

The Impact of Digital Transformation on Manufacturing Firm Performance

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Abstract: The manufacturing industry has undergone significant changes with digital technology evolving faster and faster, and the integration of digital solutions to improve enterprise performance. Based on the theoretical literature, the theoretical model of the role mechanism of "the degree of digital transformation - the level of manufacturing services - enterprise performance" is constructed by this paper. The study also verifies the impact of digital transformation on the performance of manufacturing enterprises in China and the mediating role played by the level of servitization. The results of this study are of great significance to policy makers and manufacturing companies seeking to improve their performance through digital transformation and servitization strategies.

Keywords: Enterprise Performance, Digital Transformation, Service Level, Fixed effects model.

1. Introduction

With the development of the intelligent age, digitalization, intelligence, service and greening are the main features of the new round of scientific and technological revolution and the focus of the new generation of information technology, the party's 19th National Congress report clearly puts forward "to strengthen the Internet, big data and artificial intelligence and the entity of the high degree of integration of the economy, and promote China's industry to the high-end of the global value chain". The digital transformation of businesses has become a major trend and an important step towards building a strong digital nation in China.

Manufacturing is the foundation of a country's development and a key force in its economic development. However, many Chinese enterprises face challenges in achieving practical results in their digital transformation. Understanding how digital transformation can improve business performance and learning from successful transformation experiences are now important topics in academia and industry.

With the above background, this paper will take the relevant data of manufacturing enterprises in China's Shanghai and Shenzhen cities from 2018 to 2022 as the research object and construct a multiple linear regression model, so as to analyze the effect of digital transformation on the performance of China's manufacturing enterprises, as well as to verify whether the servitization level plays a mediating role between the degree of enterprise's digital transformation and enterprise performance.

2. Theoretical Analysis and Research Hypothesis

What is understood is that digital transformation is an ability to adapt to environmental changes by leveraging digital technologies, leading to improved operational efficiency and overall performance. Enterprise performance measures the business outcomes achieved through resource investment and reflects competitiveness. The current policy measures in China that encourage traditional enterprises to

undergo digital transformation have provided a great incentive for physical enterprises to undergo digital transformation, and the increased investment in digitalization by traditional enterprises has significantly improved their own corporate performance [1,2]. Efficient asset utilization and cost-controlled innovation drive economic benefits. Based on this, according to the first hypothesis of this paper, digital transformation has a significant positive impact on China's performance of manufacturing enterprises.

The rapid development of digital transformation fosters diverse production models, and servitization through information technology (IT) is an essential means for manufacturing enterprises to create and obtain product value [3,4]. On the one hand, by integrating manufacturing with service business, companies optimize resource allocation, reduce service costs, and expand their service scale using digital technology [5,6]. On the other hand, manufacturing enterprises use the combination package of "product" + "service" establishes interactive customer relationships, boosts user loyalty, repeat purchases, and drives profitability [7,8]. Based on this, this paper proposes the second hypothesis of this paper: servitization in manufacturing has a positive mediating effect between digital technology adoption and firm performance.

3. Data Sources and Study Design

3.1. Sample and data

This paper chooses and uses all manufacturing enterprises in Shanghai and Shenzhen cities from 2018-2022 as the research object. The relevant data of Chinese manufacturing enterprises are the research objects, and the listed data are taken from CSMAR database, Wind database, and the company annual reports disclosed by listed companies on a regular basis, whose data are scientific and authoritative. To guarantee the dependability of the study results, samples will be screened on the basis of the following criteria:

- (1) Excluding ST and *ST category listed companies.
- (2) Excluding enterprises listed after 2018.
- (3) Excluding samples with serious missing data on

explanatory variables, explained variables, and control variables in the model definition.

(4) In order to avoid the negative effect of outliers on the results of the paper, the upper and lower 1% Winsorize shrinkage of all continuous variables was performed.

Finally, 1470 sample firms were screened in this paper.

3.2. Variable selection and definitions

3.2.1. Explained variables

The explained variable in this paper is corporate performance, ROA is selected as a measure of corporate performance, and ROE is selected as a proxy for ROA for robustness test.

3.2.2. Explanatory variables

The digital capital investment rate will be selected to

measure the level of digital transformation of manufacturing firms. The digital capital investment rate is the ratio of new electronic equipment hardware investment and software system investment to the total business revenue of the enterprise every year.

3.2.3. Mediating variables

In this paper, the servitization level of manufacturing industry is selected as the mediating variable. The ratio of other business income to total income of enterprises is mainly used as a norm to measure the standard of servitization.

3.2.4. Control variables

In this paper, enterprise size, proportion of shares held by the first largest shareholder, debt-to-assets ratio and growth rate of operating income are chosen as the control variables.

