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Research on the Role of Digital Economy in Industrial Structure Optimization

–Evidence from China's Provincial Panel

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Abstract: The development of digital economy not only promotes economic growth, but also promotes the optimization and development of industrial structure. Using the panel data of 31 provinces provided by China Statistical Yearbook, this paper constructs two indicators of digital economy and industrial structure optimization, and uses two-way fixed effect model to study the impact effect, heterogeneity analysis and mechanism analysis of digital economy on industrial structure optimization. The research shows that the development of digital economy has significantly optimized the industrial structure; In different regions of China, the role of digital economy in the optimization of industrial structure is different. The improvement of innovation level and social division of labor will significantly promote the optimization effect of digital economy on industrial structure. The results of this study show that it is necessary to further promote the integration of digital economy and the traditional three industries, and give full play to the enabling role of digital economy with higher quality. We should pay attention to the different impacts of digital economy on industrial structure optimization in different regions and take measures according to local conditions. It is necessary to refine the social division of labor in the region and strengthen the regional innovation ability, so as to give full play to the optimization efficiency of digital economy on industrial structure.

Keywords: digital economy, optimization of industrial structure, social division of labor, ability to innovate

1. Introduction

The Communist Party of China's 19th National Congress, in its report, proposed the idea of building a "digital China". This idea was further elaborated upon in the 14th Five-Year Plan for the Development of Digital Economy, issued by the State Council in 2021, and the Internet technology's

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infiltration of numerous industries has ushered in the digital economy era. In 2021 the China Academy of Information and Communication Technology released a White Paper on the Digital Economy Development of China, which made it clear that the foundation of digital economy growth is the unification of digital industrialization and industrial digitalization. This has not only propelled digital economy to a national strategy, but also drawn the attention of academia. which is widely accepted by the academia [1]; From the perspective of digital finance [2], believed that digital finance made China's economy more inclusive and conducive to sustainable economic development.

Exploring the existing literature, academia mainly examines the influence of digital economy on industrial structure from three angles: Primarily, the emergence of digital economy can empower traditional industries and foster digital transformation and improvement of these industries. Cao [3] held the conviction that the digital economy is the essential factor to revolutionize and create a new way of economic expansion, which is evidently a major factor in the alteration and enhancement of traditional industries, furnishing fresh stimulants for economic growth and enhancing the excellence of progress. Liu, Chen [4] believed that digital economy penetrates traditional industries through information technology, optimizes the coordination degree between traditional production departments, and then improves production efficiency. The digital economy, as Li et al [5], noted, has the effect of stimulating digital industrialization and then transforming and optimizing the industrial structure. This, in turn, has led to a growing proportion of tertiary industry, thus enhancing servitization and rationalizing the industrial structure. The development of digital economy, through the enrichment of human capital, technological innovation, and other elements, encourages the convergence and integration of various innovation subjects into clusters, thereby enhancing the efficiency of resource allocation and advancing industrial structure [6]. Digital technology's utilization was believed to augment the productivity of allocating factor resources, make market data more attainable, and, ultimately, make it easier to share factors and market information between industrial sectors, thereby promoting the collaboration of progress between them.

In conclusion, academia has recently been captivated by the study of digital economy's capacity to optimize industrial structure, and a system and logical level have been established for pertinent research. Unfortunately, there are still few articles that examine the connection between digital economy and industrial structure optimization separately, and there are deficiencies such as inadequate outlooks and inadequate comprehensive indicators. The primary aim of this paper is to construct two key indicators of digital economy and industrial structure optimization from various angles, as well as to analyze the impact of digital economy growth on industrial structure optimization and enhancement by combining theoretical and empirical research. Proposing that innovation and the social division of labor will have a beneficial effect on the optimization of digital economy's effect on industrial structure, this is the basis.

