



Research on the Influence Mechanism of Digital Technology Industry Development on Industrial Structure——Based on Output Perspective

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Abstract. In recent years, the development and application of emerging digital technologies such as big data, artificial intelligence, cloud computing, and blockchain have continuously reshaped my country's industrial structure. From the perspective of digital technology output, the digital economy is used as a proxy variable of the development level of digital technology to study the relationship between digital technology and industrial structure upgrading. The research based on grey relational entropy and dissipation theory found that the digital technology industry has become a continuous source of power for the upgrading of industrial structure. Among them, digital industrialization is the leading condition for the digital economy to play the role of industrial structure upgrading, and industrial digitization is the key support for the digital economy to play the role of upgrading the industrial structure. The impact of the digital economy on industrial advancement lags behind industrial rationalization. Therefore, China should strengthen support for digital-related technology industries, accelerate the integration of digital technology and traditional industries, drive the industrial digitization with digital industrialization, promote the upgrading of the industrial structure, and achieve high-quality economic development.

Keywords: digital technology · digital economy · industrial structure · grey relational entropy-dissipation theory

1 Introduction

The 2022 government work report proposes to “China should promote the development of the digital economy, strengthen the overall layout of the construction of digital China, build digital information infrastructure, promote the large-scale application of 5G and promote the digital transformation of industries. China also should accelerate the development of the industrial Internet, cultivate and expand integrated circuits, artificial intelligence, etc. Key software and hardware technology innovation and supply capabilities should be improved”. The report raised the digital technology development to the national strategic level. The digital technology has the characteristics of configuration based on the Internet platform, as well as the advantages of large-scale data utilization, diversified demand satisfaction, and efficient matching between supply and

demand. It plays an important role in enhancing traditional kinetic energy, cultivating new kinetic energy, and promoting high-quality economic development. At the same time, the upgrading of the industrial structure is the internal driving force for the high-quality development of China's economy, and the technological revolution is the decisive factor for the upgrading of the industrial structure. The development of the digital economy is accompanied by the rapid development of digital technology, which will inevitably affect the upgrading of China's industrial structure. But how does the development of digital technology affect my country's industrial structure? This paper takes the digital technology and industrial structure as the main research objects, studies the impact mechanism of the digital economy on the industrial structure, and provides development ideas for the development of China's digital economy and the upgrading of the industrial structure.

2 Research Summary

Most of the existing research on digital technology and industrial structure starts from the single perspective of "digital industrialization". For example, C. Q. Tao and X. Zhou [1] found that regional industrial coupling shows spatial correlation and consistency with regional economic development for the upgrading of industrial structure. H. W. Cha and P. F. Zuo [2] found that informatization has a significant positive spatial impact on the upgrading of industrial structure. Heo and Lee [3] pointed out that the information and communication industry promotes the upgrading of the industrial structure through the linkage effect. M. C. Guo [4] believes that a certain degree of orderly synergy has been formed between China's ICT industry and industrial structure.

In recent years, there have also been studies on the relationship between the digital economy and industrial structure from the perspective of the digital technology industries and their spillovers. For example, X. H. Chen, H. W. Zhang and Y. C. Wu [5] found that the digital technology development has a marginal increasing effect on China's industrial structure level. X. D. Chen and X. X. Yang [6] believes that digital industrialization is the basic and leading condition to promote the upgrading of industrial structure, but the effect of industrial digitalization in promoting the upgrading of industrial structure is more significant. S. L. Feng and D. H. Xu [7] found that digital industrialization can promote the digital transformation of traditional industries and upgrade the industrial structure.

The existing research on the relationship between the digital technology and industrial structure is mainly based on qualitative analysis, and the quantitative empirical research is relatively coarse. And the existing research results fail to reflect the process of industrial structure upgrading. Based on the entropy weight method, grey relational entropy, dissipation theory and other theoretical methods, this paper analyzes the impact mechanism and role of the digital technology from the perspective of industrial structure upgrading, and provides a reference and basis for the government's macro-control policies in the context of the digital economy.

3 Indicator Selection

- (1) Digital economy (DE): According to the “Statistical Classification of Digital Economy and Its Core Industries (2021)” published by the National Bureau of Statistics, the digital economy includes two parts: digital industrialization (DI) and industrial digitalization (ID). Digital industrialization refers to the information and communication industry, including electronic information manufacturing, telecommunications, software and information technology services, and the Internet industry. Industrial digitalization refers to the increase in output and efficiency brought about by the application of digital technology in traditional industries. Computing, artificial intelligence, robotics, Internet of Things, sensors and other technologies and their applications belong to the digital economy. The digital economy can be regarded as a series of value added caused by the transformation of digital technology. Therefore, from the perspective of output, this paper selects the added value of digital industrialization and the added value of industrial digitalization to measure the development level of the digital technology. Referring to the practice of X D Chen, the turning point of e-commerce in 2002 is selected as the starting point of the data cycle. In terms of data sources, the data from 2015 to 2020 came from the digital economy-related reports issued by the China Academy of Information and Communications Technology, and the previous years were compiled from the China Statistical Yearbook, the Ministry of Industry and Information Technology and related documents (Table 1).
- (2) Industrial structure (IS): Referring to the practice of Qian Chunhui et al., the industrial structure is measured from the two dimensions: industrial advancement (IA) and industrial rationalization (IR). Industrial rationalization represents the quality of inter-industry aggregation, and is a measure of the coupling degree between the factor input structure and the output structure. This paper uses the inverse of Theil

