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The Impact of the Digital Economy on Employment Scale in the Yangtze River Delta Region

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Abstract

Employment is the greatest livelihood and the most basic support for economic development. In recent years, the scale and scope of digital economy has expanded dramatically, triggering revolutionary changes in employment patterns. Especially in the Yangtze River Delta region. This paper is based on panel data of 41 prefecture level cities in the Yangtze River Delta region from 2011 to 2021. Firstly, the fixed-effects regression model is used to empirically analyze the impact of the digital economy on the employment scale in the YRD region, and the intermediary mechanism model is further used to verify the role of industrial structure upgrading in the digital economy's impact on the employment scale. The study finds that: The digital economy has significantly expanded the employment scale in the YRD region, indicating that the employment creation effect is greater than the employment substitution effect. In the heterogeneity analysis, this impact is more significant in the central cities of the YRD region, areas with higher levels of urbanization and well-developed digital infrastructures. The digital economy can promote the optimization and upgrading of the employment market in the YRD region through the upgrading of the industrial structure, expanding the scale of employment, optimizing the employment structure.

Keywords: Digital economy development, Yangtze River Delta region, Employment scale, Industrial structure upgrade.

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1. Introduction

The digital economy, as a new type of engine for today's economic and social development, is leading a profound industrial transformation on a global scale. It takes data resources as the key element and modern information networks as the main carrier. Through the deep integration of digital technology and the real economy, it promotes the transformation and upgrading of traditional industries, accelerates the emergence of new forms and modes. The Yangtze River Delta region, as one of the regions with the most active economic development, the highest degree of openness, and the strongest innovation ability in China, its digital economy development not only has a bearing on the region's economic prosperity, but also has a profound impact on the national and even the global economic landscape.

The development of the digital economy in the YRD region has shown remarkable results. With Shanghai as the regional central city, provincial capitals such as Nanjing, Hangzhou and Hefei, as well as economic powerhouses such as Suzhou, Wuxi, Changzhou and Ningbo as sub-centers, a "one main city with multiple sub-centers" development pattern has been formed. These cities have made remarkable progress in digital infrastructure, digital industrialization, industrial digitization, digital public services, and digital economy ecosystem, laying a solid foundation for the vigorous development of the digital economy in the YRD region. However, the rapid development of the digital economy is not only reflected in the growth of economic output and optimization of industrial structure, but also in the profound impact on the scale and structure of employment. The continuous growth of the digital economy promotes continuous technological innovation, which in turn has a profound impact on individual production and lifestyles. It not only has an employment driving effect, but also contains a powerful reshaping effect.

As a new type of economic form, the industrial characteristics of the digital economy determine that it has a unique demand for talents. On the one hand, the development of the digital economy has given rise to a large number of emerging occupations, such as big data analysts, cloud computing engineers, artificial intelligence experts, etc., which have injected new vitality into the job market. On the other hand, the development of the digital economy has also accelerated the digital transformation of traditional industries, posing new challenges to the skills upgrading and re-employment of traditional industry practitioners. The widespread application of digital technology has replaced part of the workforce and reduced the demand for labor in labor-intensive positions, which has a certain destructive effect. It can be seen that the impact of the development of the digital economy on the job market in the YRD region is complex and will bring new opportunities as well as new challenges.

Therefore, this study aims to delve into the impact of the digital economy development on the employment scale in the YRD region. By sorting out the current situation of digital economy development in the YRD region, this paper will analyze the specific impact of the digital economy on the employment market and reveal the intrinsic connection between the digital economy and employment scale, in order to provide useful reference and inspiration for the development of the digital economy and the formulation of employment policies in the YRD region.

2. Literature Review

In recent years, the rapid development of the digital economy, which relies on modern digital technologies such as big data, artificial intelligence, and the mobile Internet, has revolutionized economic growth and had a huge impact on employment. The growth of the digital economy represents an advancement in technology. As can be learned from the technological developments of successive industrial revolutions, the emergence of new technologies usually triggers unemployment by replacing labor (Trajtenberg, 2018). So, the relationship between technological progress and labor employment has attracted the attention and discussion of many scholars since the first industrial revolution. The emergence of new technologies has a dual effect on labor force employment, i.e., a substitution effect and a compensation effect (Ding et al., 2023).

2.1 The employment substitution effect of digital economy

In the process of transformation and development towards digitalization and intelligence in factories, the increase in labor productivity brought about by technological progress and the large-scale application of digital intelligent devices will gradually replace labor, leading to a decrease in employment opportunities for medium and low skilled labor, which will result in structural or cyclical unemployment, and ultimately reducing the total employment volume (Autor and Dorn, 2013; Acemoglu and Restrepo, 2018). And this substitution effect will become increasingly significant (Cheng et al., 2019). As the application of industrial robots becomes increasingly widespread, they will continue to replace low- and mid-range worker who works in highly programmatic job positions (Borland and Coelli, 2017). Based on labor market data and industrial robotics data from 1990 to 2007 in the United States, Acemoglu and Restrepo argued that adding one industrial robot to a thousand people will lead to a decrease in employment rates of 0.18% - 0.34%, and this effect is particularly evident in areas that are easily replaced, such as manufacturing (Acemoglu and Restrepo, 2020). Giuntella et al.'s regressions using data from the China Family Panel Studies (CFPS) also showed that an increase of one standard deviation in robot use in China will lead to a 1% decrease in labor force participation and a 7.5% decrease in employment (Giuntella et al., 2022).