Table 1. Variable definition table

Variable Type	Variable	Symbol	Definition
Explained Variables	Enterprise Performance	ROA	Return on Total Assets
		ROE	Return on Net Assets
Explanatory Variables	Digital Transformation	Dig	Ratio of new electronic equipment hardware investment and software system investment to total business revenue per year
Mediating Variables	Service Level	Serve	Ratio of other operating income to total revenue of the enterprise
Control Variables	Enterprise size	Size	Log of total assets
	Gearing Ratio	Lev	Total liabilities / Total assets
	Shareholding Ratio of the Largest Shareholder	Top1	Number of shares held by the largest shareholder / Total number of shares
	Operating Revenue Growth rate	Growth	(Current year's operating revenue - Prior year's operating revenue) / Prior year's operating revenue

3.3. Model design

In order to test hypothesis 1, Model1 and Model2 are developed in this paper, where both Model1 and Model2 are multiple linear regression models with the explanatory variable enterprise performance, the explained variable digital transformation and several control variables. The difference is that Model1 uses the ROA indicator for firm performance and Model2 uses the ROE indicator for firm performance.

$$ROA_{it} = \alpha + \beta_1 Dig_{it} + \beta_2 Size_{it} + \beta_3 Lev_{it} + \beta_4 Top1_{it} + \beta_5 Growth_{it} + \varepsilon_{it} \quad (\text{Model1})$$

$$ROE_{it} = \alpha + \beta_1 Dig_{it} + \beta_2 Size_{it} + \beta_3 Lev_{it} + \beta_4 Top1_{it} + \beta_5 Growth_{it} + \varepsilon_{it} \quad (\text{Model2})$$

To test hypothesis 2, this paper will use stepwise regression to verify the existence of its mediating role. Model3 is a regression model of the mediating variable servitization level

and the digital transformation of explanatory variables. Model4 is a regression model of the explained variable firm performance, the explanatory variable digital transformation, the mediating variable servitization level and several control variables.

$$Serve_{it} = \alpha + \beta_1 Dig_{it} + \varepsilon_{it} \quad (\text{Model3})$$

$$ROA_{it} = \alpha + \beta_1 Dig_{it} + \beta_2 Serve_{it} + \beta_3 Size_{it} + \beta_4 Lev_{it} + \beta_5 Top1_{it} + \beta_6 Growth_{it} + \varepsilon_{it} \quad (\text{Model4})$$

4. Empirical Tests and Analysis of Results

4.1. Descriptive statistics

In this paper, descriptive statistical analyses of the explained variables firm performance, explanatory variables digital transformation and control variables indicators were conducted as follows:

Table 2. Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max	Observations
ROA	0.0448	0.0725	-0.2529	0.2427	7350
ROE	0.0666	0.1276	-0.5325	0.3556	7350
Dig	0.1739	0.1090	0.0118	0.6109	7350
Serve	0.1739	0.1075	0.0199	0.5475	7350
Size	22.1974	1.1577	20.1403	25.8610	7350
Lev	0.3912	0.1733	0.0685	0.7977	7350
Growth	-1.0265	6.5384	-45.4974	17.0923	7350
Top1	0.3144	0.1364	0.0826	0.6770	7350

4.2. Relevance analysis

In this paper, the relevance analysis of the explained

variable firm performance, the explanatory variable digital transformation and the control variable indicators were conducted as follows:

Table 3. Correlation analysis

	ROA	ROE	Dig	Serve	Size	Lev	Growth	Top1
ROA	1							
ROE	0.941***	1						
Dig	0.014***	0.035***	1					
Serve	0.221***	0.181***	0.086***	1				
Size	0.086***	0.164***	-0.099***	-0.034***	1			
Lev	-0.348***	-0.226***	-0.089***	-0.262***	0.448***	1		
Growth	0.461***	0.521***	0.015	0.064***	0.028**	-0.092***	1	
Top1	0.174***	0.171***	-0.141***	0.086***	0.060***	-0.056***	0.098***	1

From the above table, it is clear that

The relevance coefficient between ROA and Dig is 0.014

The relevance coefficient between ROA and Serve is 0.221

The relevance coefficient between ROA and Size is 0.086

The relevance coefficient between ROA and Lev is -0.348

The relevance coefficient between ROA and Growth is 0.461

The relevance coefficient between ROA and Top1 is 0.174

and all those are significant at the 1% level

4.3. Multicollinearity test

One of the assumptions of multiple linear regression is that there has no high relevance among explanatory variables, otherwise when there has a relevance between the data, the analysis results will be biased. Therefore, in this paper, a multiple cointegration test was conducted before multiple regression, and the test results were as follows:

Table 4. Multicollinearity test

Variable	VIF	1/VIF
Lev	1.32	0.755574
Size	1.31	0.762472
Top1	1.04	0.962492
Dig	1.04	0.964568
Growth	1.02	0.976187
Mean VIF	1.15	

As can be seen from the above table, the expansion factor of the explanatory variable Digitized Transformation Dig and a number of control variables is less than 5, which indicates that there is no high relevance among the variables, i.e., there is no serious collinearity problem, i.e., the data taken in this paper are valid and can be carried out further empirical

analysis.

4.4. Effect model

In this paper, we will determine the effect model by LM test and Hausman test.