2. Theoretical and Model Analysis

2.1 Basic Assumptions of the Model

The connotation of digital economy can be divided into three parts, namely, the infrastructure of digital economy, the degree of digital industrialization and the degree of universal benefits of digital economy. Digital economic infrastructure can further improve the spatial accessibility of production factors, products and services, and promote the collaborative development among industries through the "platforming" characteristics of infrastructure. The improvement of digital industrialization is conducive to the further optimization and upgrading of China's industrial structure. The degree of inclusivity of digital economy refers to the spillover impact of digital economy on other industries, which is industrial digitalization at the industrial level.

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Based on the background of digital economy, enterprises should first collect the information they need from the massive data, and then go through data matching and summary to form the "knowledge base" they need. After that, enterprises use their knowledge reserve in the "knowledge base" in production practice, constantly improve the "knowledge base," and finally extract the "knowledge base" in line with their own characteristics. If an enterprise simply enjoys the convenience of data collection brought by the digital economy, but ignores the improvement of its own knowledge application level, it can hardly be called a real "innovative enterprise". Therefore, the more innovative the enterprise is, the more calmly it can cope with digital transformation; In a region with stronger innovation capacity, the optimization effect of digital economy on industrial structure is more obvious.

With the deepening of the social division of labor, the more refined division of labor mode further "stimulates" the effect of digital economy to optimize the industrial structure from the two levels of business model and circulation link. The more mature the business model is and the more refined the social division of labor is, the more significant the role of digital economy in the optimization of regional industrial structure is.

Based on the above analysis, the following hypotheses are proposed:

Hypothesis 1: The development of digital economy has significantly optimized the industrial structure.

Hypothesis 2: The improvement of innovation level will significantly promote the optimization effect of digital economy on industrial structure.

Hypothesis 3: The improvement of the level of social division of labor will significantly promote the optimization effect of digital economy on industrial structure.

2.2 Model Data Source and Variable Description

2.2.1 Samples and Data

In this paper, the balanced panel data of each province from 2013 to 2021 are select-ed. The output value of the three major industries and the indicators required for the measurement of macro social and economic indicators and digital economy are all from the China Statistical Yearbook and the statistical yearbooks of each province. As there are many missing indicators in Hong Kong, Macao and Taiwan, they are not included in the scope of investigation. In order to ensure the accuracy of the re-search, this paper conducts the following processing: deflate all the variables measured in the form of money, and take the 2009 CPI as the benchmark to carry out the deinflation process; The explained variables, explanatory variables and con-trol variables are winnosed by 1%, and 279 observed values of 9-year balanced panel data of 31 provinces, autonomous regions and municipalities in China are finally obtained.

2.2.2 Measurement Model

A measurement model is constructed in this paper to investigate the influence of digital economy on the optimization of industrial structure.

$$Y_{it} = \beta_0 + \beta_1 DE_{it} + \delta X_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (1)$$

Where subscripts i and t represent province and year respectively; γ_t represents year fixed effects; ε_{it} represents the random error term; DE_{it} represents the digital economic indicator, and Y_{it} represents the degree of industrial structure optimization; X_{it} is a set of control variables.

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2.2.3 Variable Description

Core explanatory variables.

This paper's primary explanatory factor is the advancement of digital economy. At present, the measurement indicators of digital economy are not unified, and scholars define the development of digital economy from different dimensions .By utilizing the entropy method, this paper synthesizes the data and pertinent literature to create an indicator system of digital economy development level from 11 indicators in three dimensions: digital infrastructure construction, digital industry development, and digital economy inclusive degree.Entropy weight calculation is employed to ascertain the weight of each indicator, thus permitting the assessment of digital economy growth in all provinces and cities. The second-level indicators of digital economic infrastructure are: the length of long-distance optical cable per square kilometer, domain names per thousand people, Internet broadband access users (ten thousand households), Internet broadband access ports (ten thousand) and mobile phone base stations (ten thousand).The total amount of telecom services (100 million yuan) and the capacity of mobile phone switches (ten thousand households) are the secondary indicators of digital industrialization development.The secondary indicators of digital inclusiveness are express delivery volume (10,000 pieces), e-commerce sales volume (100 million yuan), and the proportion of enterprises with e-commerce transactions in the total number of enterprises (%).

