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Digital Economy, Urbanization and Labor Skill Structure: An Empirical Analysis Based on Provincial Panel Data

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ABSTRACT

Based on provincial panel data from 2013-2021, this paper explores the relationship between digital economy, urbanization, and labor skill structure. By building a bi-directional fixed effect model and introducing interaction terms, the empirical findings show that digital economy has a significant positive promoting effect on the skill structure of the labor force, and urbanization plays a moderating role in it, and this promoting effect will be further enhanced with the improvement of urbanization. Accordingly, the following policy recommendations are put forward: First, strengthen the construction of digital economy and promote the development and application of digital technology. Second, promote urbanization and optimize the distribution of population and industries. Third, strengthen education and training to upgrade the skills of the workforce.

KEYWORDS

Digital economy; Urbanization; Skill structure of labor force; Two-way fixed effect model

1. INTRODUCTION

With the rapid development of information technology, digital economy has become a new engine of global economic growth. The digital economy has profoundly changed the production mode and business model of traditional industries through technological means such as digitization, networking and intelligence, and has also had a profound impact on the labor market. Driven by the digital economy, the skill structure of the workforce is undergoing major changes, which also puts forward a higher level of labor quality requirements. At the same time, the continuous advancement of urbanization has not only brought about the concentration and flow of population, but also promoted the transformation and upgrading of economic structure. In this process, the change of labor force skill structure is closely related to the promotion of urbanization. On the one hand, urbanization provides more employment opportunities and higher income level for the labor force, and promotes the improvement of labor skills. On the other hand, the advancement of urbanization also puts forward higher requirements for the skill structure of the labor force, and more high-quality labor forces are needed to support economic development.

The impact of the rapid development of digital economy and the rapid process of urbanization on the skill structure of the labor force cannot be ignored. The study of labor skill structure is of great significance for alleviating the contradiction between labor supply and demand, promoting the development of innovative talents, narrowing the regional development gap, and promoting industrial upgrading and transformation. In this context, the significance of studying labor skill structure is self-evident. This paper aims to explore the interaction between digital economy, urbanization and labor skill structure, and give corresponding policy implications. Based on this, on the basis of the review

of relevant literature, this paper builds a theoretical model, puts forward research hypotheses, and uses provincial panel data for empirical analysis to test the direct impact of digital economy on labor skill structure and the adjustment effect of urbanization rate on this impact. Finally, the paper summarizes the research conclusions and puts forward corresponding policy recommendations.

2. THEORETICAL ANALYSIS AND RESEARCH HYPOTHESIS

The rapid development of the digital economy has promoted technological innovation and industrial upgrading, bringing about major changes in production methods, which puts higher requirements on the labor force and requires the labor force to have higher professional skills and innovation capabilities. Therefore, with the deepening development of the digital economy, the demand for highly skilled labor is constantly increasing. At the same time, the application of digital technology has made some traditional jobs replaced by automation and intelligent technology, especially those with high repetitive and low skill requirements. This leads to a relative reduction in the demand for low-skilled labor, which in turn encourages labor to shift to higher-skilled jobs [1]. Within the industry, the digital economy is gradually reshaping the labor market landscape. Specifically, it has driven employment growth in high-tech manufacturing, increasing the demand for labor in this area, and correspondingly reducing the share of employment in low-tech manufacturing. This reflects a clear trend: the labor force is shifting from sectors that rely on lower skill levels to those with higher skill content. The flow of labor force to the tertiary industry makes the proportion of employment in the tertiary industry increase, while the proportion of employment in the primary and secondary industries shows a downward trend. In other words, with the in-depth application of digital technology, the demand for high-skilled labor is gradually increasing, while that for low-skilled labor is relatively decreasing [2-3]. Further, the educational requirements of the digital economy for the labor force are also becoming increasingly prominent. The advantage of the highly educated labor force in the job market is becoming more and more obvious, and their employment proportion has increased significantly. In contrast, the low-education labor force is facing a greater challenge in employment, and the proportion of employment has declined. This trend reflects the increasing demand for a workforce with advanced knowledge and skills as the digital economy develops rapidly. Therefore, this paper holds that the digital economy has a significant positive effect on the skill structure of the labor force.

The process of urbanization has promoted the agglomeration of population and economic activities, providing a broader market and more human resources for the development of the digital economy. As the urban population increases, so does the demand for digital products and services, which further stimulates the innovation and development of the digital economy. With its efficient and convenient characteristics, the digital economy has rapidly penetrated into all aspects of urban life, from e-commerce to intelligent transportation, from online education to telemedicine, the application of digital technology is constantly changing the lifestyle and work mode of urban residents. Specifically, urbanization can promote the development of digital economy through the intermediary effect of regional market-oriented reform [4], and digital economy can promote the improvement of human capital by promoting the process of urbanization [5]. With the improvement of urbanization rate, on the one hand, the scale of urban population expands, and the market demand becomes more vigorous. This provides favorable conditions for the large-scale application of the digital economy, and further promotes the development of digital economy-related industries and the optimization of the skill structure of the labor force. On the other hand, a large number of talents have flooded into cities, providing rich human resources for the digital economy. These talents are not only driving innovation and adoption of digital technologies, but also upgrading the skill level of the entire labor market through their own skills and knowledge. The theoretical analysis framework is shown in Figure 1.

