

Research on the Influence of Digital Economy Development on Manufacturing Upgrading

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Abstract. Manufacturing is the foundation of real economy. With the acceleration of the construction process of digital power, relying on digital economy to promote the digital transformation and intelligent upgrading of China's manufacturing industry has increasingly become a problem worthy of attention. In view of this, this paper establishes a panel threshold model to study the effect of digital economy development on manufacturing upgrading. The results show that before the development level of digital economy reaches the 'inflection point', the development of digital economy will significantly promote manufacturing upgrading and its impact on manufacturing upgrading has heterogeneity such as regional and digital dimensions. Combined with the research conclusions, this paper puts forward targeted policy recommendations such as changing the development model of digital economy, taking into account regional heterogeneity factors and focusing on the depth of use of digital economy.

Keywords: Development of digital economy; Manufacturing upgrading; Spatial panel model; Heterogeneity analysis.

1. Introduction

Under the impetus of the new round of global scientific and technological revolution, the world economy is gradually developing towards the digital economy. By the end of 2020, China's digital economy has reached 39.2 trillion yuan, accounting for about 38.6 % of GDP, which shows that although China 's digital economy started late, it has obvious advantages in backwardness. In the ' The Fourteenth Five-Year Plan ', it was mentioned and emphasized that digital development should be accelerated and digital China constructed. The deep integration of digital economy and manufacturing industry plays a key role in promoting the upgrading of China ' s industrial structure and promoting the high-quality development of China ' s manufacturing industry. Therefore, in the process of the development and construction of digital power and manufacturing power, exploring the effect of digital economy on the upgrading of manufacturing industry is a problem worthy of general attention and research.

2. Literature Review on the Relationship between Digital Economy and Real Economy

The term "digital economy" was proposed by Don Tapscott (1996) in his original work "The Digital Economy" and developed in the original work "Being Digital" published by Negroponte (1996). Since then, scholars have begun to carry out research related to digital economy. Ma Zhongdong et al. (2020) believed that the digital economy significantly promoted the upgrading of manufacturing quality. Yang Wenpu (2021) pointed out that compared with backward regions, the promotion effect of digital economy on economic growth in developed regions is more obvious. However, some studies have come to different conclusions. Jiang Song et al. (2020) found that the impact of digital economy on the real economy shows an inverted ' U ' type, which has a ' crowding-out effect ' on the real economy. With the rapid development of the digital economy, its measurement methods have also attracted the attention of scholars. Due to the different definitions of the concept of the digital economy, different organizations, government agencies and academic circles also have great differences in the measurement methods of the development level of the digital economy, which

can be divided into two categories, namely, direct accounting method and index system accounting method (Zhang Yanping et al., 2021).

Manufacturing upgrading is a process of industrial upgrading and the gradual evolution of production skills from simple to complex. If we study the upgrading of manufacturing industry from the perspective of digital economy, the most important thing is to clarify the connotation of digital economy. Most scholars believe that digital economy is a new economic form which takes digital knowledge and resources as the key production factors and carries out a series of economic activities based on information technology such as the Internet (Tapscott, 1996; Xu Xianchun and Zhang Meihui, 2020). By integrating into the production, trading and circulation of products, the effect of digital economy on economic development is extensive. On the one hand, digital economy can empower high-quality development (Zhao Tao et al., 2020), enhance the level of enterprise risk-taking (Chen Xiaohui and Zhang Hongwei, 2021), solve the development dilemma of regional enterprise global value chain 'low-end locking' (Sun Li and Xu Weicong, 2021), and effectively improve production efficiency through the application of digital technology and digital input (Wang Kaike et al., 2020). On the other hand, the digital economy could also bring 'digital divide' to the traditional economy (Xu Heng et al., 2020), exacerbate economic inequality (Saniee et al., 2017) and have a negative 'crowding-out effect' on the industrial real economy (Jiang Song and Sun Yuxin, 2020). As a necessary information and communication technology for the development of digital economy, Internet development and digital transformation also have a positive role in promoting the productivity of China's manufacturing industry (Huang Qunhui et al., 2019) and total factor productivity of enterprises (Zhao Chenyu et al., 2021).

In summary, the influence of existing literature on the development of digital economy and the influencing factors of manufacturing upgrading have been extensively studied, and some progress has been made in the current research. However, few literature discusses the driving effect of digital economy on manufacturing upgrading. In view of this, the possible marginal contributions of this paper are as follows: From the research perspective, unlike the existing literature that only discusses the two aspects of digital economy or manufacturing upgrading, this paper combines these two aspects to analyze the impact of the development level of digital economy on China's manufacturing upgrading.

