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An Empirical Study of Digital Economy Development for Industrial Structure Transformation and Upgrading

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Abstract. To promote industrial structure transformation and upgrading, empirical research on the digital economy's impact uses data from 247 cities in China (2016-2019). Using a fixed effect model, findings show significant promotion of industrial structure transformation across dimensions. Sub-sample and alternative variable analyses confirm these results, with controlled endogeneity. Variable impacts vary: negative coefficient for government scale ($p<0.01$), positive for higher education, openness, urbanization, and infrastructure ($p<0.01$). Conclusion: Digital economy development primarily drives transformation via consumption upgrade and technology spillover effects.

Keywords. digital economy development; industrial structure transformation and upgrading; fixed-effects model; digital economy; industrial structure

1. Introduction

At present, the basic characteristic of China's economic development is that it has shifted from a stage of rapid growth to a stage of high-quality development. In the background of economic development stage of high quality, industrial structure transformation and upgrading is not only the urgent need to adapt to the profound changes in the development environment at home and abroad, and to promote the industry to the middle and high end of the value chain, but also the fundamental guarantee to strengthen the comprehensive national strength and realize the goal of two hundred years of struggle [1]. Only by accelerating the construction of a modern industrial structure system matching the characteristics of the new era of China's economic development can we lay a solid foundation for the construction of an industrial power and provide strong support for the realization of the socialist modernization of a strong country [2].

The upgrading of China's industrial structure is at a critical stage of transformation of development mode and transformation of old and new kinetic energy, and it is urgent to establish a power mechanism supported by scientific and technological innovation and progress. Looking around the world, trade protectionism, isolationism and other trends continue to rise, the competition among big countries and the intensification of strategic

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games, the global governance system is rapidly changing, and the competition around the market, technology, talent and other aspects of the competition is more intense [3]. Digital economy has been expanded from the pure digital technology level to the major economic structural adjustment, development mode change, system evolution and other phases of the complex complexity of the characteristics of the border has been expanded to the enterprise operation, industrial integration, production and life in all aspects, the infinite number of supply and demand, factors of production and the market for docking, for the transformation and upgrading of the industrial structure provides inexhaustible power [4]. Under the existing economic situation, according to the requirements of high-quality development, how to adapt to the development of digital economy, grasp the trend, take the initiative, docking to support the construction of modern industrial structure system, has become the key to accelerate the high-quality development of China's economy, and promote the upgrading of industrial structure.

2. Literature review

Research on the relationship between industrial structure upgrading and the development of digital economy is still relatively scarce, and more attention is currently focused on the impact of information technology on industrial structure. For example, some researchers have analyzed the connection between the digital economy and the financial industry, and believe that the digital economy plays a key role in promoting the upgrading of industrial structure [5]. Information technology accelerates the speed of knowledge production and dissemination, thus promoting the evolution of industrial organization [6]. In addition, studies have shown that information technology improves the management efficiency of enterprises, which in turn promotes the transformation and upgrading of enterprises. Domestic scholars also attach great importance to the potential impact of the digital economy on the upgrading of industrial structure [7].

At the theoretical level, some scholars have analyzed the problems of insufficient technological innovation and industry monopoly faced by China's digital economy in the new development pattern. The digital economy promotes the upgrading of industrial structure by providing technical support, eliminating information asymmetry, promoting innovation and changing the mechanism of demand side, therefore, we need to take relevant measures to promote the upgrading of industry to the middle and high end [8]. In addition, the digital economy can also influence the upgrading of industrial structure by transforming traditional industries and promoting the formation of new industries, and at the same time promote the optimization and integrated development of primary, secondary and tertiary industries [9].

In terms of empirical research, some scholars have specifically explored the role of digital economy on industrial structure upgrading from the perspective of efficiency-based technological progress [10]. They established a mediation effect model to verify the influence of digital economy on industrial structure upgrading through R&D investment intensity, while taking into account the moderating variables such as the proportion of college students and enterprise size [11].

