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THE IMPACT OF DIGITAL ECONOMY ON EMPLOYMENT INDUSTRY STRUCTURE

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ABSTRACT
Based on the provincial panel data of China in the last ten years, this paper uses panel entropy method and dual fixed model to explore the impact of digital economy on employment and industrial structure, and does heterogeneity research according to the economic development of low, medium and high economic development regions. The results show that the digital economy has a good promoting effect on the primary and tertiary industries, but has an inhibiting effect on the secondary industries. According to the results, the paper puts forward some policy suggestions on the use of digital economy development, industrial upgrading and employment promotion. In order to provide an important theoretical basis for the formulation and improvement of employment policies in the world economic system and the development of digital economy.
KEY WORDS: *digital economy, industrial employment structure, double fixed effect model*

I. INTRODUCTION

In recent years, with the rapid development of the digital economy, it plays an increasingly important role in stabilizing employment and promoting development, and is gradually becoming a new driving force to promote economic development. The development of the digital economy has accelerated the replacement of humans by machines, weakening the demographic dividend in some countries. At the same time, with the application of digital technology to bring new forms of business, new industries and new employment, such as network broadcast, network sales, big data industry, etc., also provides new opportunities and challenges for the change of the world economy. Therefore, what is the impact of the digital economy on employment, it has become a question worth discussing. In this paper, the impact of digital economy on employment structure is discussed from the perspective of the three industrial structure of employment.

II. LITERATURE REVIEW

2.1 Digital Economy

IBM proposed the concept of "smart Earth" as early as 2006, and after the 2008 global financial crisis, the digital economy has been explosive growth. Real explosive growth happens. Because digital activity permeates almost every industry, it is difficult to accurately define and measure.

Some scholars used a single index to measure digital economy, such as e-commerce and electronic transaction volume, Internet penetration rate and other single indexes to measure digital economy (Mesenbourg, 2001; Zhang and Shi, 2019). With the deepening of research, scholars and institutions have begun to use comprehensive and multi-dimensional indicators to measure the digital economy. Most scholars often measure the digital economy from the dimensions of hardware and software infrastructure, e-commerce, enterprise and industry structure, demographic and labor force characteristics, and price behavior of the information economy (De Pablos, P. O., 2023; Ma, Q,2002). At the same time, some organizations, such as the US Department of Commerce (US-DOC), the Organisation for Economic Co-operation and Development (OECD), EUROSTAT, and the China Academy of Information and Communication Technology (CAICT), also measure the digital economy from different dimensions. However, there is no consensus on the definition and measurement of the digital economy.

2.2 Digital economy affects industrial employment structure

At present, scholars study the impact of digital economy on industrial structure mainly from the perspective of subdivision industry and industrial upgrading. For example, based on China's industry panel data, Yang Xianming & Hou Wei & Wang Yifan (2022) found that the impact of digital economy on the employment structure of high -, medium - and low-tech manufacturing and consumer service industries all showed an "orderly progressive upgrading" mode. The impact of digital economy on the employment structure of producer service industry and public service industry shows the "central upgrading" mode with only the proportion of medium-skilled labor increasing. For another example, Su Ce (2022) used the data of 29 provinces in China from 2011 to 2020 to verify the impact of digital economy development on the coordination and promotion of employment structure and industrial structure.

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Through the above research review and summary, it can be seen that previous scholars have made certain achievements in the definition and measurement of digital economy and its impact on the employment structure, but there are still some shortcomings: Firstly, the measurement and evaluation of digital economy lacks systematicness and comprehensiveness. Second, scholars mostly analyze the impact of employment structure from the aspects of segmented industry, mechanism and result, but the research from the perspective of digital economy is still not systematic and in-depth. To sum up, this paper will learn from previous research results, establish a systematic evaluation system of digital economy with entropy method, and deeply discuss the impact of digital economy on employment structure from the perspective of three industrial structures.