Table 1. DIGITAL ECONOMY DEVELOPMENT SUB-ITEMS AND TOTAL SCALE (UNIT: TRILLION YUAN)

Year	DI	ID	DE	Year	DI	ID	DE
2002	0.60	0.60	1.20	2011	3.00	6.50	9.50
2003	0.67	0.83	1.50	2012	3.39	7.91	11.30
2004	1.13	0.87	2.00	2013	3.82	9.68	13.50
2005	1.30	1.30	2.60	2014	4.20	12.00	16.20
2006	1.67	1.43	3.10	2015	4.80	13.80	18.60
2007	1.46	2.44	3.90	2016	5.20	17.40	22.60
2008	2.00	2.80	4.80	2017	6.20	21.00	27.20
2009	2.02	4.18	6.20	2018	6.40	24.90	31.30
2010	2.30	5.40	7.70	2019	7.10	28.80	35.90
				2020	7.50	31.70	39.20

Table 2. SUB-ITEMS AND AGGREGATE INDICATORS OF INDUSTRIAL STRUCTURE

Year	IA	IR	IS	Year	IA	IR	IS
2002	2.424	1.864	2.099	2011	2.398	3.368	2.962
2003	2.359	1.674	1.961	2012	2.4	3.969	3.311
2004	2.335	2.416	2.382	2013	2.43	4.128	3.416
2005	2.39	2.382	2.385	2014	2.454	4.821	3.829
2006	2.416	2.489	2.459	2015	2.514	5.295	4.13
2007	2.446	2.391	2.414	2016	2.56	5.192	4.089
2008	2.409	3.046	2.779	2017	2.565	5.813	4.452
2009	2.397	2.868	2.671	2018	2.574	5.846	4.475
2010	2.354	2.765	2.593	2019	2.595	6.099	4.63
				2020	2.359	12.649	8.336

index to measure the rationalization level of the industrial structure. Among them, t represents the year, $Y_{t,j}$ is the ratio of the added value of the j th industry to GDP, and $L_{t,j}$ is the ratio of the employment of the j th industry to the total employment. The larger the ir_t , the more reasonable the industrial structure.

$$ir_t = \frac{1}{TL_t} = \frac{1}{\sum_{j=1}^3 (Y_{t,j}) \ln(Y_{t,j}/L_{t,j})} \quad (1)$$

Industrial advancement represents the upgrading of the industrial structure and is a measure of the degree of development of the industry along the primary, secondary, and tertiary industries. Referring to the practice of Xu Min et al. (2015), the following index is used for measurement.

$$is_t = \sum_{j=1}^3 Y_{t,j} * j \quad (2)$$

In order to fit the above two indices scientifically and objectively, the entropy weight method is used to determine the weights of industrial rationalization and industrial advancement. The weighting result is that the industrial rationalization weight is 0.5809, and the industrial advancement weight is 0.4191. On this basis, the industrial structure indicators yearly are obtained (Table 2).

4 Experimental Inspection

4.1 Inspection Steps

Firstly, data standardization. In order to eliminate the influence of data dimension, the mean value method is used to standardize the data of digital industrialization, industrial digitization and industrial structure.

$$X'_{it} = X_{it} / \overline{X_{it}} \quad (3)$$

Secondly, calculate grey relational entropy $S(t)$ and relational entropy change $\Delta S(t)$.

$$r_{it} = \frac{\min_i \min_t |X'_0(t) - X'_i(t)| + \rho \max_i \max_t |X'_0(t) - X'_i(t)|}{|X'_0(t) - X'_i(t)| + \rho \max_i \max_t |X'_0(t) - X'_i(t)|} \quad (4)$$

$$P_{it} = r_{it} / \sum_{i=1}^n r_{it} \quad (5)$$

$$S(t) = - \sum_{i=1}^m P_{it} \ln(P_{it}) \quad (6)$$

$$\Delta S(t) = S(t) - S(t-1) \quad (7)$$

Thirdly, dismantling analysis of influencing factors. Analyze the reasons for changes in industrial structure through $|P_{it} * \ln P_{it}|$ calculation.

Fourthly, the impact structure analysis. Referring to the above methods, calculate the relationship between industrial advancement, industrial rationalization and digital industrialization, industrial digitalization, and further clarify the optimization path of industrial structure.