According to the existing literature, scholars have explored the relationship between digital economy and industrial structure from macro, meso and micro perspectives. Compared with the existing studies, the innovations of this paper are as follows: firstly, on the basis of clarifying the theoretical mechanism of digital economy development to promote industrial structure transformation and upgrading, the impact of digital economy

development on industrial structure transformation and upgrading is empirically examined on the basis of city-level data, and the results are more robust and credible, and the conclusions of this study can enrich the theories on the digital economy and the theory on the change of industrial structure to a certain extent. Secondly, the development of digital economy is highly emphasized by the state and local governments, and it is an important task in the "14th Five-Year Plan" period to promote the transformation and upgrading of industrial structure by the development of digital economy. Exploring the issue of promoting the transformation and upgrading of industrial structure through the development of digital economy can, to a certain extent, provide a reference for the promotion of high-quality economic development.

3. The research methodology

3.1. Variables and Models

- Dependent variables. This paper measures the transformation and upgrading of industrial structure from three dimensions: inter-industry structural transformation, intra-industry labor productivity improvement and industrial resource allocation efficiency improvement. The first dimension of industrial structure transformation and upgrading, i.e. inter-industry structural transformation, is measured by the proportion of output value of secondary industry, the proportion of output value of tertiary industry and the coefficient of industrial structure upgrading [12].
- Independent variables. The independent variable of this article is the development level of the digital economy. Judging from the existing literature, scholars usually use two indices when measuring the development level of the digital economy. One is the Digital Financial Inclusion Index and its related indicators from the Digital Finance Research Center of Peking University, and the other is the Tencent Research Digital China Index released by the Academy [14]. It should be noted that the Digital China Index is led by Tencent Research Institute and adopts more than 10 core data collected by big data research institutes such as JD.com, Didi, Ctrip, and Xinmei regarding WeChat, QQ, urban services, and maker spaces. The platform's full sample data, JD.com's e-commerce data, Didi's travel data, etc. are finally calculated through empowerment and standardization. Overall, the index comprehensively and objectively reflects the data output and performance of 135 indicators on the mobile side of almost all major industries from the primary industry, the secondary industry to the tertiary industry [15]. With the development of Internet information technology, mobile data can more truly reflect the development level of various industries, which is why this article uses this data.
- Control variables. What other factors will affect the transformation and upgrading of industrial structure? The scale of the government will affect the regional industrial structure through the investment surge effect and innovation-driven effect; the development of education, especially higher education, will have a direct impact on the transformation and upgrading of the industrial structure; starting from different research perspectives, it was found that opening to the outside world, urbanization, Infrastructure construction will

significantly affect the transformation and upgrading of regional industrial structure. Based on this, this article intends to include government size, higher education development level, opening to the outside world, urbanization and infrastructure construction as control variables into the empirical research model.

Based on the above analysis, this paper sets the model of digital economy development for industrial structure transformation and upgrading as the following equation (1).

$$Y_{i,t,z} = \lambda_0 + \lambda_1 \, economy_{\,i,t} + \lambda_2 X_{i,t} + \delta_{i,t} \tag{1}$$

In equation (1), Y Indicates the transformation and upgrading of the industrial structure.i denotes the sample city.t Indicates the specific year of the sample.z denotes different dimensions of industrial structure transformation and upgrading.z denotes the indicators of the first, second and third dimensions, respectively. λ denotes the parameter to be estimated.$economy$ represents the core explanatory variable, that is, the level of digital economy development;X represents a set of control variables that affect the transformation and upgrading of industrial structure;δ represents the random error term.

3.2. Data source description

The earliest issue of the "Tencent "Internet +" Index, the predecessor of the Digital China Index, was released in 2015. There are significant differences in the selection of statistical indicators between this issue's data and subsequent data. However, the data in 2016 and later remain stable overall, so ,The sample time period studied in this article is from 2016 to 2019, and the data comes from Tencent Research Institute. Except for the digital economy development level indicators, other data are derived from public data such as the "China City Statistical Yearbook" and provincial statistical yearbooks of relevant years. Individual missing values are filled in by interpolation. Due to the adjustment of administrative divisions and the serious lack of data in some cities, this article selected 247 cities at the prefecture level and above whose administrative divisions remained stable and whose data were relatively complete from 2016 to 2019 as research samples. This article uses the GDP deflator for all indicators involving currency denomination.