III. CONCEPT DEFINITION AND THEORETICAL ANALYSIS

3.1 Definition and Measurement of Digital Economy

Based on previous research results and personal research experience, this paper defines digital economy as an emerging economic activity supported by a new generation of information technology, with networks and platforms as the carrier, data as the production factor, intelligence as the direction, digital industrialization as the basis, and industrial digitalization as the main body.

With reference to the definition of digital economy and the existing research results, this paper, based on the index system evaluation method and starting from the connotation of digital economy, constructs a measurement of the development level of digital economy including digital industrialization, industrial digitalization, digital infrastructure and digital economic environment. Specifically, the selection of tertiary indicators follows the principles of systematical, scientific, hierarchical, feasibility, completeness and applicability. This paper establishes a comprehensive evaluation index system as shown in Table 1, with a total of 4 secondary indicators and 12 variables. At the same time, entropy method is used to construct a digital comprehensive evaluation economic index, recorded as Dig.

Table 1. Composition of Digital Economic Indicators

Secondary Indicators	Tertiary Indicators	Units	Indicator Direction	Representative Symbol
Industry digitization	E-commerce sales	100 million yuan	Forward	X1
	Number of computers per 100 people	number	Forward	X2
	Number of enterprises with e-commerce transactions	number	Forward	X3
Digital Industrialization	Total amount of telecommunications services	100 million yuan	Forward	X4
	Revenue from software business	100 million yuan	Forward	X5
	Mobile communication handset production	ten thousand units	Forward	X6
Digital infrastructure construction	Internet broadband access port	ten thousand units	Forward	X7
	Mobile phone switch capacity	ten thousand households	Forward	X8
	Number of domain names	ten thousand units	Forward	X9
Digital Economy Environment	Technology market turnover	ten thousand yuan	Forward	X10
	Number of students in school	people	Forward	X11
	Number of patent applications granted	pieces	Forward	X12

3.2 Industrial Structure of Digital Economy and Employment

Digital economy will affect the structural upgrading of regional industries, which will lead to changes in the employment absorption capacity of different industries, and then lead to changes in the employment structure.

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First of all, according to the "Paddy-Clark Theorem", with the improvement of economic development level, the high proportion of industrial structure and employment structure will change from the primary industry to the secondary industry, and then to the tertiary industry. That is, with the deep integration of digital economy and real economy, the development of digital economy will promote the development of industrial structure to the advanced level. The optimization and upgrading of industrial structure will also lead to the evolution of employment structure to the optimization.

Secondly, due to the different difficulty of digital economy transformation in the three industries, its ability to absorb employment will also change. The proportion of fixed assets in the tertiary industry is small, the income is fast, and it is closely related to consumption, so the cost of transformation is small and the speed is fast. The dividend brought by the development of digital economy will drive the proportion of the output value of the tertiary industry to rise, and the ability to absorb employment will also be enhanced. Due to the characteristics of high proportion of fixed assets and high technology intensity, the digital transformation of the primary and secondary industries is difficult, and the relevant workers need to receive skills training to be qualified for new production positions, so the employment absorption capacity is relatively insufficient. In addition, the secondary industry is more labor-intensive, and the development of digital economy is more likely to produce substitution effect.

Finally, with the use of digital technologies such as big data, cloud computing and the Internet of Things in production, industries deeply integrated with the digital economy will have higher production efficiency and market profits, which will lead to the increase in the demand for labor and the increase in labor remuneration, and lead to the change of employment structure among industries.

IV. MODEL ESTABLISHMENT AND EMPIRICAL ANALYSIS

4.1 Model Establishment

In order to empirically investigate the impact of digital economy on the industrial structure of employment, this paper starts from the Cobb-Douglas production function, and at the same time considers the impact of individual effect, time effect and independent variables, and sets the fixed effect model as follows:

$$\ln IA_{it} = \alpha_1 + \alpha_2 D_{it} + \alpha_3 \ln Control_{it} + \mu_i + \gamma_i + \sigma_{it}$$

Equation 1

$$\ln IB_{it} = \alpha_1 + \alpha_2 D_{it} + \alpha_3 \ln Control_{it} + \mu_i + \gamma_i + \sigma_{it}$$

