

The influence of digital transformation on technological innovation performance of automobile manufacturing enterprises

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Keywords: Digital transformation; Technology innovation performance; Automobile manufacturing industry

Abstract: In the era of digital economy, digital transformation has become an important path for automobile manufacturing enterprises to achieve innovation. Based on the balanced panel data from 2017 to 2021 of Listed Chinese A-share automobile manufacturing enterprises, this paper empirically examines the impact of digital transformation on technological innovation performance of automobile manufacturing enterprises. The results show that the digital transformation of automobile manufacturing enterprises has a significant positive impact on technological innovation performance, enterprise digital transformation also has a significant positive impact on absorptive capacity. In addition, digital transformation and absorptive capacity have a lag effect on technological innovation performance.

1. Introduction

With the advent of a new round of technological revolution and industrial revolution, digital economy has become an indispensable driving force for Chinese steady economic growth^[1]. *Chinese Digital Economy Development White Paper (2021)* shows that our digital economy reached 39.2 trillion yuan in 2020, accounting for 38.6% of GDP.

Researches on digital transformation and enterprise innovation can be broadly divided into two categories: One is qualitative analysis. Vial et al. (2019)^[2] studied the phenomenon of digital transformation on enterprise innovation from a theoretical level. Liu Qilei et al. (2021)^[3] explored the innovation of digital enabling enterprises based on the case analysis of xuzhou Construction Machinery Group and Shaanxi Automobile Group intelligent manufacturing enterprises. The other is quantitative analysis. Ferreira et al. (2019)^[4] adopted the "0-1" dummy variable of "whether the enterprise uses new digital process in the current year" to measure digital transformation, and empirically tested the direct impact of digital transformation on product service innovation. Zhang Jichang and Long Jing (2022)^[5] empirically test the impact of digital transformation on enterprise innovation performance by using the data of listed companies. All the above studies confirm the positive role of digital transformation on enterprise innovation.

In the manufacturing industry, which is closely related to our public life, the automobile manufacturing industry has been actively transforming digitally in recent years. This paper studies the

relationship between digital transformation and technological innovation performance of automobile manufacturing enterprises through empirical test, taking Listed Chinese A-share automobile manufacturing companies from 2017 to 2021 as samples.

2. Literature review and research hypothesis

2.1. Digital transformation of automobile manufacturing enterprises

At present, there is no unified definition of the concept of digital transformation, and scholars have expounded the concept of digital transformation from different levels. The differences are mainly for the subject. The discussion on the subject of digital transformation in existing studies is mainly divided into three levels, macro, meso and micro levels. At the macro level, with the state and the market as the main body, it believes that digital transformation means that the state takes full advantage of the opportunities brought by digital technology to formulate corresponding policies, so as to promote social and market changes^[6]. At the middle level, with industry as the main body, digital transformation is mainly driven by the transformation and upgrading of traditional industries by the application of digital technologies^[7]. At the micro level, take enterprises as the main body, digital transformation refers to the innovation process of enterprises using digital technology to adapt to the highly changing external environment by reshaping their vision, strategy, organizational structure, process, capability and culture^[8].

As an important micro basis of social and economic development, enterprises are also the main body of industrial transformation and upgrading, so it is very necessary to explore the digital transformation of enterprises. First, we need to know what exactly is enterprise digital transformation. Vial (2019)^[2] believes that enterprise digital transformation means that enterprises make significant changes in organizational attributes by integrating information technology, computer technology, communication technology and connection technology, so as to realize organizational transformation and respond to the digital environment.

In the era of digital economy, digital transformation has become the inevitable choice of manufacturing enterprises. As an industry integrating the great achievements of manufacturing industry, the digital transformation of automobile manufacturing enterprises is more vigorous.

According to the characteristics of automobile manufacturing industry, this paper defines the digital transformation of automobile manufacturing enterprises as the transformation and upgrading of enterprises by using digital technologies such as artificial intelligence, cloud computing, big data and Internet of things to drive the transformation of production mode and innovation of R&D and design, reshape the core competitiveness of enterprises.

2.2. Enterprise digital transformation and technological innovation performance

At present, there are two major studies on the impact of digital transformation on enterprise innovation performance.

