Research on the Impact of Digital Transformation in Manufacturing on the Dual Innovation Capability of Enterprises

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Abstract: Under the tide of the digital economy, the development of manufacturing enterprises towards digitalization and intelligence has become a new trend, as the core competitiveness that drives long-term development of enterprises, whether it can improve its capabilities through digital transformation remains to be studied. This article conducts a systematic analysis using various data from manufacturing companies listed on the A-share market from 2018 to 2023, in order to explore whether the digital transformation of manufacturing companies has an impact on their innovation capabilities. It mainly conducted benchmark regression testing, robustness testing, and heterogeneity analysis. The robustness testing used lagged variables and the Heckman two-stage method, while the heterogeneity testing classified based on regional characteristics. The empirical results indicate that the hypothesis is correct, and further analysis shows that the impact of digital transformation on dual innovation of enterprises is greater in the eastern region. Finally, we hope that this study can provide effective suggestions and relevant references for enterprises to enhance their dual innovation capabilities through digital transformation

Keywords: Manufacturing Enterprises; Digital Transformation; Exploitative Innovation; Exploratory Innovation; Robustness Check

1. Introduction

In this era filled with big data, various intelligent technologies are emerging like mushrooms after rain, and various enterprises are actively reforming and striving to catch up with the tide of the times. As the manufacturing industry is of utmost importance to our country, innovation is also urgent, so it is urgent to carry out digital transformation to improve innovation capabilities. Utilizing digital technology to improve the quality and innovate the operation, management, and service processes of enterprises like never before[1]. In this context, enterprises must enhance their competitiveness in order to be invincible in the market. Innovation is a key indicator of whether a company can continue to survive, and emphasizing the cultivation and improvement of innovation capabilities is an urgent task for enterprises at present[2]. Innovation has two aspects. On the one hand, it is to transform and optimize the existing foundation using new technologies. On the other hand, it is to directly open up a new track using new technologies. In the increasingly competitive market today, the improvement of these two innovative capabilities is particularly important for enterprises[3]. So, will the Digital shift of manufacturing company have an influence on their dual creative ability, and will it promote the improvement of their dual innovation capabilities? Further research is needed.

2. Theoretical Analysis and Research Hypotheses

Dual innovation, first mentioned by March[4] (1991) in "Exploration and Utilization in Organizational Learning," is differentiate into exploratory innovation and developmental innovation. Compared with exploratory innovation, exploratory innovation highlight on daring to explore and explore, motivating enterprises to constantly seek new resources, create new products, develop new processes, and create flexible and diverse business models that can adapt to changing market demands; Utilitarian innovation focuses more on utilization and development, with a focus on continuous improvement and deepening based on existing resources and technological support, in order to enhance efficiency and application level, making it more perfect[5].

For exploitative innovation, enterprises use

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digital technology to supervise and control production processes, adjust plans in real-time using digital technology, estimate completion time and efficiency, improve production processes, and optimize manufacturing processes. This not only reduces resource waste but also improves production efficiency by optimizing and improving on the existing processes. From another perspective, as the economy continues to improve, consumers' mentality has changed. Consumers have higher expectations for the goods or services they want to purchase, hoping that they can keep up with the trend of the times. Enterprises collect the preferences and expectations of each customer for products through extensive data information networks, and design products or services based on these specific needs,create higher value and better meet customer needs[3].

For exploratory innovation, companies can only maintain competitiveness in an increasingly competitive market by launching new products. By utilizing big data technology to investigate the external market, enterprises can enhance their sensitivity to the market and take the lead in promoting novel and unique products before losing their competitive advantage, thus quickly occupying the market[6].

Based on the analysis in the previous text, I boldly propose the following two hypotheses:

Hl: The digital transformation of manufacturing enterprises promotes exploratory innovation.

H2: The digital transformation of manufacturing enterprises promotes exploitative innovation.

3. Research Design

3.1 Instance Selection and Source of Data

This article selects A-share manufacturing listed companies from 2018 to 2023 as research data. Firstly, conduct a preliminary screening of the collected data to remove incomplete information, ST, and ST * enterprises. To further ensure the completeness and accuracy of the data, tail trimming was performed, resulting in a total sample size of 10109. The dual innovation capability and control variable data in this article are all sourced from the Guotai An database, while the explanatory variable digital transformation data was manually collected[7].