Equation 2

$$\ln IC_{it} = \alpha_1 + \alpha_2 D_{it} + \alpha_3 \ln Control_{it} + \mu_i + \gamma_i + \sigma_{it}$$

Equation 3

In the equation, i and t represent region and time respectively, and represent regression coefficients. $\alpha_1 \alpha_2 \alpha_3 \mu_i$And represent the fixed effect of province and time respectively, and represent the random disturbance term. $\gamma_i \sigma_{it} Dig_{it}$Stands for digital economy and stands for control variable.$Control_{it}$

4.1.1 Explanatory Variables

In Equations 1, 2 and 3, the explained variable, and represent the number of employees in the primary, secondary and tertiary industries in region i, which is the number of employees in region I in year t. $LA_{it} LA_{it} LC_{it}$It is used to describe the impact of digital economy on the employment scale of the primary, secondary and tertiary industries.

4.1.2 Control Variables

In order to alleviate the endogeneity problem caused by missing variables, this paper refers to the practice of existing literature and selects the following indicators as control variables:

(1) The level of economic development is measured by the GDP added value of the primary industry, the secondary industry and the tertiary industry, denoted as GA, GB and GC, and LGA, LGB and LGC in logarithmic form;
(2) The level of financial development is measured by the added value of financial industry in each region, which is denoted as FIT, and LF in logarithmic form;
(3) Residents' living standard, measured by per capita disposable income, is denoted as P, and is denoted as LP in logarithmic form;
(4) The level of aging, the number of people receiving pension insurance in each province, is denoted as O, and the logarithm is denoted as LO;
(5) Urbanization level, measured by the urban population of each province, is denoted as C, and is denoted as LC in logarithmic form;
(6) Industrial level, measured by the added value of the tertiary industry, is denoted as I, and is denoted as LI in logarithmic form;
(7) Wage level: the average wage of employed people in the region is denoted as W, and the logarithm is denoted as LW;
(8) The housing price level, the sales volume of commercial housing, is denoted as H, and LH is denoted as LH in logarithmic form;
(9) The level of social and employment security, measured by fiscal expenditure on social and employment security, is denoted as B, and LB in logarithmic form.

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4.2 Data Sources

China has a vast territory and a huge economic aggregate, and there is a phenomenon of unbalanced economic development among different regions. Meanwhile, China has made great efforts to develop the digital economy in the past decade. Therefore, China's provincial data can be used to vividly depict the impact of digital economy on the employment scale in economies of different sizes. For the accuracy of the research, the data of Hong Kong, Macao and Taiwan are excluded because of the inconsistent statistical caliber. Therefore, the data of 30 provinces in China during the ten years from 2013 to 2022 are used. All the data are from the official China Statistical Yearbook for Regional Economy, China Local Statistical Yearbook, China Labor Statistical Yearbook and China Population and Employment Statistical Yearbook, and the missing data are made up by interpolation method. The statistical description of the data is shown in Table 2.

Table 2. Statistical Description 1

Variable		Mean	Std.dev.	Min	Max	Observations
m	overall	0.1110363	0.1204768	0.0046399	0.7868452	N=300
ga	overall	2283.051	1506.405	97	6298.6	N=300
gb	overall	12354.17	10460.68	871.29	55888.7	N=300
gc	overall	15041.07	12945.99	689.15	70934.7	N=300
fit	overall	2227.602	2080.807	94.37	11058.06	N=300
p	overall	36482.9	12048.76	19873.4	84034	N=300
o	overall	418.9316	1386.069	27.55	23797	N=300
c	overall	2763.666	1748.987	280	9466	N=300
i	overall	15041.07	12945.99	689.15	70934.7	N=300
w	overall	77240.2	27426.64	38301	202435.6	N=300
b	overall	814.5955	448.7706	102.7729	2321.304	N=300

4.3 Empirical Test of Employment Industry Structure

4.3.1 Agriculture

The empirical results of Equation 1 are shown in Table 3.