One argues that the digital transformation of enterprises has a significant positive effect on the technological innovation performance of enterprises. Forman and Zeebroeck (2012)^[9] believe that enterprises can promote r&d cooperation between different organizations through the use of the Internet. Li Shanshan and Xu Xiangyi (2019)^[10], Shen Guobing and Yuan Zhengyu (2020)^[11] and Wang Wenna et al. (2020)^[12] found that the application of Internet technology by enterprises can significantly promote the technological innovation of enterprises. Meng Weijun et al. (2022)^[13], Huang Jiegen et al. (2021)^[14], Zhang Jichang and Long Jing (2022)^[5] used the data of listed companies to find a positive correlation between enterprise digital transformation and innovation efficiency and innovation performance.

The other found that the impact of enterprise digital transformation on enterprise innovation is not always positive. KOHTAMAK et al. (2019) ^[15] found an inverted U-shaped relationship between service digitalization and corporate performance through empirical analysis of financial and service digitalization data of more than 7,000 credit cooperatives in the United States. GEBAUER et al. (2020) ^[16] conducted case studies on 52 industrial enterprises and found the paradox of enterprise digitization. Yu Feifei et al. (2021) ^[17] also found an inverted U-shaped relationship between digitalization level and innovation performance by using the questionnaire survey data of 283 enterprises.

Now the digital transformation of enterprises in China is in its early stage, and the impact of digital transformation on technological innovation performance in this period should be positively correlated according to existing studies. Therefore, we propose research hypothesis 1: digital transformation of automobile manufacturing enterprises has a positive impact on technological innovation performance.

In the era of digital economy, the enterprise ecological environment changes constantly, enterprise and between enterprises and the boundary of the external environment is gradually being broken, the enterprise through the digital transformation for stakeholders to share knowledge, enable enterprise fast connect internal and external information source, realize the interaction between internal cognitive and external environment to learn ^[18]. Enterprises can use the massive information brought by digital transformation to absorb, integrate and coordinate the information with the existing resources within the enterprise, in order to promote the technological innovation of enterprises. So we propose hypothesis 2: absorptive capacity plays a mediating role between digital transformation and firm innovation performance.

3. Research design

3.1. Sample selection and data sources

The initial research sample of this paper includes all listed Chinese A-share auto manufacturing companies from 2017 to 2021. In this paper, the data are processed as follows: (1) the enterprises which are ST and *ST in the sample period are excluded; (2) Eliminate enterprises with serious data loss; (3) In order to avoid the abnormal influence of outliers on the model estimation, all continuous variables are adjusted by tail-shrinking, and the tail-shrinking object is the upper and lower 1% observation value. After the above processing, a total of 470 observations of 94 automobile manufacturing enterprises were obtained. The data comes from CSMAR database, and the digital transformation data in 2021 is collected by Juchao Information Network.

3.2. Definition of variables

3.2.1. Explained variable: enterprise technological innovation performance

In the existing literatures, there are mainly two ways to measure technological innovation of enterprises: one is to use patents as measurement indicators, and the total amount of authorized patents of enterprises ^[18,19] or the number of cited patents ^[20] as measurement indicators; Second, the sales volume of new products is used as the measurement index of technological innovation performance ^[15].

However, since China does not require the sales revenue of new products to be included in the disclosure content of the annual report of an enterprise, considering the availability and validity of data, this paper adopts the total number of effective patents and the total number of patents applied in the current year to measure the technological innovation performance of an enterprise.

3.2.2. Explanatory variable: enterprise digital transformation

There is no unified standard for the measurement of enterprises' digital transformation, and a more feasible method is that Wu Fei et al. [21] use the frequency of keywords related to digital transformation in the annual reports of listed enterprises to construct the index of enterprises' digital transformation. We also draws on this practice

3.2.3. Mediating variable: absorption capacity

Referring to the practice of Zhang Jichang and Long Jing [5], absorptive capacity is selected as the intermediary variable, and the ratio of annual R&D investment and operating income of sample enterprises is adopted to measure and expressed by RDC.

3.2.4. Control variables

We learn from relevant studies of previous scholars [5,15,21]. We selected listed years, enterprise size, profitability, ownership concentration, asset and liability level and proportion of independent directors as control variables.