Furthermore, in the context of the rapid development of artificial intelligence, the impact on employment is even more profound. Compared to industrial robots, artificial intelligence, as a system with a certain degree of autonomy and intelligent behavior that can achieve specific goals, its most significant feature is that it enables machines to have intelligence and complete self-learning (Brynjolfsson and McAfee, 2014). Frey and Osborne divided 702 occupations in the United States into high risk, medium risk and low risk according to their vulnerability to automation, and predicted that 47% of American workers will be replaced by the rapid development of automation in the next 20 years (Frey and Osborne, 2017). As for the degree of substitution of AI for China's labor force, 278 million labor forces are expected to be replaced by AI by 2049. And the substitution of AI for women, the elderly, low education and low-income labor forces has a greater impact (Zhou et al., 2020). Nowadays, artificial intelligence based on deep learning can perform logical judgment analysis through big data and continuously optimize algorithms in massive amounts of data (Schwab, 2017).

2.2 The employment creation effect of digital economy

In terms of creative effect, although digital technology represented by artificial intelligence and industrial robots poses a certain threat to labor employment. But scholars remain optimistic about the future of digital technology. Some studies believe that technological progress can directly achieve employment growth by creating new products, new machines, new industrial sectors and other product innovations (Cortes et al., 2017). Specifically, in the era of digital economy, a large number of new occupations are constantly emerging. From the perspective of job creation types, the development of digital technology mainly increases some flexible employment, stimulates entrepreneurial activity and increases employment in remote areas. With the spread of the Internet, the online office mode has spawned many new jobs. These new jobs break through the constraints of employment space and time, make employment forms more flexible and diversified, and can increase employment (Spreitzer et al., 2017). Aghion et al used French manufacturing data to verify that the creative effect of automation is greater than the substitution effect, which promotes employment as a whole (Aghion et al., 2020). When breaking down the impact of the digital economy on the scale of employment across industries, it can be seen that the growth of the digital economy will further free up labor in the agricultural sector and promote employment growth in the service sector while reducing manufacturing employment (Dauth et al, 2017). That is to say, although the development of digital economy will significantly reduce the employment of the secondary industry, it is rapidly penetrating into the tertiary industry, which makes the employment creation effect of digitalization of service industry significant (Wu and Yang, 2022). The development of artificial intelligence, ICT industry and the application of various new technologies will expand production boundaries and provide more employment opportunities for the labor force. There is an employment compensation effect dominated by high-end service industry and technology intensive industry (Frank, 2018). From the perspective of skill structure of employment, digital technology progress will screen different skilled workers. Although low skilled jobs will become more easily replaced, while enterprises continue to strengthen technological innovation, they will continue to increase the demand for high-skilled labor force, thus increasing the number of jobs (Lordan and Neumark, 2018). At the same time, in terms of gender, the digital economy has brought new opportunities to improve the gender gap in employment. The development of digital economy has a particularly significant effect on the employment of female workers (Gómez et al., 2014). First, it will increase women's employment opportunities, and the employment form represented by e-commerce live broadcasting will bring more development opportunities for women and enhance women's autonomy in work. The second is to increase labor income, accelerate women's economic independence, and realize the rational allocation of women's labor resources (Wasserman and Richmond-Abbott, 2005; World Bank, 2016; Aly, 2020).

Therefore, measuring the impact of the digital economy on labor employment requires a combination of creation and substitution effects, rather than separating these two effects. If the substitution effect is greater than the creation effect, it will inhibit labor employment. If the creation effect is greater than the substitution effect, it will promote labor employment.

3. Theoretical analysis and research hypothesis

Throughout the history of economic and social development, technological advancements have had a significant impact on employment, but the intensity and scope of the impact of the digital economy are unprecedented.

The impact of the development of the digital economy on employment scale is mainly in two aspects: substitution effect and creation effect, and its mechanism of action is as follows: Firstly, the advanced technology brought by the digital economy has replaced outdated manpower, forming a path for machines to replace manual, physical, and mental labor, reducing employment opportunities and labor demand (Acemoglu and Autor, 2011). Secondly, the application of digital technology not only expands the scale of production in society, but can also be combined with traditional industries to jointly create new occupations and jobs, increasing employment demand (Koch et al., 2021). Taken together, the ultimate role of the digital economy in affecting the size of employment depends on the overall effect of both the substitution effect and the creation effect. The former occupying a dominant position will lead to a decrease in employment demand level, while the latter will lead to an increase in employment demand level. And the overall effect is also tied to the time span. In the short term, the application of digital technology may cut jobs in some traditional industries and replace a large number of labor force, resulting in a reduction in the size of employment. But in the long run, as the development of the digital economy continues to deepen, infrastructure construction will become more and more perfect, the scale of production in the market will continue to expand, new industries and professions will emerge one after another, and the substitution effect will be offset by the creation effect, ultimately forming a situation of expanding employment scale. The development of the digital economy can optimize the structure of the allocation of labor factors, which in turn leads to the optimization of the division of labor in society and an increase in employment. The development of the digital economy can optimize the allocation structure of labor factors, thereby leading to the optimization of the division of labor in society and an increase in employment. On the one hand, the development of the digital economy provides a better employment platform for high skilled workers, guiding them to engage in high-end digital industries. On the other hand, the digitization of consumption triggered by the digital economy will create a large number of low-skill-biased jobs for low-skilled workers, such as delivery drivers and couriers, which achieves the optimal allocation of labor factors and an increase in employment.