Table 3. Empirical Result 1

	Agriculture	
	Alpha.	t
Dig	0.0858*	1.68
LGA	0.0696	0.58
LF	0.0735	0.99
LC	0.04196	0.15
LO	0.0192*	1.76
LP	0.0663	0.14
LI	0.0646	0.45
LW	0.6117	1.56
LH	0.0229	0.47
LB	0.0420	0.28
Cons	13.7122***	8.97
Time Effect	YES	
Area Effect	YES	
R-squared	0.7773	
Prob > F	0.0000	

Annotation: *** p<0.01, ** p<0.05, * p<0.1

The results of the model are shown in Table 3. The fitting index R^2 of the model is 0.7773, P value is 0.0000, which proves that the model fits well, and the results are significant within 1% confidence interval. It can be seen from the results in Table 3 that the coefficient of digital economy is positive, which proves that the digital economy has a positive effect on agriculture in general.

According to the GDP per capita, this paper ranks ten areas as a group and forcibly divides them into three groups: low economic development areas, medium economic development areas and high economic development areas. The results of heterogeneity test are shown in Table 4.

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Table 4. Empirical Results 2

	High PGDP		Medium PGDP		Low PGDP	
	Alpha.	t	Alpha.	t	Alpha.	t
Dig	0.0593	0.77	0.0805	0.62	0.0531	1.05
LGA	0.3350***	3.2	0.3685***	2.56	0.0402	0.72
LF	0.3170***	2.4	0.0435	0.38	0.1922***	3.38
LC	0.2555	0.69	0.4300	0.91	-0.4681**	2.26
LO	0.4664***	3.21	0.0243	1.09	0.0030	0.14
LP	1.6525***	3.48	0.6391	1.03	0.5753**	2.04
LI	0.2341*	1.54	0.0314	0.17	0.0244	0.35
LW	2.0151***	5.53	0.3501	0.81	0.1691	0.99
LH	0.0007	0.01	0.0187	0.29	0.0096	0.30
LB	0.1370	1.07	0.3608*	1.78	0.3995***	6.10
Cons	12.5871***	4.62	15.2688***	5.14	14.8179***	11.91
Time Effect	YES		YES		YES	
Area Effect	YES		YES		YES	
R-squared	0.8731		0.7513		0.9292	
Prob > F	0.0000		0.0000		0.0000	

Annotation: *** p<0.01, ** p<0.05, * p<0.1

The fit of the above three sets of models is good, and all of them are significant within 1% confidence interval. It can be seen that the impact of digital economy on agricultural employment is positive in low economic areas and high economic areas, but negative in medium economic areas. The basic trend of the impact of digital economy on the employment of the primary industry shows a "U" shape.

4.3.2 Industry

The empirical results of Equation 2 are shown in Table 5.

Table 5. Empirical Results 3

	Industry 1		Industry 2	
	Alpha.	t	Alpha.	t
Dig	0.0658**	1.96	0.2743*	1.61
Dig^2			0.9744*	1.85
Dig^3			1.0189	1.32
LGB	0.1370*	1.89	0.1359*	1.66
LF	0.0440	0.62	0.0497	0.68
LC	0.7485**	2.43	0.7139	2.3
LO	0.0028	0.25	0.0031	0.29
LP	0.7813*	1.53	0.8015	1.56
LI	0.1177	0.84	0.1217	0.86
LW	0.0322	0.11	0.0302	0.11
LH	0.0908**	2.46	0.0916**	2.45
LB	0.0677	0.62	0.0553	0.48
Cons	4.4891	1.30	4.8340*	1.95
Time Effect	YES		YES	
Area Effect	YES		YES	
R-squared	0.9333		0.9338	
Prob > F	0.0000		0.0000	

Annotation: *** p<0.01, ** p<0.05, * p<0.1

It can be seen from the results in Table 5 that the coefficient of digital economy is negative, which proves that the impact of digital economy on industry is generally inhibiting. The main reason is that there is more large-scale machine production in industry. However, with the development of digital economy, industrial robots have a stronger substitution effect on labor in this large-scale production.