3. Data Source, Variable Description and Econometric Model Setting

3.1 Data sources

In order to study the influence of the development of digital economy on the upgrading of China's manufacturing industry, the data of this paper are taken from the digital inclusive financial index report of Peking University, EPS data platform - China Macroeconomic Database, and CEInet Statistics Database - provincial annual database. According to research needs, the time interval of sample data is set in 2011 - 2020; since the sample data of Hong Kong, Macao and Taiwan are difficult to obtain, this paper sets the scope of the sample data in 31 provincial administrative regions except Hong Kong, Macao and Taiwan. Related data processing using stata16.0 software, specific indicators can be seen in table1 : definition of variables and descriptive statistics.

3.2 Variable Description

1) Explained variable: manufacturing upgrading. As for the measurement of manufacturing upgrading, there are many different methods in the academic circle, and there is no agreement yet. However, the view that the upgrading of manufacturing industry is from the original low value-added industrial structure to the high value-added industrial structure is generally accepted by scholars. Therefore, this paper uses the product of industrial enterprises above scale to measure the upgrading of manufacturing industry, and in order to facilitate calculation, logarithmic processing is carried out.

2) Explanatory variable: digital economy. Referring to the previous relevant literature, this paper follows the existing research context, and selects the digital inclusive financial index of Peking

University Digital Finance Research Center to measure the development of digital economy. Since 2016, the research team of the Digital Finance Research Center of Peking University and the Research Institute of Ant Group has continuously updated a set of indexes by using the massive data of digital inclusive finance from Ant Group. It is an authoritative indicator to measure the level of digital financial development in China. Therefore, it is reasonable and credible to represent the level of digital economic development.

3) Control variables Considering the research content, this paper selects the following three control variables:

Development level of service industry. The process of manufacturing upgrading includes the structure optimization of traditional industries, scientific and technological innovation, information technology transformation and other needs of the service industry to participate in support. Therefore, to achieve the goal of manufacturing upgrading, it is inseparable from the interaction and promotion of producer services. Therefore, this paper uses the level of service industry development as a control variable and the proportion of tertiary industry added value in GDP in each province to measure.

Scale of foreign investment. In recent years, the structure of foreign investment has gradually tilted to the manufacturing industry. The technology spillover effect brought by foreign investment enterprises is conducive to promoting the technological progress of China ' s manufacturing industry. The introduction of high-quality foreign capital is helpful to promote the upgrading of China ' s manufacturing industry. This paper mainly refers to the practice of existing research, using the proportion of foreign investment enterprises ' total import and export in GDP to measure the scale of foreign investment.

Urbanization level. In the process of urbanization, on the one hand, the aggregation of talents drives the change of demand structure, promotes the structural optimization and upgrading of manufacturing products, and further promotes the upgrading of manufacturing industry; on the other hand, with the improvement of urbanization level, finished infrastructure, developed information network and efficient production efficiency will promote the transformation and upgrading of manufacturing industry. Therefore, this paper draws on the research of Shi Zhengrong to select the level of urbanization as a control variable and use the urbanization rate to measure.

Table 1. Definition of variables and descriptive statistics

variables	symbols of variables	definition of variables	observations	mean	standard deviation	minimum value	maximum value
explained variable	<i>Finished</i>	the product of industrial enterprises above scale	310	25.011	1.259	19.558	27.228
explanatory variable	<i>Index</i>	the digital inclusive financial index	310	216.235	97.030	16.220	431.930
	<i>Service</i>	development level of service industry	310	48.939	9.066	32.600	83.800
control variables	<i>FDI</i>	scale of foreign investment	310	0.112	0.163	0.000	0.9440
	<i>Urban</i>	urbanization level	310	58.050	13.142	22.810	89.600

It can be seen from table 1 that the difference between the maximum and minimum value of the digital inclusive financial index is large, which reflects that although the development of China ' s digital economy is late, the development of China ' s digital economy has gradually accelerated in the past decade, and has entered the fast lane of development and made great achievements. However, the standard deviation value is 97.030, which reflects that there is a big gap in the development of digital economy among different regions, reflecting the imbalance of regional development in the development of digital economy.

