

Study on the Influence of Digital Economy on the High-Quality Development of Manufacturing Industry in Henan Province

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Abstract: As a populous province, Henan Province in China has provided a large amount of labor force for the development of Henan's manufacturing industry. However, in recent years, with the rise of China's labor costs, some manufacturing industries have been transferred, exposing the lack of development potential and development momentum of Henan's manufacturing industry. Therefore, it is of great significance to clarify the role of digital economy in promoting the high-quality development of manufacturing industry in Henan Province to reverse the high-quality development of manufacturing industry in Henan Province at this stage. Based on the data of Henan Province from 2017 to 2022, this paper uses the entropy weight method to measure the comprehensive score of digital economy and high-quality development of manufacturing industry. Through the mediating effect model, the innovative role of digital economy is obtained, which plays a part of intermediary role in the process of digital economy enabling the high-quality development of manufacturing industry in Henan Province. From the above analysis, the following conclusions are drawn: 1. The level of digital economy and the high-quality development of manufacturing industry in Henan Province are on the rise; the benign pattern of common development between the digital economy system and the high-quality development system of the manufacturing industry has gradually formed; the digital economy promotes the high-quality development of regional manufacturing through technological innovation.

Keywords: Digital Economy; High-quality Development of Manufacturing Industry; The Mediating Effect Model

1. Introduction

General Secretary stressed the need to build a new development pattern with the domestic cycle as the main body and the domestic and international dual cycles promoting each other. As the main body of the national economy, the manufacturing industry plays a pillar role in the country's economic development. How to promote the manufacturing industry to a high level of quality development and form a new competitive advantage is an urgent problem to be solved.

As a populous province, Henan Province also has rich resources and a large population as a manufacturing province. As one of the important manufacturing bases in the country, Henan Province has continuously expanded the scale of manufacturing in recent years, but there are still bottlenecks restricting its development. For example, the market share of products in the manufacturing industry in Henan Province is low, and the ability of scientific and technological innovation and production efficiency need to be further improved. At the same time, with the continuous changes in the external economic environment, these problems have hindered the transformation and upgrading of the manufacturing industry in Henan Province to a certain extent.

With the digital economy gradually becoming an important strategic position in our country, although it is still in the primary stage in Henan Province, it has become a powerful tool to promote the high-quality development of manufacturing industry in Henan Province. The digital economy will greatly change the development mode, production mode and management mode of the manufacturing industry in Henan Province, thus helping the new development of the manufacturing industry in Henan Province. At the same time, Henan Province is actively promoting supply-side structural reforms and strengthening technological innovation^[1]. On the other hand, the digital economy is also constantly developing and has gradually become an important support for the development of manufacturing industry in Henan Province. It is conducive to promoting the coordinated development of digital industry and manufacturing industry in Henan Province.

The purpose of this paper is to explore the influence mechanism and optimization path of digital economy on the high-quality development of manufacturing industry in Henan Province, and to provide reference for the digital transformation and high-quality development of manufacturing industry in Henan Province.

2. Research Status

2.1. Measurements for the digital economy

Qin Jianqun et al. (2022)^[2] believe that the digital economy has a positive effect on the upgrading of industrial structure. The digital economy has regional heterogeneity in the upgrading of China's industrial structure, and technological innovation and financial development have a certain intermediary effect. Qin Huining and Yang Xin^[3] found that the digital economy expands human capital accumulation and stimulates entrepreneurial vitality, which in turn drives the high-quality development of the manufacturing industry. On the whole, the digital economy can not only provide new kinetic energy for the development of the manufacturing industry, promote the manufacturing industry to achieve quality change, efficiency change and power change, but also accelerate the development of advanced manufacturing clusters, which is conducive to China's manufacturing industry to break the situation of vertical extrusion and low-end locking, break through the 'dilemma' of high-end blockade and low-end catch-up, and enhance the position of manufacturing industry in the global value chain.

