantly moderates the effects of digital transformation. State-owned enterprises exhibit a notably stronger performance improvement effect from digital transformation than non-state-owned enterprises.

This study aligns with Qi et al. (2020)'s perspective on the ‘multiplicity of digitalisation impact mechanisms,’ indicating that when digitalisation is combined with process optimisation, it can overcome the ‘IT paradox’ proposed by Hajli et al. (2015) and enhance corporate performance. Additionally, this study quantitatively validates Chen et al. (2019)'s concept of ‘digital economy-driven multidimensional innovation,’ supplementing Fan (2020)'s theoretical framework through a path-specific analysis of innovation inputs and outputs. Unlike the conclusions of Zhao Fang et al. (2023), which focus on the innovation advantages of state-owned enterprises, this study reveals that under the backdrop of digital transformation, the ‘resource diversion effect’ (Huan Jin et al., 2024) of state-owned enterprises further widens the performance gap between them and non-state-owned enterprises. Additionally, existing literature often limits its exploration of the mediating role of

innovation to a single perspective. This study, however, examines the mediating effects of both innovation input and output dimensions, providing a more comprehensive understanding of the transmission mechanism between innovation, digital transformation, and corporate performance. Notably, existing research often overlooks the time lag inherent in the innovation conversion process. This study, however, employs dynamic analysis to find that innovation outputs require at least two years to exert a significant impact on corporate performance. This finding challenges the prevailing notion that innovation outcomes yield immediate results and poses a profound challenge to the currently dominant short-term performance evaluation paradigm.

5. Conclusion

This study makes a theoretical contribution by distinguishing the differentiated roles of innovation inputs and outputs, thereby deepening our understanding of the entire 'input-output' process driven by digital transformation. Additionally, by introducing the perspective of property rights heterogeneity, it reveals the moderating role of institutional environments on digital transformation outcomes, providing a new analytical dimension for research on digital transformation in emerging economies.

In terms of practical implications, enterprises should incorporate digital transformation into their core strategies and establish mechanisms to promote digitalisation and innovation in tandem. They should pay attention to the time lag in the conversion of innovation results and maintain strategic determination. Policy makers should formulate differentiated support policies for non-state-owned enterprises, reduce barriers to transformation through tax incentives and resource matching, and leverage the exemplary role of state-owned enterprises to promote the overall digital transformation of the manufacturing industry.

This study has the following limitations: the sample scope is limited to A-share listed companies, which may affect the external validity of the conclusions; the measurement of digital transformation primarily relies on text analysis methods, and the characterization of the depth of digital technology application needs to be strengthened; and the heterogeneous characteristics of manufacturing sub-industries have not been fully considered. Future research could expand the sample scope to non-listed companies, develop multi-dimensional digital transformation measurement indicators, and conduct comparative studies of industry segments to provide more targeted theoretical guidance.

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