3.3 Measurement Model Setting

In order to analyze the impact of the development level of digital economy on manufacturing upgrading, this paper sets the basic econometric model as follows:

$$Finished = a_0 + a_1Index + a_2Service + a_3FDI + a_4Urban + \lambda_i + \varepsilon_{it} \quad (1)$$

where a_0 represents the constant term; a_i ($i=1, 2, 3, 4$) represents the coefficient before the explanatory variable, and a_1 is the coefficient before the explanatory variable, which is the focus of this paper, because it reveals the impact of the development of digital economy on the upgrading of manufacturing industry. Service, Urban and FDI are a series of control variables, which are economic variables that may affect the upgrading of manufacturing industry in addition to the explanatory variable; λ_i is the provincial fixed effect; ε_{it} is a random perturbation term.

4. Effect of Digital Economy Development on Manufacturing Upgrading

4.1 Basic model estimation

By analyzing the standard deviation of explanatory variables in definition of variables and descriptive statistics, it can be seen that there are great differences in the development level of digital economy in 31 administrative regions in the past decade. Therefore, this paper first uses the high-dimensional fixed utility model to carry out the basic regression of variables, that is, under the control of provinces, the explanatory variable is regressed with the explained variable, and the regression results with high fitting degree are obtained, as shown in table 2.

The regression coefficient of the explanatory variable obtained under the control of provinces is ‘0.002’, and it is obvious at the level of 1 %. This shows that there is a positive correlation between the development of digital economy and the upgrading of manufacturing industry, that is, from the perspective of effect size, in the case of other conditions remain unchanged, the level of manufacturing upgrading will increase by about 0.002 units per unit increase in digital economy; the coefficient before the development level of service industry is ‘-0.021’, which is negatively correlated with the explained variable, and shows indigenous at the level of 1 %, indicating that the development of service industry will inhibit the upgrading of manufacturing industry to a certain extent. This may be due to the fact that China 's domestic service industry occupies most of the service industry, so this conclusion is consistent with our economic common sense. The goodness of fit of the model $R^2 = 0.9895$, which shows that the fitting degree of the model is good, and the development of digital economy can effectively promote the continuous upgrading of manufacturing industry.

Table 2. Regression results of digital economy and manufacturing upgrading

	estimated value	t	P	95 % confidence interval
<i>Index</i>	0.002*** (0.000)	7.04	0.000	(0.0014, 0.0026)
<i>Service</i>	-0.021*** (0.003)	-6.34	0.000	(-0.0279, -0.0147)
<i>FDI</i>	-0.018 (0.229)	-0.08	0.938	(-0.4688, 0.4330)
<i>Urban</i>	0.004 (0.006)	0.67	0.502	(-0.0073, 0.0149)
constant term	25,394*** (0.282)	90.02	0.000	(24.8387, 25.9494)
observations	310	310	310	310

Note: * * *, * *, * are expressed at the level of 1 %, 5 %, 10 % respectively; () is the standard deviation.

4.2 Endogeneity test

In addition to the positive impact of the development of the digital economy on the manufacturing industry, the upgrading of the manufacturing industry will also affect the development level of the digital economy to a certain extent. Therefore, Model (1) may produce endogenous problems caused by reverse causality, that is, there are endogenous errors in the model estimation results. In order to solve this problem, this paper will use a simple instrumental variable method, select the lag phase of the digital economy as the tool variable of the digital economy. This is because the development level of the digital economy in the previous year is highly correlated with the development level of the digital economy in that year, but there is no direct connection with the development level of the manufacturing industry in that year. Therefore, the one-period lag of the digital economy can basically meet the requirements as an instrumental variable. The detailed results of endogeneity test are shown in Table 3.

Table 3. Endogeneity test: instrumental variable method

	estimated value	standard deviation	P	95 % confidence interval
<i>Index</i>	0.0036***	0.0009	0.000	(0.0019, 0.0054)
<i>Service</i>	-0.0914***	0.0080	0.000	(-0.1072, -0.0757)
<i>FDI</i>	1.1466**	0.5169	0.027	(0.1334, 2.1598)
<i>Urban</i>	0.0637***	0.0072	0.000	(0.0495, 0.0778)
constant term	24.8564***	0.3811	0.000	(24.1094, 25.6033)

Note: * * *, * *, * are expressed at the level of 1 %, 5 %, 10 % respectively

As can be seen from the regression results of table 3, the regression coefficient of the digital economy is 0.0036, which is still greater than zero, and the p value is less than 0.01. The model (1) passed the endogeneity test by 1 %.

4.3 Panel threshold model estimation

In order to study whether the impact of the digital economy on the upgrading of the manufacturing industry will change dramatically due to the degree of development of the digital economy, this paper will use a single threshold data model for regression on the basis of the above empirical research. The regression results are shown in Table 4.