2.2. Measurement of high-quality development of manufacturing industry

Internationally, the U.S. Bureau of Economic Analysis (BEA) defines the concept of the digital economy and uses the supply-use table to measure the digital economy of the United States on the basis of examining India's national accounts statistics. The European Commission^[4] has developed and published the Digital Economy and Society Index (DESI), which compiles the digital economy and social development index from the perspectives of broadband access, human capital, Internet applications, digital technology applications, and digital public services. In terms of the specific path to promote the upgrading of the advanced manufacturing industry structure, Cai Tingting and Wu Songqiang compared the specific measures of the digital economy in the United States, Japan and Germany to empower the advanced manufacturing industry, and concluded that the development of China's advanced manufacturing industry needs to lay a solid digital infrastructure. On the basis of improving industrial clusters, we should pay attention to the cultivation of 'dual' talents who are both proficient in digital technology and proficient in manufacturing technology.

3. Data source and index establishment

3.1. Data sources

This paper mainly studies the level measurement, influencing factors and optimization path of digital economy enabling the high-quality development of manufacturing industry in Henan Province, in order to ensure the authenticity and reliability of data. The data of this paper mainly come from Henan Statistical Yearbook, China Statistical Yearbook and China Statistical Data Application Support System. Considering the possible lack of implementation time and data of digital economy, this paper mainly selects relevant data such as high-quality development of manufacturing industry, digital economy and technological innovation of digital economy in Henan Province from 2017 to 2022.

3.2. Variable selection

3.2.1. Explained variables

High-quality development of manufacturing industry (Y). This paper refers to the research results of Li Shiheng et al.^[4], fully combines the five development concepts, takes into account the characteristics of the manufacturing industry and the characteristics of the data, and constructs a high-quality development evaluation system for the manufacturing industry. By using the entropy method to give the weight of each index, the comprehensive index score of high-quality development of manufacturing industry in Henan Province from 2017 to 2022 is calculated. The explained variable

is the comprehensive index score of high-quality economic development calculated by the entropy method.

3.2.2. Explanatory variables

Digital economy development level (F). As a new form of business, there is no uniform standard for judging the connotation of digital economy, which is based on the research of scholars such as Song Yang^[5]. This paper chooses three secondary indicators from the scale of digital economy, the development level of digital economy and the application level of digital economy. The entropy method is used to measure the comprehensive score of digital economy and the development level of digital economy, which is used as the explanatory variable of this paper.

3.2.3. Intermediary variables

Digital technology innovation capability (M). This paper refers to the research of Xing Hao^[6] and so on. According to the scientific and integrity principles of model construction, patented technology can represent the technological innovation ability of enterprises to a certain extent. Therefore, the number of patent authorizations represents the ability of enterprises to innovate in digital economy technology.

3.2.4. Control variables

Based on the research of Ding Yali^[7], this paper takes the development of other industries in Henan Province, the industry competition of manufacturing industry and the change of manufacturing policy as the operation control variables. In order to achieve a more accurate measurement of the impact of the digital economy on the high-quality development of manufacturing industry in Henan Province.

3.3. Establishment of index system

3.3.1. Construction of digital economic evaluation index system

The selection of digital economic indicators mainly considers the influencing factors of digital economy on the high-quality development of enabling manufacturing industry, and adopts five secondary indicators : digital economy scale, digital economy development speed, digital industry development, digital economy application level and digital infrastructure. (See Table 1)

Table 1 Composition of digital economy index system.