Table 5. LM test and Hausman test

Test	Chi2 Value	P Value
LM	64.25	0.0000
Hausman	21.63	0.0014

From the above table, the Chi2 value of 64.25 and p-value of 0.0000 in the LM test results indicate that the random effect is better than the mixed regression.

Then from the table, the results of Hausman test, Chi2 value is 21.63 and the p-value is 0.0014<0.01, which indicates that the fixed effect is better than the random effect. So this paper should use fixed effect model.

4.5. Basis regression and robustness test

In this paper, multiple linear regressions will be conducted for Model1 and Model2 respectively using fixed effects model. ROA indicator is used as the base regression model for the explanatory variable firm performance in Model1. ROE indicator is used as the robustness check model for the explanatory variable firm performance in Model2. The specific regression results are as follows:

Table 6. Base regression and robustness test

	Model1	Model2
	ROA	ROE
Dig	0.0009*	0.0009*
	(2.06)	(2.03)
Size	0.0168***	0.0347***
	(8.49)	(10.05)
Lev	-0.1162***	-0.1067***
	(-14.02)	(-7.38)
Growth	0.0035***	0.0068***
	(41.16)	(45.75)
Top1	0.0393***	0.0698***
	(2.75)	(2.80)
_cons	-0.2809***	-0.6565***
	(-6.32)	(-8.47)
R^2	0.299	0.323
adj. R^2	0.093	0.124
F	425.8046	474.6537
N	6450	6450

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

As can be seen from the regression results of Model1, the regression coefficient of Dig is 0.0009 and the t-value is 2.06, with a significant positive relevance at the level of 10%. It illustrates that the deeper the extent of digital transformation of manufacturing enterprises in China, the higher the level of their corporate performance. The explanation for this result is as follows, the increased digital investment of traditional enterprises significantly improves their own corporate performance. After digital transformation, enterprises improve the economic benefits of digital transformation by increasing the efficiency of asset use and improving their independent innovation capacity on the basis of cost control.

Then from the regression results of Model2, the regression coefficient of Dig is 0.0009 and the t-value is 2.03, with a significant positive relevance at the level of 10% and remains basically consistent with the results of Model1. It indicates that the regression underlying this paper passes the robustness test and the degree of digital transformation of Chinese manufacturing enterprises has a significant positive effect on their enterprise performance.

4.6. Intermediary mechanism test

Table 7. Intermediary mechanism test

	Model3	Model4
	Serve	ROA
Dig	0.0370***	0.0015*
	(3.46)	(2.05)
Serve		0.0571***
		(3.99)
Size		0.0329***
		(9.46)
Lev		-0.0966***
		(-6.59)
Growth		0.0068***
		(45.86)
Top1		0.0678***
		(2.72)
_cons	-0.0836	-0.6291***
	(-1.33)	(-8.10)
R^2	0.003	0.325
adj. R^2	-0.247	0.126
F	9.3036	399.3874
N	7350	6450

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

From the regression results of Model3, the regression coefficient of Dig is 0.0370 and t-value is 3.46, which is significant at 1% level. From the regression results of Model4,

the regression coefficient of Dig is 0.0015, the t-value is 2.05, which is significant at 10% level; the regression coefficient of Serve is 0.0571, the t-value is 3.99, which is significant at 1%

level. In conclusion, it shows that the digital transformation of Chinese manufacturing firms can enhance their service level, which in turn improves their corporate performance.

5. Research Findings and Policy Implications

5.1. Research conclusions

Based on the 2018-2022 data of digital transformation, service level, and enterprise performance of sample manufacturing enterprises, this paper uses a multiple linear regression model for empirical analysis and combines theoretical analysis with empirical research to explore the relationship among manufacturing digitalization, service level, and enterprise performance. This paper reaches the following important conclusions: (1) Digital transformation of the sample manufacturing industry can promote the improvement of enterprise performance. It is serving as a long-term strategy to enhance competitiveness and adapt to the digital economy. (2) Servitization in manufacturing industry has a positive mediating effect between digital technology application and enterprise performance. Improving servitization levels enhances production and operational efficiency, resulting in improved firm performance.

5.2. Policy Implications

5.2.1. Increase digital investment and enhance enterprise value chain

For enterprises, it suggests enhancing digital investment in infrastructure, such as artificial intelligence and internet technology, while leveraging software tools like big data analysis and industrial network design for improved supply chain collaboration and market responsiveness. The integration and alliance between software and manufacturing industries are vital for driving digital transformation, establishing a collaborative digital platform, and adapting to market demands in China's manufacturing sector.

5.2.2. Promote the service of manufacturing industry and extend the industrial chain

To enhance the service aspect of manufacturing enterprises,

they should integrate digitalization across multiple fields and diversify their offerings. Extending the manufacturing industry's value chain improves the quality of terminal services and generates revenue through manufacturing services. The development trend of manufacturing service focuses on connecting with consumer demands, enhancing consumer satisfaction, and elevating the service level of traditional manufacturing.

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