Standardization of indicators：

$$X'_{\theta ij} = \frac{X_{\theta ij} - min\{X_{\theta 1j},\ldots,X_{\theta nj}\}}{max\{X_{\theta 1j},\ldots,X_{\theta nj}\} - min\{X_{\theta 1j},\ldots,X_{\theta nj}\}} \quad (2)$$

Where $X'_{\theta ij}$ is the JTH indicator of the ith province in the θ year, i=1,2, ... ,31, j=1,2... ,11, θ=1,... ,9.

Determine the index entropy value：

$$H_j = -\frac{1}{ln(dn)} \sum_{\theta=1}^{d} \sum_{i=1}^{n} [Y_{\theta ij} ln(Y_{\theta ij})] \quad (3)$$

Among them, $Y_{\theta ij} = \frac{X'_{\theta ij}}{\sum_{\theta=1}^{d} \sum_{i=1}^{n} X'_{\theta ij}}$, d said the year span.

Determine the utility value of index information:

$$G_j = 1 - H_j \quad (4)$$

Determine the weight of indicators:

$$W_j = \frac{G_j}{\sum_{j=1}^{m} G_j} \quad (5)$$

Where m is the number of indicators.

Determination of comprehensive score:

$$DE_{\theta i} = \sum_{j=1}^{m} (W_j X'_{\theta ij}) \quad (6)$$

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2.2.4 Explained Variable

This paper begins by constructing two secondary indicators, the industrial structure rationalization index TL, to gain a comprehensive comprehension of industrial structure optimization. Subsquently, the entropy weight method is employed to assign weights to ascertain the level of optimization.

Among them, TL and R indicators are based on Gan et al [7].

2.2.5 Control Variables

This paper introduces a set of indicators that can influence the upgrading of industrial structure as control variables, to prevent any missing variables. These indicators are used to control other factors, apart from the development of digital economy, that may influence the upgrading of industrial structure. In Table 1 are the descriptive statistical outcomes of the primary explanatory factors, the elucidated factors, and the control factors.

Table 1: Descriptive statistics.

Variable name	Sample number	Mean standard	Deviation	Minimum	Maximum
DE	279	0.134	0.010	0.018	0.640
Y	279	0.136	0.131	0.011	0.902
Pgdp	279	10.310	0.388	9.593	11.262
FDI	279	1.775	2.973	0.022	18.556
Edu	279	0.023	0.006	0.009	0.042
Olddep	279	0.155	0.042	0.070	0.267
Urban	279	0.290	0.144	0.044	0.835
Policy	279	0.133	0.352	0.050	0.226

3. Empirical Results

3.1 Benchmark Regression Results

This paper's Hausman test demonstrates that fixed effects are superior to random effects. Table 2 reveals the fixed effect regression results, which show the digital economy's level has a noteworthy positive correlation with the optimization of industrial structure, thus confirming Hypothesis 1-both before and after the incorporation of control variables.

Government interference among the control variables detrimentally impacts the optimization of industrial structure. The reason may be that although the government can regulate the market, it misjudges the market price trend or violates the market rules by receiving instructions from the higher government. The optimization of industrial structure is not always achieved through the advancement of economic aggregate and urbanization, as demonstrated by the inverse correlation between economic growth and urbanization in each area. Moreover, the dearth of education among our nation's populace renders the amalgamation of industry, university, and research inadequate to effect this optimization. The attraction of foreign investment does not necessarily result in the optimization of regional industrial structure, as evidenced by the significant and negative foreign investment levels. Furthermore, the population structure is also negative and significant, implying that the decrease of the working-age population does not contribute to the optimization of the industrial structure.

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Table 2: Benchmark regression results.