4. Result analysis

4.1. Analysis of empirical results

This article first uses the mixed estimation model for empirical research. The results show that: the F test rejects the null hypothesis of using the mixed estimation model at the 1% significance level, so this article should not use the mixed estimation model [16]. Subsequently, this paper used the variable intercept model for empirical research, and found that: the P value of the BP-LM test was 0.0000, indicating that the random effects model was better than the mixed estimation model; the P value of the Hausman test was 0.0000, indicating that the fixed effects model was better than Random effects model. Therefore, this article decided to adopt the fixed effects model, and the empirical results are shown in Table 1, Table 2.

Table 1. Regression results of digital economy development promoting inter-industry structural transformation

	Interpreted variable: ratio2		**Interpreted variable: ratio3**		**Interpreted variable: R**	
	RE	FE	RE	FE	RE	FE
economy	0.1912***	0.1466***	0.1339***	0.1001***	0.1529***	0.1727***
	(0.0013)	(0.0059)	(0.0000)	(0.0000)	(0.0039)	(0.0045)
govsize	-0.1012***	-0.0972***	-0.1351***	-0.1906***	-0.1426***	-0.1009***
	(0.0062)	(0.0000)	(0.0049)	(0.0061)	(0.0000)	(0.0025)
highedu	0.1567***	0.1685***	0.1421**	0.1542***	0.1327**	0.1716***
	(0.0000)	(0.0016)	(0.0307)	(0.0000)	(0.0411)	(0.0012)
fdi	0.1038***	0.1564***	0.1128***	0.1701***	0.1228**	0.2302***
	(0.0000)	(0.0043)	(0.0000)	(0.0062)	(0.0259)	(0.0000)
urate	0.0098***	0.1011***	0.1826***	0.1062***	0.2226***	0.1109***
	(0.0019)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0024)
incon	0.2126***	0.2968***	0.1965**	0.1211***	0.1893**	0.1312***
	(0.0008)	(0.0000)	(0.0377)	(0.0000)	(0.0411)	(0.0011)
Constant term	1.0251***	1.2687***	1.3612*	1.011**	1.322***	1.127***
	(0.0000)	(0.0068)	(0.0675)	(0.0468)	(0.0000)	(0.0037)
Region and time fixed effects	yes	yes	yes	yes	yes	yes
Adjusted R^2	0.2217	0.3015	0.2403	0.3119	0.2512	0.3215
F-statistic	30.1229	49.3622	28.8615	50.0218	76.6328	49.3613
F test		19.1215*** [0.0000]		48.1419*** [0.0000]		22.2328*** [0.0000]
BP-LM test	45.5621*** [0.0000]		59.9616*** [0.0000]		70.2128*** [0.0000]	
Hausman test		80.0125*** [0.0000]		69.3612*** [0.0000]		90.0129*** [0.0000]

Note: *, **, and *** represent the significance levels of 10%, 5%, and 1% respectively.

Table 2. Regression results of digital economy development promoting intra-industry labor productivity improvement