First-level Index	Second-level Index	Defines	Index Attribute	Weight (%)
Digital Economy Capacity	Digital Economy Size	The total size of the digital economy (trillion yuan)	(+)	15.738
	The Speed of Digital Economy Development	The year-on-year growth rate of digital economy scale	(+)	21.496
	The Application Level of Digital Economy	(Digital economy scale / GDP ^ 100)	(+)	21.157
	The Proportion of High-tech	Expenditure in digital industry development	(+)	16.516
	Digital Infrastructure	Internet broadband access port number (ten thousand)	(+)	25.094

3.3.2. The construction of high-quality development index system of manufacturing industry

In the selection of high-quality development indicators for the manufacturing industry, six indicators are selected from the factors that promote the development of the manufacturing industry. (See Table 2)

Table 2 : Composition of high-quality development index system of manufacturing industry

First-level Index	Second-level Index	Defines	Index Attribute	Weight (%)
High-quality manufacturing development	The added value of industry	New added value in the process of enterprise (trillion yuan)	(+)	18.018
	Enterprise Innovation	The number of enterprise patent applications (pieces)	(+)	23.633

	Ability			
	Resource utilization efficiency	Benefits created by the manufacturing industry / manufacturing costs	(+)	13.415
	Speed efficiency	Manufacturing labor productivity (yuan / person)	(+)	20.975
	Innovation-driven	Number of invention patents per 10,000 population (pieces)	(+)	23.869

4. The measurement and evaluation of the high-quality development level of digital economy and manufacturing industry in Henan Province

4.1. Digital economy measurement results

According to the steps of the entropy method, this paper makes full use of SPSSPRO to calculate the weight of each part of the index data of Henan 's digital economy from 2017 to 2022, and finally obtains the comprehensive score of Henan 's digital economy from 2017 to 2022. (See Table 3)

Table 3: The comprehensive score of digital economy in Henan Province from 2017 to 2022.

YEAR	GF
2017	0.1652
2018	0.4386
2019	0.3154
2020	0.3630
2021	0.6764
2022	0.9979

Through Table 3, it can be clearly seen that the comprehensive score of digital economic capacity in Henan Province tends to rise as a whole from 2017 to 2022, and the growth rate will increase significantly from 2020 to 2022, with remarkable results. From 2020 to 2022, it has increased by nearly 0.3 every year. It can be seen that Henan Province is paying more and more attention to the digital economy. From all aspects, digital infrastructure accounts for the largest proportion of digital economic capacity, accounting for 25.094 %, and the speed of digital economic development accounts for the second, 21.496 %. It can be seen that digital infrastructure has contributed greatly to the development of digital economy in Henan Province. The development of digital industry has the least pulling effect on the development of digital economy.(See Figure 1)

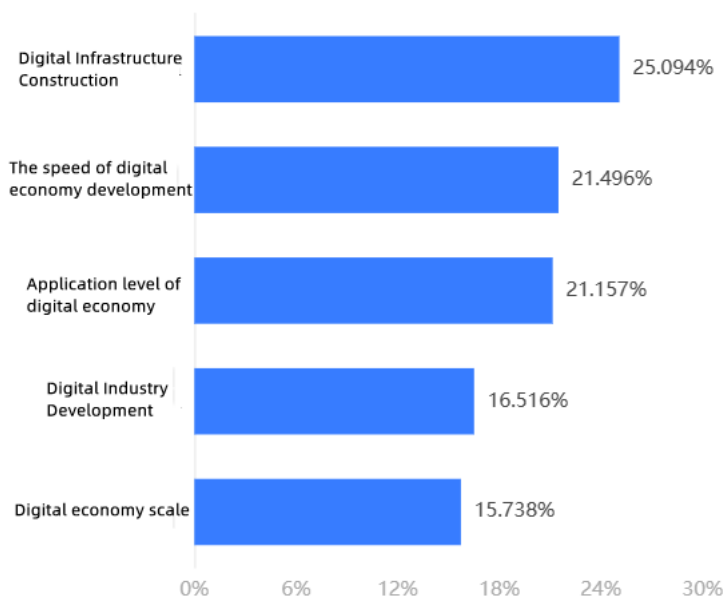


Figure 1:Histogram of comprehensive score of digital economy in Henan Province from 2017 to 2022.