Table 4. Threshold regression results

	Index ≤ 235.3341	Index > 235.3341
<i>Index</i>	0.0011165*** (6.18)	-0.0011411 (-7.04)
<i>service</i>	-0.203384*** (-10.99)	-0.0027256 (-0.89)
<i>FDI</i>	-2.547747 (-0.65)	-1.127247*** (-3.64)
<i>urban</i>	0.0458523** (-0.50)	0.9167562*** (3.47)
constant term	-0.4998308** (-2.96)	

Note: * * *, * *, * are expressed at the level of 1 %, 5 %, 10 % respectively; () is value of z.

The regression results of table 4 show that in the process of the impact of the digital economy on the upgrading of manufacturing industry, the threshold variable has passed the single threshold test. As can be seen from table 4, 235.3341 is the 'inflection point' for the digital economy to promote manufacturing upgrading, that is, with the continuous development of the digital economy, when the digital economy develops to point 235.3341, its impact on manufacturing upgrading will begin to jump. In the first stage, the digital economy has a positive role in promoting the upgrading of manufacturing industry, while in the second stage it shows a negative role in restraining, which shows

that when the digital economy reaches a certain level, a new development mode is needed, and if the development mode of the digital economy is not changed, it will have a negative effect on the upgrading of manufacturing industry ; the level of service industry development has changed from the first stage to the second stage, indicating that the impact of service industry development on manufacturing upgrading will be weakened when the digital economy develops to a certain level ; the scale of foreign investment has changed from non-obviousness in the first stage to obviousness in the second stage, which shows that with the improvement of digital economy, the impact of foreign investment scale on manufacturing upgrading will become more and more obvious ; the urbanization level has always been significantly positive in promoting manufacturing upgrading.

4.4 Heterogeneity analysis

Region grouping estimation

Table 5. Region grouping estimation results

	eastern region	central region	western region
<i>Index</i>	0.003** (0.001)	0.005*** (0.001)	0.006*** (0.001)
<i>Service</i>	-0.074*** (0.013)	-0.002 (0.015)	-0.185*** (0.022)
<i>FDI</i>	0.100 (0.665)	0.174 (1.899)	6.446*** (1.906)
<i>Urban</i>	0.055*** (0.016)	-0.063*** (0.009)	0.034** (0.010)
constant term	25.056*** (0.555)	27.727*** (0.748)	30.199*** (1.185)
N	120	70	120

Note: * * *, * *, * are expressed at the level of 1 %, 5 %, 10 % respectively; () is value of t.

Based on the differences of regional economic development level and resource endowment, this paper analyzes the heterogeneity of the impact of digital economy on manufacturing upgrading from three different regions in China. The analysis results are shown in Table 5.

The (2) - (4) column of Table 5 shows the regression results of the eastern, central and western regions in turn. From the results, it can be seen that in different regional samples, the estimation results of digital economy on manufacturing upgrading are consistent with the benchmark regression. This shows that on the whole, the promotion effect of digital economy on manufacturing upgrading does not change substantially due to regional differences. However, compared with the eastern region, the impact of the development of digital economy in the central and western regions on the upgrading of manufacturing industry is more obvious. The reason may be that the eastern region has developed economy, relatively perfect infrastructure, high-tech talents and policy support, and the industry has tended to be service-oriented. The dividend of the impact of digital economy on the upgrading of manufacturing industry may have been released in advance. For the central and western regions, under the promotion of national policies such as building ' western digital economy ', the central and western regions are gradually strengthening the construction of information infrastructure and using policy advantages to develop big data industry, so that new technologies and new models such as digital economy have been developed rapidly and vigorously. Therefore, the development of digital economy will have a greater marginal impact on the upgrading of manufacturing industry.

Grouping of different dimensions of digital economy

According to the report of the digital inclusive financial index of Peking University, the current digital inclusive financial index includes three sub-dimensions: digital financial coverage breadth index, digital financial use depth index and inclusive financial digitization degree index. Therefore, this paper will conduct heterogeneity analysis from these three dimensions. Through the Beijing University Digital Inclusive Financial Index report, the data of the three indicators for nearly 10 years

from 2011 to 2020 are obtained, and the three indicators are regressed with the explained variables respectively. The regression results are shown in table 6.

Table 6. Grouped estimation results of different dimensions of digital economy

	coverage breadth	use depth	digitization degree
<i>Coverage</i>	0.002*** (0.000)		
<i>Depth</i>		0.001*** (0.000)	
<i>Digitization</i>			0.001*** (0.000)
<i>Service</i>	-0.019*** (0.003)	-0.017*** (0.003)	-0.019*** (0.003)
<i>FDI</i>	-0.280 (0.239)	-0.421* (0.229)	-0.333* (0.198)
<i>Urban</i>	0.008 (0.007)	0.020*** (0.005)	0.021*** (0.004)
constant term	25.140*** (0.343)	24.487*** (0.235)	24.484*** (0.161)
N	310	310	310

Note: * * *, * *, * are expressed at the level of 1 %, 5 %, 10 % respectively; () is the standard deviation.