3.2 Variable Definition

Table 1. Variable Control Table

Variable type	Variable Name	Symbol	Variable measurement
Dependent variable	Exploitative innovation	JJ	Add 1 to the sum of the number of utility model and design patent applications and take the natural logarithm
	Exploratory innovation	TP	Add 1 to the number of invention patent applications and take the natural logarithm
Explanatory variables	Digital transformation	DT	Add 1 to the total frequency of digital transformation keywords in the annual report of the enterprise and take the natural logarithm
control variable	Asset size	Size	Take the natural logarithm of the total assets at the end of the year
	Concentration of equity	Top10	The sum of the shareholding ratios of the top ten shareholders
	Dual employment integration	Dual	The concurrent position of Chairman and General Manager is 1, otherwise it is 0
	Growth potential	Growth	(Total operating revenue for the current year - Total operating revenue for the previous year)/(Total operating revenue for the previous year)
	Listing period	Age	Logarithmically processed enterprise listing time and square
	Operating cash flow	Cash	Cash flows generated from operating activities/total assets
	Return on total assets	Roa1	Profit before interest and tax/average total assets

(1) Explained variable: Dual innovation capability. This article in the light of the research approach of Xu Ning et al[8]. (2019) The measurement of dual innovation capability is based on the number of patents obtained by the enterprise, where exploratory innovation capability is judged by the amount of patent of invention subscribes filed by enterprises, and exploitative innovation capability is judged by the number of model utility and design employ of the enterprise. To further ensure the accuracy of the data, all data is logarithmically processed by adding one.

(2) Explaining variable: Digitization. This article

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follows the approach of Wu Fei et al[9]. (2021) and uses Python text mining to statistically analyze the frequency of digitized feature words appearing in the whole annual reports of public company to make further efforts make certain the reliability of the data, this article performs logarithmic processing.

(3) Control variables: There are many factors that affect the dual innovation capability, and digital transformation is only one direction of our research. In order to make the results more realistic, this article also considers other influencing factors, such as asset size, equity concentration, and listing period. The correspondence delimiting of particular alternating quantity are shown in Table 1.

3.3 Model Construction

The digitization and duplicato-innovation model of manufacturing firm, as shown in equations (1) and (2):

$$TP_{i,t} = \alpha_0 + \alpha_1 DT_{i,t} + \alpha_k Control_{i,t} + \sum Year + \sum industry + \varepsilon_{i,t} \quad (1)$$

$$JJ_{i,t} = \alpha_0 + \alpha_1 DT_{i,t} + \alpha_k Control_{i,t} + \sum Year + \sum industry + \varepsilon_{i,t} \quad (2)$$

Among them, Year and industry represent the stabilization influence of year and profession. This study used a dual fixed effects model of time and industry for regression analysis.

4.Positive Economics

4.1 Descriptive Statistics

The descriptive statistical results are shown in Table 2. In terms of digital transformation, the average value of the variable DT for digital transformation is 1.632, indicating that most manufacturing enterprises are still in the primary stage of digital transformation, with a lowest value of DT is 0 and the highest is 5.037. This means that the digital transformation process between different enterprises is fluctuating. In terms of dual innovation capability, the lowest value of variable utilization innovation (JJ) is 0, the highest value is 5.981, the average value is 1.501, and the standard deviation is 1.532; The minimum value of exploratory innovation (TP) is 0, the maximum value is 6.201, the average value is 1.411, and the standard deviation is 1.423; There are also many differences in the level of importance that enterprises attach to innovation capability, and not all enterprises attach importance to the cultivation of innovation capability.

Table 2. Descriptive Statistics

variable	Sample size	average	Maximum value	minimum value	standard deviation	median
DT	10109	1.632	5.037	0	1.263	1.609
JJ	10109	1.501	5.981	0	1.532	1.386
TP	10109	1.411	6.201	0	1.423	1.099
Size	10109	15.41	32	3	7.622	14
Top10	10109	56.30	88.64	22.68	14.18	56.17
Dual	10109	0.305	1	0	0.460	0
Growth	10109	0.0880	0.893	-0.323	0.167	0.0640
Age	10109	2.592	3.466	1.099	0.571	2.639
Cash	10109	0.0570	0.272	-0.132	0.0630	0.0530
Roa1	10109	0.0330	0.223	-0.401	0.0690	0.0350
SOE	10109	0.291	1	0	0.454	0
Lev	10109	0.409	0.885	0.0610	0.181	0.408
TOP1	10109	32.24	71.40	8.659	13.55	30

4.2 Regressive Analysis

The results of Table 3 are the outcome analysis of digital transformation and dual innovation capabilities. According to Model 1, the outcome between digitization and transformation and exploitative innovation capability shows a coefficient of 0.189 for digital transformation, which is conspicuousness at the 1% horizontal. This explain that digital transformation can improve exploitative innovation capability. According to Model 2, the outcome between digitization and transformation and exploitative innovation capability shows that the factor for digitization and transformation is 0.202, which is conspicuousness at the 1% horizontal. This proves that digital transformation also has a positive promoting effect on the enhancement of creative Ability. So, hypothesis 1 of this article has been validated. With the widespread use application of digital technology, it has accelerated the digital transformation of

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enterprises, improved the put into circulation and efficiency of inside information, as well as the susceptibility of the external environment, relief the problem of information asymmetry, and thus enhanced the innovation capability of enterprises.