	No control variables are added	Add control variables
Variables	Y	Y
DE	0.346*** (0.071)	0.637*** (0.107)
Policy		-0.048 (0.229)
Pgdp		-0.112*** (0.031)
Olddep		-0.531*** (0.193)
\Urban		-0.262* (0.149)
FDI		-0.019*** (0.006)
Edu		-0.597 (2.098)
constant term	0.072*** (0.008)	1.384*** (0.323)
observed value	279	279
R2	0.490	0.544
Controlling for time effects	YES	YES
Controlling for province effect	YES	YES

Note: The figures in parentheses are standard errors, and ***, ** and * indicate significance at the levels of 1%, 5% and 10%, respectively. () The inside value is the standard error.

3.2 Robustness Test

This paper utilizes two methods to evaluate the dependability of the regression results: substituting digital economic indicators and utilizing the sample subinterval technique.

The two methods yielded relatively strong regression outcomes.

Table 3: Robustness test: replacing digital economic indicators.

Variables	Replacement index	Subinterval of sample
DE		0.253* (0.130)
DE_1	0.044** (0.019)	
Policy	-0.044 (0.243)	0.112 (0.252)
Pgdp	-0.095*** (0.033)	-0.074** (0.033)
Olddep	-0.315 (0.207)	-0.267 (0.228)
Urban	-0.259 (0.158)	-0.493*** (0.156)
FDI	-0.003 (0.006)	-0.008 (0.007)
Edu	-0.856 (2.226)	1.773 (2.650)
constant term	1.190*** (0.353)	0.958*** (0.351)
observed value	279	217
R2	0.487	0.421
Year FE	YES	YES
Province FE	YES	YES

3.3 Dealing with Endogenous Problems

The instrumental variable method is employed in this paper to address the endogeneity issue and ensure the accuracy of the empirical regression, despite the potential causal link between digital economy and industrial structure optimization. Nevertheless, there are numerous elements that affect the optimization of industrial structure, and the issue of missing variables may arise.

We selected the amount of post offices in each region in 1985 as an instrumental variable, based on pertinent studies [8], to gauge the advancement of traditional communication technology in a

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region.This paper constructs the panel instrumental variable by introducing variables that alter over time, thereby allowing for the cross-sectional data of the number of post offices in each region in 1985 to be compared with the panel data of the paper, utilizing Nunn and Qian's processing method [9] .The instrumental variable of digital economic indicators for the research problem in this paper is the number of post offices in each region in 1985 and the interaction term is constructed by utilizing the digital economic indicators for each year.

Table 4 displays the regression results, and Wald F and LM statistics demonstrate that the instrumental variable is not vulnerable to weak instrumental variable, over-identification, or under-identification.

Table 4: Endogeneity problem: Instrumental variable regression.

Variables	Y
DE	1.064*** (0.141)
Policy	-0.044 (0.229)
Pgdp	-0.139*** (0.031)
Olddep	-0.791*** (0.201)
Urban	-0.287* (0.149)
FDI	-0.035*** (0.007)
Edu	-0.346 (2.102)
Cragg-Donald Wald F	320.127 {16.38}
Anderson canon. corr. LM	143.532 [0.00]
R2	0.513
Controlling for time effects	YES
Controlling for province effect	YES

Note: () The inside value is the standard error, [] the inside value is the p-value, and {} the inside value is the critical value of Stock-Yogo weak identification test at the level of 10%.

4. Mechanism Test and Heterogeneity Analysis

4.1 Mechanism Testing

Through the above analysis, this paper has confirmed that the development of digital economy can significantly optimize the regional industrial structure, and has passed the robustness test and endogeneity treatment. Based on this, this part mainly verifies whether regional innovation capacity and social division of labor can positively stimulate the optimization effect of digital economy on industrial structure, that is, to verify Hypothesis 2 and Hypothesis 3.