H_1: The development of digital economy can expand the employment scale in the Yangtze River Delta region.

The essence of industrial structure change is the change in the proportion of production factors within the same industry and between different industries, and its inherent core is technological progress. The digital economy is a powerful engine that promotes high-quality economic and social development. The transformation of industrial structure is an important part of high-quality development. Information technology is the key to changing the industrial structure (Jaakkola et al., 1992). The digital economy is becoming a new driving force for leading industrial structure upgrading, and it is constantly promoting the integration and development of the three major industries (Giudice, 2016; Caputo et al., 2016). Digital industrialization is a pioneering foundation, and digital technology has given rise to new forms and modes of business that are driving changes in the industrial structure. Industrial digitization is the dominant condition. Digital technology empowers industrial development and deeply integrates with traditional industries, improving enterprise production efficiency, resource allocation efficiency and management efficiency. This will finally realize industrial intelligent and digital transformation (Krogh, 2012; Laudien and Pesch, 2019).

Improving labor productivity, improving technological efficiency and intensifying competition among industries are the main ways for digital economy to adjust industrial structure (Xie et al., 2016). At the micro level, digital technology transformation has optimized the production and operation processes of enterprises, broadened the coverage radius of products and services, and helped improve the production efficiency of enterprises (Dedrick and Kraemer, 2005). At the meso level, through the digital transformation of many links such as production, circulation, distribution, and consumption, the digital economy has optimized the layout of the industrial chain, further enhanced the correlation of the industrial chain, which has helped to promote the improvement of industrial operation efficiency. At the macro level, the widespread application of digital technology and the rapid development of digital infrastructure have improved the capacity of the entire society to integrate and exchange data, as well as the ability to integrate digital universal technologies. The investment and use of data elements have also spawned new industries, new forms and new modes, which have helped to promote the innovation among market entities and the connectivity of economic activities.

Further studies have shown that the digital economy can contribute to the upgrading of industrial structure through the human capital dividend, the level of innovation and entrepreneurship, scientific and technological innovation, and the social division of labor (Nambisan et al., 2018; Briel et al., 2018).

H2: The development of digital economy can expand the employment scale in the Yangtze River Delta region through industrial structure upgrading.

4. Empirical Design and Data Description

4.1 Model building

To examine the impact of digital economy development in the Yangtze River Delta region on the employment scale of prefecture level cities, a fixed effects regression model is constructed:

$$EA_{it} = \alpha_0 + \alpha_1 DigE_{it} + \sum_{k=1}^{n} \delta_k X_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (1)$$

Among them, EA represents the employment scale of each region; $DigE$ represents the level of regional digital economic development; X is the collection of control variables; α_0 is the intercept term; δ represents the regression coefficients of each control variable; λ_i is the fixed effect of the city; μ_t is the fixed effect of the year; ε_{it} represents the random disturbance term.
Furthermore, in order to examine the possible mechanisms of the impact of digital economy development on employment scale in the Yangtze River Delta region, an intermediary mechanism model is constructed based on equation (1) for testing and analysis. The specific model settings are as follows:

$$ZJ_{it} = \beta_0 + \beta_1 DigE_{it} + \sum_{k=1}^{n} \rho_k X_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (2)$$

ZJ represents the mediating variable.

4.2 Sample selection

4.2.1 Dependent variable

The dependent variable is employment scale, which measures the total number of employed persons in a region across the entire society. In terms of indicator selection, this chapter uses the total number of employed persons in the region for measurement. At the same time, logarithmic processing is applied to reduce the impact of data fluctuations.

4.2.2 Explanatory variable

The explanatory variable is the digital economy development index. The existing digital economy development level index mostly adopts a multi-level indicator construction system, which examines indicators at one level from 3 to 5 dimensions. At the same time, due to issues such as data continuity, accessibility, and coverage, the construction of the digital economy index needs to balance the comprehensiveness and accessibility of the indicators.

Based on the research purpose of the impact of the digital economy on the employment effect of the Yangtze River Delta, combined with the availability of relevant data at the city level, this paper measures the development level of the urban digital economy in the YRD from five dimensions: Internet penetration rate, number of mobile Internet users, digital economy related practitioners, digital economy related output, and digital inclusive financial index. The selection of specific indicators includes: per capita telecommunications business volume, the proportion of the number of employees in the information and software technology service industry, the number of mobile phone users per 100 people, the number of Internet broadband users per 100 people, and the Peking University Digital Inclusive Finance Index. After standardization, entropy value processing is carried out to measure the comprehensive development level of the digital economy in various regions.

The entropy method is used in this article to calculate the following steps:

Standardize the positive indicators as follows:

$$y_{ij} = \frac{x_{ij} - min\{x_{ij}\}}{max\{x_{ij}\} - min\{x_{ij}\}} \quad (i = 1,2,\dots,m; j = 1,2,\dots,n) \tag{3}$$

Standardize the negative indicators as follows:

$$y_{ij} = \frac{max\{x_{ij}\} - x_{ij}}{max\{x_{ij}\} - min\{x_{ij}\}} \quad (i = 1,2,\dots,m; j = 1,2,\dots,n) \tag{4}$$

Calculate the proportion q_{ij} of the j indicator in the i year:

$$q_{ij} = \frac{y_{ij}}{\sum_{i=1}^{m} y_{ij}} \tag{5}$$

Calculate the entropy value e_j of the i indicator:

$$e_j = -\frac{1}{lnm} \sum_{i=1}^{m} (q_{ij} \times lnq_{ij}) \tag{6}$$

$e_j \in [0,1]$, when $q_{ij} = 0$, make $q_{ij} \times lnq_{ij} = 0$

Calculate the coefficient of difference $g_j$for the j indicator:

$$g_j = 1 - e_j \tag{7}$$

Calculate the weight w_j of the j indicator:

$$w_j = \frac{g_j}{\sum_{j=1}^{n} g_j} \tag{8}$$

Calculate the comprehensive score s_i of various indicators:

$$s_j = \sum_{j=1}^{n} w_j \, y_{ij} \tag{9}$$

The final result is the Digital Economy Development Level Index (DigE), as well as the entropy weights of each sub level indicator.