3.2.5. Model specification

To test the research hypothesis, this paper sets the following model:

$$EIP_{i,t} = \beta_0 + \beta_1 EDT_{i,t} + \sum \beta_k Control_{i,t} + \sum Year + \varepsilon_{i,t} \quad (1)$$

$$RDC_{i,t} = \beta_0 + \beta_1 EDT_{i,t} + \sum \beta_k Control_{i,t} + \sum Year + \varepsilon_{i,t} \quad (2)$$

$$EIP_{i,t} = \beta_0 + \beta_1 EDT_{i,t} + \beta_2 RDC_{i,t} + \sum \beta_k Control_{i,t} + \sum Year + \varepsilon_{i,t} \quad (3)$$

In the above models, I represents the enterprise, T represents time, EIP represents technological innovation performance, EDT represents digital transformation of the enterprise, RDC represents R&D capability, Year represents Year, is time dummy variable, Control is the Control variable selected above, and ε is random error term.

4. Empirical test

Table 1: Regression analysis results

VARIABLES	(1) EIP	(2) RDC	(3) EIP	(4) EIP
EDT	5.199** (2.34)	0.074*** (5.09)		4.719** (2.07)
RDC			9.930 (1.42)	6.511 (0.91)
Controls	-	-	-	-
Year	-	-	-	-
Constant	-515.095*** (-5.85)	5.855*** (10.19)	-575.116*** (-5.91)	-553.218*** (-5.67)
Observations	470	470	470	470
R-squared	0.141	0.175	0.135	0.143

t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Regression analysis results through Stata are shown in **Table 1**, and column (1) and (4) are listed as test results of hypothesis 1. The results show that enterprise digital transformation does have a

positive impact on technological innovation performance, which is significant at the 5% level. (2) is listed as the test result of hypothesis 2. The result shows that enterprise digital transformation has a positive impact on absorptive capacity, which is significant at 1% level.

Table 2: Lag one stage regression analysis results

VARIABLES	(1) EIP_lag	(2) EIP_lag	(3) EIP_lag
EDT	5.948** (2.33)		4.806* (1.83)
RDC		17.890** (2.28)	14.237* (1.76)
Controls	-	-	-
Year	-	-	-
Constant	-597.824*** (-6.39)	-709.818*** (-6.78)	-684.057*** (-6.50)
Observations	470	470	470
R-squared	0.178	0.178	0.185

t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Considering that in reality, whether an enterprise conducts digital transformation is affected by many subjective and objective factors, in order to correct the possible sample selection bias, this paper re-regresses the Heckman two-step method and finds that the regression results of the main explanatory variables do not show significant changes. At the same time, this paper uses digital transformation of enterprises as the independent variable, and one period lag of technological innovation performance as the dependent variable, and then re-substitutes it into the model for measurement (**Table 2**). The results show that the coefficient sign and significance are not changed, indicating that there is no reverse causality. The empirical analysis conclusion of this paper is robust.

5. Conclusions and suggestions

The research conclusions of this paper are as follows:

First of all, the digital transformation of Chinese automobile manufacturing enterprises has a positive impact on their technological innovation performance, which is the same as the existing research results of other industries (such as high-tech enterprises) ^[5].

Secondly, digital transformation has a significant positive impact on absorptive capacity. However, the effect of digital transformation on technological innovation performance is not influenced by absorptive capacity as a mediating variable.

Finally, digital transformation and technology absorptive capacity have a lag effect on technological innovation performance.

Based on the above research conclusions, this paper puts forward the following suggestions:

First, automobile manufacturing enterprises should further deepen the digital transformation and elevate it to the strategic level. The digitalization development of Chinese enterprises is still in the initial stage, and the automobile manufacturing industry has announced digitalization transformation in recent years. In the current era of digital economy, it is of great significance for automobile manufacturing enterprises to grasp digital transformation, and promoting enterprise digital transformation to the strategic level can better promote enterprise all-round digital transformation to embrace digital economy.

Next, in the process of digital transformation, automobile manufacturing enterprises should pay attention to the coordination of digital technology with their own internal resources and other

enterprise resources. Automobile manufacturing industry belongs to capital and technology intensive industry. How to make good use of internal and external resources to promote enterprise digital transformation is the key. Digital transformation should not only focus on superficial digital technology equipment and operating software. Instead, enterprises should rely on their existing resources and combine digital technology to improve production design, manufacturing process, cost management, technological innovation, marketing, business model and strategic innovation.

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