	Interpreted variable: pergdp2		**Interpreted variable: pergdp3**		**Interpreted variable:hightech**	
	RE	FE	RE	FE	RE	FE
economy	0.1311***	0.2202***	0.1225***	0.1906***	0.1812***	0.1006***
	(0.0018)	(0.0054)	(0.0000)	(0.0000)	(0.0000)	(0.0029)
govsize	-0.2027***	-0.1086***	-0.1865**	-0.2736**	-0.1925***	-0.1301***
	(0.0000)	(0.0000)	(0.0311)	(0.0346)	(0.0000)	(0.0012)
highedu	0.1329***	0.1906***	0.1846***	0.1168***	0.1638***	0.1502***
	(0.0000)	(0.0012)	(0.0012)	(0.0000)	(0.0000)	(0.0000)
fdi	0.1215***	0.1606***	0.1417***	0.1102***	0.1201**	0.1071***
	(0.0000)	(0.0013)	(0.0000)	(0.0000)	(0.0268)	(0.0000)
urate	0.1012***	0.1625***	0.1357***	0.1201***	0.1116**	0.1909***
	(0.0000)	(0.0000)	(0.0000)	(0.0012)	(0.0312)	(0.0000)
incon	0.2001***	0.2828***	0.1968**	0.2626***	0.2829***	0.1503***
	(0.0026)	(0.0000)	(0.0458)	(0.0000)	(0.0000)	(0.0013)
Constant term	0.9812***	1.002***	1.1168***	1.0109**	1.1125***	1.8621**
	(0.0000)	(0.0019)	(0.0000)	(0.0468)	(0.0000)	(0.0367)
Region and time fixed effects	yes	yes	yes	yes	yes	yes
Adjusted R^2	0.2128	0.3116	0.2657	0.3012	0.2418	0.3112
F-statistic	89.3622	59.2151	75.5218	68.2617	40.0215	78.2625
F test		25.5622*** [0.0000]		89.1653*** [0.0000]		65.5621*** [0.0000]
BP-LM test	78.8513*** [0.0000]		65.5204*** [0.0000]		90.0127*** [0.0000]	
Hausman test		71.5629*** [0.0000]		59.9521*** [0.0000]		100.0217*** [0.0000]

As can be seen from Table 1 and Table 2, the previous hypothesis 1, hypothesis 2 and hypothesis 3 have been verified respectively. In other words, the development of the digital economy has a significant promoting effect on the transformation and upgrading of the industrial structure in the first, second and third dimensions. At the same time, it can also be seen that different control variables have different impacts on the transformation and upgrading of industrial structure. The coefficient of the government scale variable is negative and passes the test at the 1% level; the level of higher education development, opening up to the outside world, urbanization The coefficients of variables such as , infrastructure construction and so on are positive and pass the test at the 1% level.

4.2. Robustness check

Taking into account the huge differences in development between different cities in my country, this article eliminates the samples included in the four first-tier cities of Beijing, Shanghai, Guangzhou and Shenzhen, and once again tests the impact of digital economic development on the transformation and upgrading of industrial structure. The coefficient size, significance level and economic significance of the core explanatory variables have not changed substantially, indicating that the development of the digital economy has a significant impact on the transformation and upgrading of the industrial structure in the first, second and third dimensions, which further This shows that the benchmark regression results studied in this article are robust and credible.

It can be seen from the test results of the above subsamples that the basic conclusions of this article are robust. However, there may be other factors that bias the results. For example, there may be certain deviations in the measurement results of the development level of the digital economy. By reviewing the "China Cities Statistical Yearbook" of relevant years, this article uses the number of mobile phone users in each city at the end of the year as a proxy variable for the development level of the digital economy. Based on the previous analysis ideas, it re-examines the impact of digital economy development on the transformation and upgrading of industrial structure. The basic conclusions of this article remain robust.

5. Conclusion

On the basis of clarifying the internal mechanism by which the development of the digital economy promotes the transformation and upgrading of industrial structure, this paper uses data from 247 cities at prefecture level and above in my country from 2016 to 2019, and uses a fixed effect model to analyze the structural transformation between industries and the improvement of labor productivity within industries. and improving industrial resource allocation efficiency to demonstrate the impact of digital economic development on the transformation and upgrading of industrial structure from three dimensions. Empirical analysis found that the development of the digital economy has a significant role in promoting the transformation and upgrading of the industrial structure in the first, second and third dimensions. The empirical results of sub-sample data and the empirical results using alternative variables support this. 1. Research conclusion; after controlling for endogeneity issues, the research conclusion still holds. The mechanism test found that the development of digital economy mainly promotes the

transformation and upgrading of industrial structure through consumption upgrade effect and technology spillover effect.

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