4.2.3 Control variable

In this paper, the following variables are selected as the control variables of the empirical analysis model of the digital economy affecting the employment scale in the YRD region.

Gov. Regional infrastructure and economic development environment are important factors affecting the employment of the labor force, relying on the financial support of the local government. This paper uses the ratio of local fiscal expenditure to regional GDP of each prefecture level city to measure the degree of government intervention in each region.

Public. Public service is an important factor affecting labor migration, which includes the absorption capacity of labor in each region, thus positively affecting the development of employment. The share of general public service expenditures in total fiscal expenditures of each prefecture level city is used to measure the level of public service in each region.

Security. Regional social security and employment expenditures can effectively enhance the risk-taking ability of the labor force, especially the unemployed labor force, and have a positive impact on the scale of employment. The share of social security and employment expenditures of each prefecture level city in the total fiscal expenditure is used to measure the level of social security and employment expenditures in each region.

Tech. The level of science and technology profoundly affects the employment environment of a region and has a positive impact on labor force employment. This paper selects the proportion of science and technology expenditures of each city in the total fiscal expenditure to measure the level of science and technology investment in each region.

PGDP. The level of regional economic development directly affects the scale of employment, and this paper adopts the per capita GDP of each city to indicate the level of economic development of each region.

FDI. The inflow of foreign capital can usually drive the regional economic development, provide a large number of jobs, and play a positive role in the increase of employment scale. The ratio of FDI to GDP of each city is used to measure the foreign investment dependence of each region.

Education. Education investment has an important impact on labor force employment, and the level of education is closely related to the employability and comprehensive quality of the labor force. The proportion of education expenditure in the total fiscal expenditure of each city was chosen to measure the level of education investment in each region.

4.3 Data sources

The study population in this paper consists of 41 cities in the YRD region. The time span of the econometric regression sample in this paper is 2011-2021, totaling 11 years. Some missing data of certain years in each region are filled in by interpolation. The data in this paper mainly come from China Urban Statistical Yearbook, Shanghai Statistical Yearbook, Jiangsu Statistical Yearbook, Zhejiang Statistical Yearbook, Anhui Statistical Yearbook, and Statistical Yearbook of each prefectural level city under them. The digital financial inclusion index is taken from the Digital Finance Research Center of Peking University.

4.4 Variable descriptive statistics

Table 1 shows the descriptive statistical results of each variable. The maximum value of the explanatory variable Digital Economy Development Level Index is 0.82349, the minimum value is 0.02859, the mean is 0.24424, the standard deviation is 0.13893, and the range is 0.7949. This indicates that there are certain differences in the level of digital economic development among cities in the YRD region. In terms of employment scale, the original data was logarithmically processed due to the influence of its dimensions, with a standard deviation of 0.666, indicating regional differences in employment scale among cities. In terms of control variables, there is a slight difference between the maximum and minimum values of each variable, but the overall concentration is near the mean, with a total of 451 observed values.

Table 1: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ES	451	335.512	228.81	45.56	1376.2
lnES	451	5.608	0.666	3.819	7.227
DigE	451	.244	.139	.029	.823
Gov	451	.166	.062	.076	.356
Public	451	.1	.024	.042	.179
Security	451	.107	.024	.042	.184
Tech	451	.035	.022	.004	.142
PGDP	451	73776.12	39881.996	10090	199017
lnPGDP	451	11.047	0.599	9.213	12.201
FDI	451	.027	.017	.002	.093
Education	451	.175	.032	.094	.267

4.5 Variable correlations

Table 2 reports the results of the correlation analysis between the explanatory variable, the dependent variable, and the control variable. This result preliminarily shows that there is a positive relationship between the development of the digital economy and the scale of urban employment in the YRD region, with a correlation coefficient of 0.403. On the control variables, Security, Tech, PGDP and Education are all positively correlated with employment scale. Although Gov, Public and FDI are shown to be negatively correlated with employment scale, the exact results need to be verified by regression analysis.