Next, in order to further consider that the growth of the digital economy itself is affected by its own development, and the impact of the digital economy on industrial employment marginal growth rate is also affected by the digital economy itself, quadratic and

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Volume: 8 | Issue: 11 | November 2023 - Peer Reviewed Journal

cubic options are added to the model. The results are shown in Industry 2 in Table 5. It can be seen that the impact of digital economy on the employment of the secondary industry shows a downward curve, that is to say, with the development of economy, the impact of digital economy on the employment of the secondary industry should be mainly negative, and its tangent rate of change is inverted "U" shape, that is, the change of marginal impact rate increases first and then decreases. The main reason is that the digital economy leads to the large-scale application of industrial robots to replace labor, and at the same time makes the industrial upgrading, forcing the unemployed in the industry to transfer to other industries, so that in the initial stage of development, this substitution effect changes rapidly, with the development of the economy, the gradual stability of personnel flow, this substitution effect is also gradually weakened.

Further, the heterogeneity test is carried out on the three groups of low economic development areas, medium economic development areas and high economic development areas, and the results are shown in Table 6.

Table 6. Empirical Results 4

	High PGDP		Medium PGDP		Low PGDP	
	Alpha.	t	Alpha.	t	Alpha.	t
Dig	0.1219*	1.90	0.0530	0.65	0.0377	0.49
LGB	0.0256	0.27	0.0364	0.55	0.3541***	4.37
LF	0.0571	0.53	0.0760	1.07	0.0498	0.62
LC	0.0311	0.12	1.3226***	4.49	0.6628**	1.97
LO	0.4249***	3.58	0.0022	0.16	0.0180	0.56
LP	1.5484***	3.85	0.4098	1.04	0.2124	0.50
LI	0.1440	0.90	0.2164*	1.84	0.0304	0.27
LW	0.8784***	2.94	0.5410**	2.01	0.4471*	1.72
LH	0.1188**	2.16	0.1077***	2.53	0.1645***	3.40
LB	0.0844	0.82	0.2841**	2.22	0.0969	0.92
Cons	11.0000***	5.29	1.0477	0.57	1.6222	0.93
Time Effect	YES		YES		YES	
Area Effect	YES		YES		YES	
R-squared	0.5729		0.9594		0.9479	
Prob > F	0.0000		0.0000		0.0000	

Annotation: *** p<0.01, ** p<0.05, * p<0.1

The fitting degree of the above three groups of models is good, and all of them are significant within the 1% confidence interval. It can be seen that the impact of digital economy on agricultural employment is negative in both low and high economic areas, and at the current stage of China's development, with the economic growth, digital economy has a relatively large inhibitory effect on industrial employment. The reason for this is that China's general industrial structure still needs to be upgraded. In most regions, industrial economy still accounts for a large proportion, and digital economy has a strong substitution effect on industrial employment.

4.3.3 Service

The empirical results of Equation 3 are shown in Table 7.

Table 7. Empirical Results 5

	Service	
	Alpha.	t
Dig	0.0386*	1.58
LGC	0.0577	0.38
LF	0.0320	0.57
LC	1.0260***	5.28
LO	0.0014	0.19
LP	0.6083*	1.69
LI	0.0000	(omitted)
LW	0.3770*	1.81
LH	0.0433	0.84
LB	0.0263	0.24
Cons	3.0814	1.44

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Volume: 8 | Issue: 11 | November 2023 - Peer Reviewed Journal

Time Effect	YES
Area Effect	YES
R-squared	0.9629
Prob > F	0.0000

Annotation: *** p<0.01, ** p<0.05, * p<0.1

As shown in Table 7, the fitting index R^2 of the model is 0.9629, P value is 0.0000, which proves that the model fits well, and the results are significant within 1% confidence interval. It can be seen from the results in Table 7 that the coefficient of digital economy is positive, which proves that the digital economy has a positive effect on agricultural service industry in general.

Furthermore, the heterogeneity test is conducted on the three groups of low economic development areas, medium economic development areas and high economic development areas, and the results are shown in Table 8.