It can be seen from Table 6 that the estimation results of the three indicators of digital financial coverage breadth index, digital financial use depth index and inclusive financial digitization degree on manufacturing upgrading are consistent with the benchmark regression. The coefficients before the three indexes are positive and statistically significant. This shows that on the whole, the three sub-dimensions of the digital economy will promote the upgrading of manufacturing industry; however, by comparing the three sub-dimensions of the digital economy, it can be seen that compared with digital financial use depth index and inclusive financial digitization degree, the impact of digital financial coverage breadth on manufacturing upgrading is more obvious. It can be seen that in the past decade, in the process of promoting the upgrading of manufacturing industry, the breadth of digital finance has played a major role in promoting. This may be because China is in the initial stage of digital economic development, which needs to pay more attention to accelerating the popularization of digital economy. For example, in some economically backward areas, people can get the required services through computers, mobile phones and other terminal equipment, the use of these terminal equipment will improve the regional coverage of the digital economy; in addition, the digital economy allows small and medium-sized enterprises and low-income groups to enjoy financial services and lower access barriers, thereby increasing the coverage of social groups in the digital economy.

5. Conclusions and recommendations

This paper studies the impact of digital economy on the upgrading of manufacturing industry by setting a nonlinear model and conducting basic regression, endogeneity test, threshold regression and heterogeneity analysis of the model. The research shows that the development level of digital economy has a significant role in promoting the upgrading of manufacturing industry before reaching the 'inflection point' in the threshold model, and the promotion of digital economy on manufacturing upgrading shows different effects in the eastern, central and western regions and three sub-dimensions. Based on the above research, this paper puts forward the following suggestions:

First, seize the opportunity to change the development model of digital economy. In the digital wave, the continuous development of networking, informatization and intelligence can bring convenient and efficient services to the development of manufacturing industry, improve the quality and efficiency of manufacturing development, and also greatly save the time and transaction costs of

enterprises, thus continuously promoting the transformation and upgrading of manufacturing industry. However, according to the results of the threshold model in this paper, it can be seen that the role of the development of digital economy in promoting the upgrading of manufacturing industry is not always existing and continuous, but will undergo a leap change when the development of digital economy reaches a certain stage, and even will be completely opposite to the original effect. Therefore, China ' s provinces should take into account the innovative development and accurate transformation of the digital economy while accelerating the development of the digital economy. When the digital economy develops to the ' inflection point ' mentioned in this paper, we should change the original digital economy development model and re-plan the new model of digital economy development at the technical and institutional levels, so as to adapt to the development and change of manufacturing industry and lead the healthy and long-term development of digital economy, so as to achieve the purpose of strengthening the driving effect of digital economy on the upgrading of manufacturing industry.

Second, taking into account the factors of regional heterogeneity, promote the development of digital economy in the eastern, central and western regions coordinately. Since the level of China ' s digital economic development is unbalanced among regions, our government should make overall coordination and strategic planning according to the current situation and characteristics of regional digital economic development. For example, since the eastern region as a whole is relatively active in the development of digital economy, on the basis of consolidating and improving the development of digital economy in the eastern region, the government should appropriately promote the elements and resources needed for the development of digital economy to continue to shift to the central and western regions. According to the advantages and disadvantages of digital economic development in different regions, the development plan is formulated to promote the sharing and exchange of digital economic development achievements among the eastern, central and western regions, and the government plays a coordinating role in the overall layout of digital economic development.

Third, from focus on cover breadth of digital economy gradually shift to focus on use depth of digital economy. According to the statistics of the report on the digital inclusive financial index of Peking University, the growth rate of digital financial use depth index in four years from 2016 to 2020 exceeds that of the digital financial coverage breadth index. This shows that with the continuous development of the digital economy, when the coverage of digital inclusive finance reaches a certain extent, the space for further expansion is limited, and the use depth of digital finance has gradually become the main driving force for the development of the digital economy. The future development of the digital economy will mainly rely on the further expansion of the use depth of digital finance. Therefore, we must conform to the development trend of the digital economy, and gradually shift the focus of the development of the digital economy to the depth of the use of the digital economy, so that the development of China ' s digital economy is gradually separated from the era of extensive enclosure, and then to a new stage of deep expansion.

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