Table 2: Correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ES	1.000								
DigE	0.403	1.000							
Gov	-0.213	-0.332	1.000						
Public	-0.176	-0.220	-0.162	1.000					
Security	0.028	-0.060	0.299	-0.391	1.000				
Tech	0.205	0.487	-0.431	-0.328	-0.150	1.000			
PGDP	0.167	0.765	-0.655	-0.097	-0.126	0.580	1.000		
FDI	-0.110	-0.047	-0.042	-0.276	-0.080	0.250	-0.007	1.000	
Education	0.349	-0.207	-0.268	0.252	-0.141	-0.166	-0.263	-0.259	1.00

5. Analysis of Empirical Results

5.1 Baseline regression results

According to the econometric model set up in the previous section, Tables 3 present the regression results of the level of digital economy development on the scale of employment in the Yangtze River Delta region. Individual and time factors are controlled for in the model. The results of the baseline regression show that the level of digital economy development has a significant positive impact on the employment scale in the YRD region, and the estimated coefficient is positive at a significance level of 1%. The regression coefficient is 0.378, which means that for every 1% increase in the digital economy development index, the employment scale will increase by 0.378%. This indicates that the development of the digital economy has effectively expanded the employment scale in the YRD region, increased employment opportunities for the labor force, and created more job opportunities, verifying Hypothesis 1 proposed in this paper. When observing the regression results of control variables, it can be found that: The level of government intervention increases the size of regional employment, and the regression coefficient is positive at the 10% level of significance, with a specific value of 0.475, whose increase by one unit will cause an increase in the size of employment by 0.475 units. The level of public service also has a significant positive impact on the size of employment, which is consistent with expectations. The regression coefficient is 1.933, indicating that a 1-unit increase in the level of public service will lead to a 2.47-unit increase in employment. The regression coefficient of social security and employment expenditure is 1.143, and it has passed the 1% significance test. Scientific and technological inputs and the level of regional economic development both have a positive impact on the size of employment at the 1%

significance level. A 1% change in either factor will lead to a corresponding change of 1.306 units and 0.407 units in the size of employment. The significantly negative impact of FDI on employment size may be due to the fact that foreign capital inflows are mostly in capital- and technology-intensive industries, which suppresses employment opportunities and demand for low- and medium-end industries and low-skilled labor.

Table 3: Baseline regression result

Variables	(1) Employment Scale	(2) Employment Scale	(3) Employment Scale
DigE	0.482***	0.560***	0.378***
	(0.142)	(0.129)	(0.112)
Gov		1.323***	0.475*
		(0.226)	(0.258)
Public		2.470***	1.933***
		(0.480)	(0.443)
Security		1.268***	1.143***
		(0.468)	(0.408)
Tech			1.306***
			(0.374)
PGDP			0.407***
			(0.0517)
FDI			-1.288***
			(0.483)
Education			-0.0483
			(0.349)
Constant	5.490***	4.869***	9.615***
	(0.0350)	(0.0962)	(0.635)
Observations	451	451	451
R-squared	0.981	0.985	0.989
City	YES	YES	YES
Year	YES	YES	YES

Note: Standard errors are in brackets. *, **, and *** represent significance at the 10%, 5% and 1% levels respectively. The following tables are the same.

5.2 Robustness tests

Robustness testing is an essential part of empirical research, which is used to examine the explanatory power of indicators and the rationality of model methods. This paper selects the following methods to test the robustness of the regression estimation of the impact of the development level of the digital economy on the employment scale in the Yangtze River Delta region.

Replacement of explanatory variables: Replacing the urban-level digital economy development index with the provincial-level digital economy development index to test the robustness of the regression model.
Control fixed effects: In the previous regression, only the fixed effects of cities and time were controlled. Adding the fixed effects of provinces to overcome the bias caused by omitted variables.
Replacement of estimation methods: The estimation methods of the fixed effects model mainly include the within-group deviation method and the least squares dummy variable (LSDV) method, and in this paper, will replace the LSDV for the robustness test.
Elimination of extreme values: Considering the external and objective impact of the COVID-19, the relevant index data in 2020 may have a large deviation. Therefore, the 2020 data will be excluded and regression will be conducted again after excluding the influence of extreme values to test the robustness of the regression model.
Table 4 presents the outcomes of four robustness tests. The findings indicate that, while there are slight variations in the correlation coefficient between the level of digital economic development and the employment scale in the YRD region, the overall direction and significance of the effect align with the baseline regression results, which have not changed the basic conclusions of the previous article. This suggests that the research findings of the regression model presented in the previous article are robust and reliable.

Table 4: Robustness tests

Variables	(1) Change Explanatory variable	(2) Control fixed effects in provinces	(3) LSDV	(4) Drop 2020
DigE	0.522** (0.214)	0.378*** (0.112)	0.378*** (0.112)	0.312*** (0.118)
Constant	9.515*** (0.626)	9.615*** (0.635)	11.21*** (0.649)	9.240*** (0.641)
Control Variables	Y	Y	Y	Y
Observations	451	451	451	410
R-squared	0.989	0.989	0.989	0.990
City	YES	YES	YES	YES
Year	YES	YES	YES	YES

5.3 Endogenous processing

5.3.1 Selection of tool variables

The issue of endogeneity is an important topic that cannot be ignored in empirical research, due to data availability with some factors that cannot be directly measured, and the fact that the level of digital economy development may generate endogeneity bias due to the existence of bidirectional causality with the size of employment. This paper adopts the instrumental variable method for regression test. This paper selects the level of historical postal and telecommunications development as an instrumental variable for the digital economy. From the perspective of China's social development process, the development of Internet technology is based on the popularization of fixed telephones, and the number of fixed telephones satisfies the relevance requirement as an instrumental variable of the digital economy. Secondly, due to the development of communication technology, the rise of mobile phones has gradually reduced and eliminated the impact of fixed telephones as traditional communication tools on employment, which makes the historical level of development of post and telecommunications meet the exclusionary requirements of instrumental variables to a certain extent. At the same time, in order to avoid the incalculable problem caused by this cross-sectional data in panel data regression, the number of Internet users in the previous year in the study period was introduced as a variable over time, and the interaction term was obtained by multiplying the number of fixed telephones per 100 people at the city level in the YRD in 1984, which was used as a tool variable for the development of the digital economy in the YRD, and the two-stage least squares method was used for regression testing.