4.2. The measurement results of high-quality development of manufacturing industry

According to the formula of entropy method, the comprehensive scores of all aspects of high-quality development of manufacturing industry are calculated. (See Table 4)

Table 4: Indicators and comprehensive index scores of high-quality development of manufacturing industry in Henan Province from 2017 to 2022.

YEAR	GF
2017	0.0001
2018	0.2366
2019	0.3630
2020	0.4528
2021	0.7265
2022	0.9999

From Table 4, it can be seen that the comprehensive score of high-quality development of manufacturing industry in Henan Province in 2017-2022 is steadily rising, from 0.00007 in 2017 to 0.9999 in 2022, with a significant increase. It can be seen that the efficiency growth rate of high-quality development of manufacturing industry in Henan Province has accelerated significantly during this period.

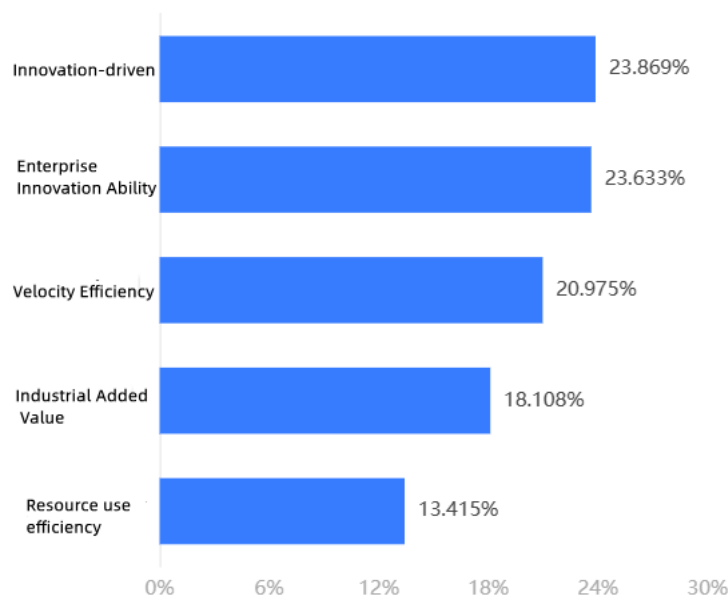


Figure 2 : Comprehensive score histogram of each index of high-quality development of manufacturing industry in Henan Province.

According to the weight of each index calculated by entropy method, it can be seen that innovation-driven has a more obvious role in promoting the high-quality development of manufacturing industry. Its proportion weight is 23.869 %, and the innovation ability of the second manufacturing enterprise is 23.633 %. The resource utilization efficiency accounted for the smallest proportion, 13.415 %. Therefore, the high-quality development of manufacturing industry in Henan Province should improve the utilization of manufacturing resources, such as water resources and coal resources. Only in this way can we promote the high-quality development of manufacturing industry. (See Figure 2)

5. Research on the optimization path of the high-quality development of the manufacturing industry in Henan Province enabled by the digital economy

5.1. Mediation effect model setting

The path of digital economy as an intermediary variable to drive the high-quality development of manufacturing economy in Henan Province is one of the main contents of this paper. Based on the

research results of scholars, the intermediary effect model is established with the high-quality development and innovation of manufacturing industry as the intermediary variable. The construction of the model is as follows :

$$Y_{it} = \beta_0 + \beta_1 Y_{it-1} + \beta_2 F_{it} + \beta_3 X_{it} + \varepsilon_{it} \tag{1}$$

$$M_{it} = \alpha_0 + \alpha_1 F_{it} + \varepsilon_{it} \tag{2}$$

$$Y_{it} = \eta_0 + \eta_1 F_{it} + \eta_2 M_{it} + \eta_3 X_{it} + \varepsilon_{it} \tag{3}$$

Among them, *i* and *t* are provinces and years respectively ; Y_{it} is the explanatory variable, Y_{it-1} is the lagging data of high-quality economic development level, F_{it} is the explanatory variable, M_{it} is the intermediary variable manufacturing high-quality development innovation, X_{it} and ε_{it} are the control variables and random disturbance items respectively. The β_2 in the equation represents the total effect, the η_1 in the equation represents the direct effect, and the α_1 and η_2 in the equation represent the mediating effect.