Table 8. Empirical Results 6

	High PGDP		Medium PGDP		Low PGDP	
	Alpha.	t	Alpha.	t	Alpha.	t
Dig	0.1206***	2.43	0.1398*	1.57	0.0343	0.70
LGC	0.0003	0.00	0.4822***	2.95	0.1248*	1.76
LF	0.0038	0.04	0.0417	0.42	0.0486	0.92
LC	0.4019**	2.04	2.1938***	5.70	0.9910***	5.04
LO	0.3185***	3.46	0.0088	0.45	0.0147	0.69
LP	0.4694*	1.55	1.1149**	2.04	0.2212	0.78
LI	0.0000	(omitted)	0.0000	(omitted)	0.0000	(omitted)
LW	0.3598*	1.54	0.6999*	1.86	0.4344***	2.55
LH	0.0111	0.26	0.0516	0.90	0.0755**	2.36
LB	0.0102	0.13	0.1782	1.05	0.0282	0.43
Cons	1.1092	0.70	9.4943***	3.86	1.1009	0.96
Time Effect	YES		YES		YES	
Area Effect	YES		YES		YES	
R-squared	0.8213		0.9533		0.9833	
Prob > F	0.0000		0.0000		0.0000	

Annotation: *** p<0.01, ** p<0.05, * p<0.1

The fit of the above three sets of models is good, and all of them are significant within 1% confidence interval. It can be seen that the impact of digital economy on the employment of service industry is positive in both low economic areas and high economic areas, but negative in medium economic areas. The basic trend of the impact of digital economy on the employment of tertiary industry shows a "U" shape.

V. CONCLUSIONS AND POLICY RECOMMENDATIONS

5.1 Comprehensive Analysis

According to the above empirical results, the coefficient α of the digital economy affecting the employment of the three industries can be summarized in Table 9.

Table 9. Coefficients of Digital Economy Affecting Employment in the Three Industries

	Agriculture	Industry	Service
Overall	0.0858	0.0658	0.0386
High PGDP	0.0593	0.1219*	0.1206
Medium PGDP	0.0805	0.0530	0.1398
Low PGDP	0.0531	0.0377	0.0343

Annotation: *** p<0.01, ** p<0.05, * p<0.1

The following conclusions can be inferred:

1. The digital economy has a positive impact on the employment of the primary industry and the tertiary industry, but a negative impact on the employment of the secondary industry;
2. The basic trend of the impact of the digital economy on employment in the primary and tertiary industries exhibits a "U"

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Volume: 8 | Issue: 11 | November 2023 - Peer Reviewed Journal

shape, initially experiencing inhibition before subsequently increasing.

3. The impact of digital economy on the employment of the secondary industry is basically a downward curve;

4. Although on the whole, the increasing effect of digital economy on the employment of the primary industry is more than that of the tertiary industry, it may be limited by the development stage of China's overall economy, which is not accurate enough. It can be seen from the heterogeneity test by region that with the development of economy, the promoting effect of digital economy on the tertiary industry is greater than that on the primary industry.

5.2 Policy Suggestions

Based on the above conclusions, this paper puts forward the following policy recommendations for the world economy:

First, take advantage of the digital economy to increase the employment capacity of high-end industries, especially high-end manufacturing. On the one hand, actively promote the digital transformation of enterprises, especially the manufacturing industry, and further liberate productivity with the help of factor resources of the digital economy; On the other hand, speed up the construction of new infrastructure, especially the construction of new infrastructure represented by big data and 5G, and fully release the effect of the digital economy on creating new jobs.

Second, better play the role of the digital economy in optimizing the industrial employment structure, and give full play to the employment absorption capacity of the tertiary industry. On the one hand, the advantages of the Internet can be leveraged to expand the one-way connection of traditional industries into a network topology, accelerate the development of the tertiary industry, and increase employment. On the other hand, it guides traditional industry personnel to turn to some tertiary industries that are difficult to be replaced by the digital economy and can also be developed with the help of the Internet, such as pension, housekeeping, childcare and other service industries.

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