5.3.2 2SLS test results

As shown in Table 5, the first column reports the first-stage regression results using the historical level of post and telecommunications development as an instrumental variable. The results show that the historical level of post and telecommunications development in the YRD region has a significant positive impact on the digital economy at the 1% level. This indicates that the higher the level of development of the former postal and telecommunications industry, the more advantages it has in the development of the digital economy today. The model also passed the Kleibergen-Paap rk LM test and Kleibergen-Paap rk Wald F test, indicating the validity of the selection of instrumental variables. The second column reports the regression results of the second stage using the historical level of post and telecommunications development as an instrumental variable. The results show that after addressing the endogenous problem, the impact of the development of the digital economy on the employment scale in the YRD region remains significantly positive at the 1% level, indicating that the development of the digital economy can significantly promote the increase in the employment scale in the YRD region.

Table 5: 2SLS test results

Variables	(1) Historical level of postal and telecommunications development		(2) Explanatory variable lagged by one period	
DigE		1.0737*** (6.3103)		0.5421*** (3.0493)
IV	0.3716*** (15.9794)		0.6390*** (7.7472)	
Gov	-0.0548	0.4653*	-0.0152	0.4305
	(-0.3659)	(1.8088)	(-0.2230)	(1.5569)
Public	-0.2035	1.9102***	-0.0581	2.1812***
	(-1.2338)	(4.2374)	(-0.6529)	(4.4513)
Security	-0.3127	1.4825***	-0.2512*	1.2701***
	(-1.6796)	(3.5404)	(-1.9800)	(2.8149)
Tech	0.7080***	0.9786***	0.0955	1.1875***
	(4.4741)	(2.7742)	(0.8623)	(3.0983)
PGDP	0.0068	0.3930***	0.0058	0.4019***
	(-0.2509)	(-7.4028)	(-0.3661)	(-7.2011)
FDI	-0.1401	-1.0449**	-0.1748	-1.0885*
	(-0.6334)	(-2.1417)	(-1.6522)	(-1.8891)
Education	0.1707	-0.0447	-0.1233	-0.1848
	(0.6750)	(-0.1249)	(-1.3202)	(-0.4669)
LM statistic	6.695***		22.173***	
Wald F	374.258***		48.796***	
Observations	451	451	410	410
R-squared	0.8190	0.3635	0.8573	0.3948
City	YES	YES	YES	YES
Year	YES	YES	YES	YES

This paper also selects the lagged period of the explanatory variable, the level of digital economic development, as an instrumental variable. As shown in the third column of Table 5, the regression results of the first stage show that the impact of this instrumental variable on the digital economy is significantly positive at the 1% level. The model passed the LM test and Wald F test, indicating that the selection of instrumental variables was reasonable. The regression results of the second stage show that after addressing the endogeneity problem, the impact of the level of digital economy development on the employment scale in the YRD region is still significantly positive at the 1% level, indicating the robustness of the baseline regression conclusion of the impact of the digital economy on the employment scale in the YRD region.

5.4 Heterogeneity analysis

5.4.1 Central and peripheral cities

The Yangtze River Delta region includes four provinces and municipalities, namely Shanghai, Jiangsu, Zhejiang and Anhui, with a total of 41 cities. In order to create a world-class urban cluster and innovation highland, the State Council executive meeting in 2016 deliberated and approved the "Yangtze River Delta Urban Cluster Development Plan", which included the 27 cities listed in Table 6 into the scope of the Yangtze River Delta urban cluster and established a collaborative development metropolitan area.

Table 6: List of Yangtze River Delta Urban Agglomeration

Province/municipality name	City name
Shanghai	Shanghai
Jiangsu Province	Nanjing, Wuxi, Changzhou, Suzhou, Nantong, Yancheng, Yangzhou, Zhenjiang, Taizhou
Zhejiang Province	Hangzhou, Ningbo, Wenzhou, Jiaxing, Huzhou, Shaoxing, Jinhua, Zhoushan, Taizhou
Anhui Province	Hefei, Wuhu Ma'anshan, Tongling, Anqing, Chuzhou, Chizhou, Xuancheng

The 27 cities within the urban agglomeration are relatively concentrated, and can mutually assist each other in economic development. The speed and quality of digital economic development here are relatively high. The remaining 14 cities are relatively dispersed and located in the marginal areas of the YRD, where the development of the digital economy is relatively slow. Therefore, this paper divides 41 cities into center and edge regions to explore the regional heterogeneity of the impact of the digital economy on the employment scale in the YRD region. Table 7 reports the results of the impact of the development of the digital economy on the employment scale of different regional cities in the YRD region. The results show that the development of the digital economy has a significant positive impact on the employment scale of central cities in the YRD region, and passes the test at the 1% statistical level. For peripheral cities, although the development of the digital economy has a positive impact on their employment scale, the significance level has not been reached, indicating that the impact is not strong enough. Secondly, from a numerical perspective, the regression coefficient of the development of the digital economy on the employment scale of central cities is 0.434, which is much larger than the regression coefficient of 0.0655 for peripheral cities, further indicating that the development of the digital economy has a better promoting effect on the employment scale of core cities within the YRD urban agglomeration than peripheral cities outside the YRD urban agglomeration. This may be due to the good collaborative development between central cities, as well as the relatively developed economies of each city, which provide a high-quality development environment for the digital economy. The foundation for the development of digital economy-related industries is good, with a wide range of digital application scenarios and significant employment creation effects, which in turn creates a huge demand for labor, further expanding the scale of employment.