In order to verify Hypotheses 2 and 3, the model is set as follows:

$$Y_{it} = \beta_0 + \beta_1 DE_{it} + \beta_2 Pa_{it} + \beta_3 DE_{it} \times Pa_{it} + \delta X_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (7)$$

$$Y_{it} = \beta_0 + \beta_1 DE_{it} + \beta_2 Consu_{it} + \beta_3 DE_{it} \times Consu_{it} + + \delta X_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (8)$$

The logarithm of R&D expenditure of industrial enterprises of a certain size is used to gauge regional innovation capability, denoted by Pait. Consuit is a measure of the social division of labor, This paper adopts the method of Yi et al [10]. As a proxy indicator, the proportion of total retail sales of consumer goods in GDP is taken into consideration. In Table 5, Inter-Pa and Inter-Co represent the cross terms of the moderating effect, respectively.

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Table 5 reveals that the more advanced the regional innovation potential, the more refined the labor division, and the more influential digital economy development is in the optimization of industrial structure. Therefore, Hypotheses 2 and 3 of this paper are verified.

Table 5: Mechanism test: moderating effect.

Variables	Y	Y
DE	-1.885** (0.855)	-1.214* (0.675)
Inter-Pa	0.165*** (0.055)	
Inter-Co		0.218*** (0.076)
Patent	-0.024 (0.017)	
Policy	-0.001 (0.226)	0.020 (0.220)
Pgdp	-0.093*** (0.036)	-0.167*** (0.032)
Olddep	-0.499** (0.193)	-0.240 (0.195)
Urban	-0.251* (0.147)	-0.235 (0.142)
FDI	-0.027*** (0.007)	-0.023*** (0.006)
Edu	0.787 (2.124)	-1.163 (2.038)
Consu		0.039** (0.017)
constant term	1.507*** (0.322)	1.641*** (0.317)
observed value	279	279
R2	0.561	0.586
Year FE	YES	YES
Province FE	YES	YES

4.2 Heterogeneity Analysis

Based on strong and scientific empirical research results, this paper examines whether the promotion of mechanical structure by digital economic growth is heterogeneous at the regional level.

Table 6 shows the regression results of regional heterogeneity. First of all, we can find that the impact of digital economy on industrial structure optimization in both the central and eastern regions is positive and significant, and the coefficient in the eastern region is greater than that in the central region. This result shows that the eastern region has a better resource endowment and a better development environment, and the digital economy can fully release the optimization effect of industrial structure; The "late-comer advantage" in the central region is relatively obvious, but the development of digital economy in the western region is not significant.

In the southern region, the impact of digital economy on industrial structure optimization is more favorable than that in the northern region.

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Table 6: Heterogeneity analysis: Characteristics of digital transformation and export scale.

	North	South	West	East	Central
DE	-0.005095	0.9841***	0.1079	0.6397***	0.4714***
	(0.2235)	(0.1361)	(0.08617)	(0.2351)	(0.1418)
Pgdp	-0.1152**	-0.09623	-0.08917***	-0.1278	-0.07081***
	(0.04550)	(0.07199)	(0.01540)	(0.08287)	(0.02501)
Olddep	-0.1519	-0.5417**	-0.01426	-1.0309**	-0.7873***
	(0.2926)	(0.2546)	(0.1180)	(0.4461)	(0.2128)
Urban	-0.1897	-0.3468	-0.1970**	-0.4832	0.3509**
	(0.2063)	(0.2110)	(0.09503)	(0.3190)	(0.1418)
FDI	0.01256	-0.03890***	0.09033***	-0.02640**	0.007204
	(0.03585)	(0.007023)	(0.02839)	(0.01156)	(0.01419)
Edu	-0.2114	1.2950	-0.3522	-9.7349	2.5232
	(3.2077)	(2.5974)	(1.1204)	(8.0895)	(2.2718)
Policy	0.1463	-1.1527***	0.3365***	-0.8342	0.7159***
	(0.3215)	(0.3528)	(0.1137)	(0.6054)	(0.1226)
constant term	1.3313***	1.3583*	0.9018***	2.1918**	0.6068**
	(0.4999)	(0.7228)	(0.1556)	(0.9521)	(0.2923)
Observed value	135	144	108	99	72
R2	0.4723	0.7156	0.8851	0.5401	0.9486