4.2 Analysis of Results

According to the results in Table 3, the impact of the digital economy on the industrial structure can be divided into three stages: The first stage is before 2012. Under the background of the informatization strategy, the field of information technology has not yet achieved breakthrough progress, the integration of information technology and industry is not effective, and the digital economy has not yet become an important factor affecting the industrial structure. The second stage is from 2012 to 2014. With the continuous development of information technology and the deepening of industrial integration, digital industrialization has gradually become the driving factor of the industrial structure. The third stage is from 2014 to 2019. With the continuous advancement of the digital empowerment process, digital has become an important force in promoting the upgrading of the industrial structure, and the effect of industrial digitalization in promoting the upgrading of the industrial structure is more significant.

By repeating the calculation process related to the industrial structure, the following relationships between industrial advancement, industrial rationalization and digital

Table 3. ENTROPY CHANGE AND DISMANTLING OF INDUSTRIAL STRUCTURE GREY CORRELATION

Year	Entropy Change	$\Delta IP \cdot \ln PI$		Year	Entropy Change	$\Delta IP \cdot \ln PI$	
		DI	ID			di	ID
2002				2011	0.009	0.009	0.000
2003	0.010	0.005	0.005	2012	0.002	-0.002	0.004
2004	-0.008	0.001	-0.009	2013	0.007	-0.013	0.020
2005	0.007	0.004	0.003	2014	-0.002	0.001	-0.003
2006	0.008	0.009	-0.001	2015	-0.023	-0.010	-0.012
2007	0.004	-0.005	0.009	2016	-0.050	-0.013	-0.037
2008	0.000	0.005	-0.006	2017	-0.032	-0.015	-0.017
2009	0.018	0.004	0.014	2018	-0.022	-0.004	-0.019
2010	0.028	0.013	0.015	2019	-0.022	-0.010	-0.012
				2020	0.076	0.040	0.036

Table 4. DIGITAL INDUSTRIALIZATION AND INDUSTRIAL DIGITALIZATION $\Delta IP \cdot \ln PI$ VALUE UNDER THE SPLIT OF INDUSTRIAL STRUCTURE

Year	$DI \Delta P \cdot \ln P$		$ID \Delta P \cdot \ln P$	
	IA	IR	IA	IR
2003	0.002	0.007	0.002	0.007
2004	0.008	-0.005	0.001	-0.016
2005	0.002	0.007	0.001	0.004
2006	0.006	0.010	0.000	-0.001
2007	-0.005	-0.005	0.005	0.011
2008	0.011	0.000	0.003	-0.011
2009	0.001	0.006	0.008	0.017
2010	0.008	0.013	0.009	0.018
2011	0.017	-0.009	0.007	-0.005
2012	0.009	0.005	0.012	-0.001
2013	-0.012	-0.013	0.016	0.020
2014	-0.009	0.008	-0.013	0.004
2015	-0.012	-0.009	-0.013	-0.010
2016	-0.007	-0.016	-0.023	-0.042

(continued)

Table 4. (continued)

Year	DI Δ P·lnP		ID Δ P·lnP	
	IA	IR	IA	IR
2017	-0.017	-0.013	-0.018	-0.015
2018	-0.003	-0.004	-0.015	-0.020
2019	-0.009	-0.010	-0.012	-0.012
2020	-0.008	-0.013	-0.010	0.091

economy are obtained. We found that the impact of the digital economy on industrial advancement lags behind industrial rationalization. The main reason is that the advancement of industrial structure is mainly affected by industrial digitization. Industrial digitization is a long-term process of decoupling traditional industrial models, reshaping new industrial forms, and adding value under the background of digital integration. In comparison, the development of the information technology industry and the integration of information technology under the background of the digital economy are accompanied by large-scale personnel flows between industries, making the digital economy rapidly become an important factor in the rationalization of the industrial structure.

Comparing the relationship between the industrial structure and the digital economy in 2020, in the context of uncertainty, the digital economy can still promote the advanced level of the industry, but the rationalization of the industry may return to a state of shock adjustment. Among them, the digital industrialization can still promote the rationalization of the industrial structure and optimize the matching relationship between factor input and output (Table 4).

5 Conclusion

This paper first obtains the quantitative indicators of industrial structure based on the entropy weight method, then from the perspective of direct and indirect output of digital technology, uses the grey relational entropy model to analyze the relationship between industrial advancement, industrial rationalization and digital industrialization, industrial digitization, and draws the following conclusions: Firstly, the digital technology industry has become a continuous source of power for the upgrading of the industrial structure. Secondly, digital industrialization is a prerequisite for the digital economy to play its role in upgrading its industrial structure, and industrial digitization is the key for the digital economy to play its role in upgrading its industrial structure.

Thirdly, the impact of the digital technology industry on industrial advancement lags behind industrial rationalization. Based on the above research conclusions, in the future, we should continue to vigorously promote the development of the digital economy, support the development of digital industries such as big data, artificial intelligence, cloud computing, and blockchain, strengthen the integration of digital technology and traditional industries, promote the process of industrial digitization, optimize the industrial

structure with digital industrialization and industrial digitization as the starting point, and promote the rationalization and advancedization of industries.

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