Table 3. Basic Regression Table

	(1)	(2)
	JJ	TP
DT	0.189***	0.202***
	(15.57)	(17.29)
Size	-0.036***	-0.000
	(-5.66)	(-0.03)
Top10	0.009***	0.005***
	(7.36)	(4.17)
Dual	-0.110***	-0.125***
	(-3.51)	(-4.30)
Growth	0.185*	0.383***
	(1.92)	(4.21)
Age	0.345***	0.001
	(3.89)	(0.01)
Cash	1.642***	1.020***
	(6.13)	(3.92)
Roa1	1.554***	1.646***
	(6.16)	(7.06)
_cons	0.348*	0.486***
	(1.95)	(2.88)
N	10105	10105
F	126***	76***
p	0.000	0.000
r2	0.158	0.111
industry	YES	YES
particular year	YES	YES

Note: *, * *, * * * respectively indicate significance at the 10%, 5%, and 1% levels; The t statistic is enclosed in parentheses.

4.3 Robustness Test

(1) Lagged explanatory variable

It will take some time to prove the effectiveness of digital transformation for enterprises to enhance their dual innovation capabilities. Therefore, this article uses data with digital transformation variables delayed by one year, and then conducts regression testing again. The data in columns (1) and (2) of Table 4 can prove that the regression results obtained this time are consistent with the benchmark regression results mentioned earlier, thus further verifying our hypothesis.

(2) Heckman two-phase examination

To address endogeneity issues arising from sample selection, we followed the approach of previous researchers[10] and utilized the Heckman two-phase examination model. From column (3), it can be seen that in the first phase of Heckman examination, it is remarkable positive at the 1% horizontal. From columns (4) and (5), it can be seen that in the second stage of Heckman regression, after controlling for IMR, in the light of the results, there is a positive correlation at the 1% standard, indicating that sample selection bias does not affect the research conclusions of this article.

Table 4. Robustness Test

	Variable lag		Heckman two-stage method		
	(1)	(2)	(3)	(4)	(5)
VARIABLES	TP	JJ	Transformation	TP	JJ
DT				0.231***	0.196***
				(11.79)	(9.83)
L.DT	0.206***	0.184***			
	(14.50)	(12.52)			
IV			0.000***		
			(7.40)		
IMR				0.349	1.695***
				(1.06)	(4.90)
_cons	-1.922***	-1.261***	-0.746*	-2.514***	-2.539***
	(-4.17)	(-2.65)	(-1.65)	(-4.26)	(-4.12)
control variable	YES	YES	YES	YES	YES
industry	YES	YES	YES	YES	YES
particular year	YES	YES	YES	YES	YES
N	7177	7177	7642	6057	6057
r2	0.119	0.159		0.111	0.133

4.4 Heterogeneity Test

Table 5. Heterogeneity Test of Table Regions

	Eastern region		Central and Western Regions	
	(1)	(3)	(2)	(4)
	TP	JJ	TP	JJ
DT	0.233***	0.215***	0.115***	0.128***
	(15.83)	(13.81)	(4.23)	(4.65)
_cons	-2.093***	-1.379***	-0.406	0.591
	(-4.70)	(-2.94)	(-0.53)	(0.76)
N	6083	6083	2471	2471
r2	0.128	0.165	0.089	0.129
industry	YES	YES	YES	YES
particular year	YES	YES	YES	YES

This article uses the regional distribution of manufacturing enterprises for heterogeneity

analysis. Divide manufacturing enterprises into eastern and central western regions based on geographical distribution, and then examine the impact of digital transformation on dual innovation in the eastern and western regions respectively. The results in Table 5 indicate that exploratory innovation and exploitative innovation are significant at the 1% level in both the eastern and central western regions, but their coefficients are higher in the eastern region compared to the central western region. Therefore, this indicates that manufacturing enterprises in the eastern region, driven by factors such as more advanced technology and abundant resources, have promoted the improvement of dual innovation level. The impact of digital transformation on binary innovation in the central and western regions is relatively weak, which may be due to the immature development of digital technology, hindering the improvement of exploratory and developmental innovation levels.

5. Research Conclusion and Implications

This article uses data from A-share manufacturing companies from 2018 to 2023 to study the relationship between digital transformation and dual innovation capabilities, and explores whether utilizing digital transformation can enhance dual innovation capabilities. After conducting a series of empirical studies, it has been concluded that: (1) digital transformation in manufacturing can promote the improvement of dual innovation capabilities, and the higher the degree of digital transformation, the more beneficial it is for enterprises to enhance their dual innovation capabilities; (2) Compared with the central and western regions, the promotion effect of digital transformation on binary innovation capability is more prominent in the eastern region.

Based on the research results of this article, the following suggestions are proposed: firstly, the government should provide targeted and active support, improve development policies, strengthen talent cultivation, actively promote the digital transformation of manufacturing enterprises, contribute to improving their dual innovation capabilities, and create a better development environment; Secondly, due to geographical reasons, the speed of digital transformation in the central and western regions is relatively slow. Therefore, we should actively utilize government policy support, continuously learn and improve, accelerate enterprise transformation, and enhance innovation capabilities.

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