Table 7: Results of city heterogeneity analysis

Variables	(1) Central city	(2) Edge cities
DigE	0.434***	0.0655
	(0.123)	(0.351)
Constant	10.01***	11.52***
	(0.855)	(1.351)
Control Variables	Y	Y
Observations	297	154
R-squared	0.992	0.984
City	YES	YES
Year	YES	YES

5.4.2 Urbanization level

The level of urbanization is an important factor affecting the development of the digital economy, and it is closely related to employment opportunities. Areas with a high level of urbanization also have better digital economic infrastructure and development environments. This paper uses the urbanization rate, which is the proportion of urban population to the total population, to measure the level of regional urbanization. Further distinguish the differences in the impact of the digital economy on the employment scale in the YRD region between high and low urbanization levels. Table 8 shows the impact of the digital economy on the employment scale in the YRD region under different levels of urbanization. The results show that the development of the digital economy has a positive impact on the employment scale in high-urbanization areas at a significance level of 10%, with a regression coefficient of 0.372. However, the impact on low-urbanization areas is negative, with a regression coefficient of 0.282. This may be due to the fact that areas with a higher level of urbanization have a relatively complete digital infrastructure, the endowment and allocation of resource factors are more complete than those with a lower level of urbanization, and the job-creating effect of the development of the digital economy is obvious. In areas with low levels of urbanization, their infrastructure and public service levels are difficult to support the high-quality development of the digital economy, and as labor migrates to areas with high levels of urbanization, the employment scale in such areas will correspondingly shrink.

Table 8: Results of urbanization levels heterogeneity analysis

Variables	(1) High level of urbanization	(2) Low level of urbanization
DigE	0.372*	-0.282
	(0.202)	(0.347)
Constant	9.495***	10.14***
	(1.147)	(1.091)
Control Variables	Y	Y
Observations	238	213
R-squared	0.556	0.608
City	YES	YES
Year	YES	YES

5.4.3 Broadband China Pilot Policy

In 2013, the State Council issued the "Broadband China" Strategy and Implementation Plan, which divided a total of 120 "Broadband China" demonstration cities in three batches. Broadband network is a strategic public infrastructure for the development of the digital economy, which plays an important supporting role in the development of the regional digital economy. This paper selects the data of "broadband pilot cities in China" in the Yangtze River Delta region from 2011-2021, and distinguishes whether or not it is divided into pilot areas with a 0-1 variable. To further explore the impact of digital economy on employment scale in the Yangtze River Delta region under the differences in broadband pilot projects in China. As shown in Table 9, the heterogeneity analysis results of the "Broadband China" pilot are as follows. The results show that the positive impact of the development of the digital economy on the employment scale in the pilot areas of Broadband China is significant at the 1% statistical level, while there is no significant effect on the employment scale in non-pilot areas. In terms of the regression coefficient, the value is 0.759 for the pilot areas and 0.176 for the non-pilot areas, indicating that the impact of the development of the digital economy on the employment scale in the YRD region is significantly heterogeneous under the broadband China pilot policy.

Table 9: Results of the Broadband China Pilot Policy heterogeneity analysis

Variables	(1) Yes	(2) No
DigE	0.759***	0.176
	(0.246)	(0.152)
Constant	12.85***	8.690***
	(1.885)	(0.797)
Control Variables	Y	Y
Observations	126	325
R-squared	0.996	0.988
City	YES	YES
Year	YES	YES

6. Mechanism Testing

Based on the theoretical and mechanism analysis above, this paper finds that the development of the digital economy has a positive impact on both industrial structure and employment scale, and the upgrading of industrial structure can promote the expansion of employment scale. Therefore, industrial structure upgrading is selected as the mediating variable of the impact of the digital economy on the employment scale in the YRD region. In terms of indicator construction, the ratio of the output value of the tertiary industry to the output value of the secondary industry is selected to measure the upgrading of industrial structure. Table 10 shows the estimated results of the mechanism of the digital economy affecting the industrial structure upgrading of the YRD region's employment scale. The results show that the development of the digital economy has a positive impact on the employment scale in the YRD region at a significance level of 1%, with a regression coefficient of 0.378. The impact of the development of the digital economy on the upgrading of the industrial structure in the YRD region is also positive at a statistical level of 10%, with a regression coefficient of 0.580. The direction of the effect is consistent with the scale of employment, verifying Hypothesis 2. By promoting the development of the digital economy, it can effectively promote the upgrading of the regional industrial structure, thus expanding the scale of employment in the YRD region, increasing the total amount of employment, and boosting "full employment".