5. Conclusions

Using the panel data of 31 provinces in the China Statistical Yearbook, the two-way fixed effect model is used to study the impact, heterogeneity and mechanism analysis of digital economy on industrial structure optimization. This paper constructs two indicators of digital economy and industrial structure optimization. The digital economy has significantly promoted the optimization of industrial structure; innovation and social division of labor will further strengthen this effect. In the eastern and central regions, the digital economy has a greater impact on the optimization of industrial structure, while the western region has not reached the same level. First of all, we must promote the integration of the digital economy and the traditional three industries, pay full attention to the enabling capacity of the digital economy, and give full play to its greater advantages. First of all, increase financial support, technical support and tax support for the digital transformation of the primary industry. Farmers should be encouraged and guided to use artificial intelligence, cloud computing, big data and other technologies to improve production efficiency and product quality. In addition, policy guidance and data support for the digital transformation of the secondary industry should be strengthened. The government holding cross-industry seminars can encourage enterprises to strengthen cooperation, thus further promoting the application of digital technology in manufacturing and industry. In addition, the government should further promote the integration of the digital economy and the tertiary industry. Introduce policies to promote the digital transformation of the service industry and improve the information level and service level of the service industry. We should pay attention to the different effects of optimizing the industrial framework of digital economy in different regions and adjust measures to local conditions. Local governments should solve the problem of unbalanced and inadequate development and solve the problem of digital divide. We should strive to optimize the industrial structure of the digital economy according to our own regional characteristics, rather than blindly copying experience, taking into account the economic base, cultural differences, resources, industrial framework and other objective factors of each region. In the process of promoting the optimization of industrial structure and the development of digital economy,

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the central government should highly effectively unify, synchronize and timely correct the problems existing in local governments to ensure the healthy and optimized development of industrial structure and digital economy. Achieve digital economy excellence.

How to adapt measures to local conditions and what indicators each province should start from to achieve industrial upgrading still need further discussion. In the context of digital economy, how enterprises should realize innovation and avoid the status quo of blindly enjoying data welfare still needs further research and discussion.

References

[1] *Wang, J. & Zhou, Shengjia. The current situation, characteristics and spillover effect of China's digital industry development [J]. Journal of Quantitative & Technical Economics, 2021,38(03): 103-119.*

[2] *ZHANG X W. Research on the evolution of innovation mode under the condition of digital economy. Economist, 2019,No.247(07):32-39.*

[3] *Cao Zhengyong. Research on the new manufacturing mode to promote the high-quality development of China 's industry under the background of digital economy [J].Theoretical discussion, 2018 (02):99-104.*

[4] *Liu Yang, Chen Xiaodong. The Impact of China 's Digital Economy Development on Industrial Structure Upgrading [J].Economic and Management Research, 2021,42 (08) : 15-29*

[5] *Li Zhiguo, Che Shuai, Wang Jie. Digital economy development and industrial structure transformation and upgrading: based on the heterogeneity test of 275 cities in China [J]. Journal of Guangdong University of Finance and Economics, 2021,36(05):27-40.*

[6] *Zuo, P., Jiang, Q. & Chen, J. The development of Internet, Urbanization and the Transformation and upgrading of China's Industrial Structure [J]. Journal of Quantitative & Technical Economics, 2020,37(07):71-91.*

[7] *Qian Chunhui, Zheng Ruogu, Yu model. The impact of China 's industrial structure change on economic growth and volatility [J].Economic Research, 2011,46 (05):4-16.*

[8] *Zhao, T., Zhang, Z. & Liang, S. K. Digital economy, entrepreneurial activity and high-quality development: empirical evidence from Chinese cities [J]. Management World, 2020,36(10):65-76.*

[9] *Nunn, N.and N. Qian. U.S. Food Aid and Civil Conflict[J]. American Economic Review，2014，104(6):1630-1666.*

[10] *Yiming, Weng Liying, Xu Changsheng. Financial friction, innovation and entrepreneurship, and economic growth-from the perspective of division of labor [J].World Economic Exchange, 2019, No.251 (04):1-17.*