5.2. Mediation effect test results and analysis

Through the intermediary effect model test steps, this paper tests the relationship between digital economy, digital economy innovation and high-quality development of manufacturing industry through SPSSPRO. (See Table 5)

Table 5 : Test results of mediating effect model.

Variable	Digital Economy Scale	Digital Economic Innovation	High-quality Manufacturing Development
Digital Economy	0.0158** (4.097)	0.048** 2.82	0.008*** 6.268
Digital Economic Innovation			0.884
R^2	0.309	0.126	0.993
F	1.785	0.574	202.121

*, **, *** represent the significance level of 1 %, 5 % and 10 % respectively.

The above table shows the parameter results of the three types of regression models of mediating effect, including non-standardized coefficient, standardized coefficient, t value, significant P value, fitting R^2 , F test, etc.

- Model 1 : $Y = C1X1 + \dots + CnXn + e1$, that is, the independent variable X and the dependent variable Y are used to construct the regression model.

- Model 2 : $M1 (1 \sim M) = A1X1 + \dots + A1Xn + e2$, that is, the independent variable X and the intermediary variable M are used to construct the regression model (if there are multiple intermediary variables, there are multiple models).

- Model 3 : $Y = C' 1X1 + \dots + C' nXn + B' 1X1 + \dots + B' nXn + e3$, that is, the independent variable X and the intermediary variable M are combined with the dependent variable Y to construct the regression model.

It can be seen from Table 5 that the digital economy not only promotes the high-quality development of the manufacturing industry, but also has a positive impact on the innovation of the digital economy. After adding the mediating variable to Model 3, the coefficient of digital economic innovation is 0.884, showing a certain significance, indicating that the mediating variable digital economic innovation can enable the high-quality development of manufacturing industry in Henan Province.

Table 6: Mediation effect size results.

Item	Digital Industry Development => High-tech Enterprises => Digital Economy Scale
Inspection Conclusion	Partial Mediation
c gross effect	-4.386
a*b Mediating Effect	-2.474
c' Direct Effect	-1.912
Proportion of Effect	76%

It can be seen from Table 6 that the digital economy affects the high-quality development level of manufacturing industry in Henan Province through 76 % of digital technology innovation. Therefore, digital economy innovation plays a part of intermediary role in the high-quality development of manufacturing industry in Henan Province.

6. Conclusion

6.1. The development level of digital economy and manufacturing industry in Henan Province is generally on the rise

The high-quality development score of the manufacturing industry passed from 0.0001 in 2017 to 0.9999 in 2022. This shows that the achievements of high-quality development of digital economy and manufacturing industry in Henan Province in recent years are very significant, and the development trend of the two is getting better and better.

6.2. The digital economy has significantly promoted the high-quality development of manufacturing industry in Henan Province

Through the grey correlation analysis, it can be seen that the digital economy has a very obvious role in promoting the high-quality development of manufacturing industry in Henan Province. The correlation between digital economy and digital infrastructure in the high-quality development of manufacturing industry in Henan Province is the deepest, indicating that digital infrastructure plays an important role in enabling the high-quality development of manufacturing industry in Henan Province.

6.3. Digital economy and digital technology innovation together enable the high-quality development of manufacturing industry in Henan Province

Based on the results of intermediary effect test, it is concluded that the digital economy will promote the high-quality development level of manufacturing industry in Henan Province, and also have a positive impact on digital technology innovation. In the high-quality development of manufacturing industry in Henan Province, digital technology innovation plays a part of intermediary role.

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