Table10: Results of mechanism tests

Variables	(1) Employment Scale	(2) Employment Scale	(3) Industry Structure	(4) Industry Structure
DigE	0.482***	0.378***	0.770**	0.580*
	(0.142)	(0.112)	(0.299)	(0.324)
Gov		0.475*		1.253***
		(0.258)		(0.329)
Public		1.933***		-0.588
		(0.443)		(0.578)
Security		1.143***		-0.644
		(0.408)		(0.623)
Tech		1.306***		1.676*
		(0.374)		(0.947)
PGDP		0.407***		0.0856
		(0.0517)		(0.0553)
FDI		-1.288***		0.378
		(0.483)		(0.707)
Education		-0.0483		2.521***
		(0.349)		(0.468)
Constant	5.490***	9.615***	0.820***	-0.669
	(0.0350)	(0.635)	(0.0736)	(0.687)
Observations	451	451	451	451
R-squared	0.981	0.989	0.892	0.904
City	YES	YES	YES	YES
Year	YES	YES	YES	YES

The impact mechanism of industrial structure upgrading on employment lies in: The upgrading of industrial structure will give birth to a large number of emerging professions and jobs, increase employment demand, and expand the scale of employment. The industrial structure is closely related to the employment of the tertiary industry, and the upgrading of the industrial structure will also lead to an increase in per capita wage income. According to the "Petty-Clark theorem", labor will gradually flow from the primary industry to the secondary industry, and from the secondary industry to the tertiary industry, ultimately leading to changes in the employment market.

For the primary industry, the application of modern spatial information technology and big data has greatly promoted the development of modern agriculture, promoting the upgrading of agriculture to digital and intelligent. For the secondary industry, technological innovation brought by the digital economy is empowering traditional manufacturing, driving the transformation and upgrading of manufacturing, and significantly improving its modernization level. For the tertiary industry, digital technologies such as big data have helped the service industry to flourish. Financial, logistics, retail, cultural and sports service industries are gradually realizing a smart service model. The digital economy has significantly improved the scale, efficiency, and quality of related industries, and its ability to absorb employment is also constantly increasing. In general, the digital economy will promote the optimization and upgrading of regional industries, which in turn will promote the increase of employment scale.

7. Conclusion and policy recommendations

This paper uses the panel data of 41 prefecture level cities in the Yangtze River Delta region from 2011-2021 to construct a two-way fixed effect model to conduct regression analysis of the impact of digital economy development on the employment scale in the YRD region, and conducts robustness tests and endogenous processing. Further, it explores regional heterogeneity and group heterogeneity by sample. Finally, it analyzes the impact mechanism by constructing a mediation mechanism model.

The main conclusions are as follows: the development of the digital economy has a promoting effect on the expansion of the employment scale in the YRD region, indicating that the overall employment creation effect of the development of the digital economy in the YRD region is greater than the employment substitution effect. This impact is more significant in the central cities, areas with higher urbanization levels, and areas with well-developed digital infrastructure. The upgrading of industrial structure plays an intermediary role in the promotion of the expansion of employment scale in the YRD region by the development of the digital economy. The changes in industrial structure driven by the development of the digital economy can effectively improve the efficiency and quantity of employment in the YRD region.

Based on the above theoretical and empirical analysis conclusions, this paper puts forward the following policy recommendations:

- The booming development of new forms of employment brought about by the digital economy has had a disruptive impact on traditional forms of employment, gradually making it an important means of stabilizing employment. To fully unleash the employment dividend of the digital economy, the first step is to promote the development and growth of the digital industry and expand the vast employment space. Cities should grasp the development opportunities of the digital economy, continuously implement the strategy of driving development through innovation, make efforts to promote the expansion of the development scale of the Internet, big data, artificial intelligence, blockchain, cloud computing and a series of digital technology-related industries, encourage the open sharing and efficient use of digital resources, gradually build digital industry clusters with advanced technology as the core, absorb digital skilled personnel, and give full play to the job-creating effect of the digital economy.

- All regions should speed up the cultivation of new professional talents. First, deepen the reform of higher education and vocational education and improve the dual training plan of comprehensive employability and employment skills. Guided by the scientific and technological research and the training of high-skilled talents to promote the innovation and development of digital economy, cities should establish a whole chain training system for education chain, industrial chain and talent chain, promote the interdisciplinary integration of computer, big data, software engineering and other disciplines with other fields, and constantly expand the scale of personnel training in artificial intelligence, industrial Internet, cloud computing, block chain and other fields, so as to transport more suitable professionals for the job market and improve the employment rate. Second, pay attention to the training of medium skilled labor force. The employment of medium skilled labor force is the most impacted in the development of digital economy, and skill training is urgently needed. Internet platforms should be widely used to carry out vocational skills training, such as remote online courses, live teaching and other situations, integrate offline teaching and online training, give full play to the educational function of the platform, and carry out vocational skills training efficiently according to the personalized training mechanism of the labor force individual difference system. At the same time, cities can also appropriately improve the work treatment of digital technology posts, formulate gradient subsidy policies, and attract talents to flow into the digital industry.
- Accelerate the process of industrial digital transformation, promote the optimization and upgrading of industrial structure, and further promote the development of the employment market. The first is to promote the transformation and upgrading of traditional industries. For the primary industry, cities should accelerate the process of agricultural modernization and enhance farmers' digital skills. For the secondary industry, promote manufacturing innovation, especially the innovation of core key technologies. For the tertiary industry, government should give full policy support and vigorously promote platform construction to provide more accurate and efficient intelligent services. Second, break the barriers to the flow of labor between industries and optimize the allocation of labor resources. Promote the equalization of public services and rationally guide the distribution of labor resources in the three industries. Third, actively cultivate emerging industries and future industries. According to market demand and technological development trends, cities should actively cultivate and develop emerging industries, especially strategic emerging industries such as Internet of things, big data, cloud computing, block chain and artificial intelligence. Through policy support and market guidance, cities should promote the rapid growth of emerging industries, provide new growth points for the job market, and promote the upgrading of the job market.

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