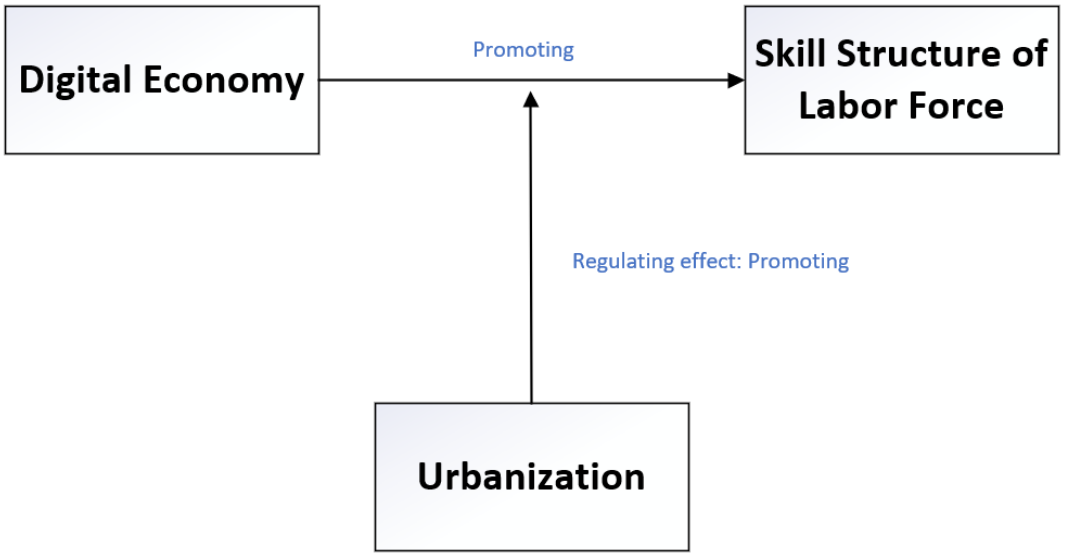

Figure 1. Theoretical analysis framework

Accordingly, this paper proposes the following theoretical hypotheses:

H1: The digital economy has a positive effect on the skill structure of the workforce.

H2: With the increase of urbanization rate, the digital economy has a stronger role in promoting the skill structure of the labor force.

3. RESEARCH DESIGN

3.1. Model Construction

3.1.1. Baseline regression model

Based on research hypothesis 1, this paper uses provincial panel data to set a bi-directional fixed-effect model to test the impact of digital economy on labor skill structure. The specific model is shown in equation (1).

$$lab_{it} = \alpha_0 + \alpha_1 dig_{it} + \alpha_2 X_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (1)$$

In the model, lab stands for labor skill structure, dig stands for digital economy, X stands for a set of control variables affecting labor skill structure, including regional economic development level, government support, and opening to the outside world, i and t stand for region i and period t respectively, α stands for parameter to be estimated, λ stands for individual fixed effect, and if stands for period fixed effect. ε is the random disturbance term of the model.

3.1.2. Modulating effect model

In order to further test the regulating effect of urbanization rate on digital economy and labor skill structure, urbanization rate and interaction terms between digital economy and urbanization rate are added on the basis of benchmark model (1) to obtain model (2), as shown in Formula (2).

$$lab_{it} = \beta_0 + \beta_1 dig_{it} + \beta_2 urb_{it} + \beta_3 dig_{it} \times urb_{it} + \beta_4 X_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (2)$$

In the model, urb is the urbanization rate, dig×urb is the interaction term between the digital economy and the urbanization rate, in order to investigate the moderating effect of the urbanization rate on the

digital economy and the skill structure of the labor force, β represents the parameter to be estimated, and other variables are defined in the same model (1).

3.2. Variable Selection

3.2.1. Explained variables

Labor-skill structure lab: In this paper, referring to the research of Hui Shupeng et al. [6], workers with college education or above are regarded as high-skill labor, and those with high school education or below are regarded as low-skill labor, and the ratio of the two is used to measure the labor-skill structure.

Table 1. Evaluation index system of labor skill structure

sort	Educational level
Low education level	Primary school education and below
	Junior high school education
	High school education
High level of education	Junior college degree
	Bachelor's degree
	Postgraduate education: Master's degree and doctor's degree

3.2.2. Explanatory variables

Digital economy: Based on the relevant studies of Zhao Tao and Zhang Zhi et al. [7], this paper constructs a digital economy evaluation index system to measure the development level of digital economy in each province from five aspects, such as Internet penetration rate, relevant employees, relevant output, mobile phone penetration rate, and inclusive development of digital finance, and calculates the digital economy through the entropy method.

Table 2. Digital economy evaluation index system

Comprehensive index	Primary index	Secondary index	Weight
Digital economy	Internet penetration	100 people with broadband Internet access	0.1067
	Mobile phone penetration	Number of mobile phone users in 100 people	0.0837
	Relevant practitioners	Computer services and software industry employees accounted for the proportion of urban units employed	0.3299
	Relevant output situation	Total telecommunications services per capita	0.3932
	Inclusive development of digital finance	Digital Financial Inclusion Index	0.0865

3.2.3. Adjust variables

Urbanization rate: This paper uses the proportion of urban population to total population in each province to measure urbanization rate.

3.2.4. Control variables

In order to reduce the estimation bias caused by missing variables, the following variables are selected: (1) regional development level: measured by per capita GDP. (2) Salary of employed personnel: the

average salary of employed personnel is measured. (3) Government support: the logarithmic measurement of education expenditure in fiscal expenditure is adopted. (4) International direct investment: the number of foreign direct investment of each province is taken. (5) Opening to the outside world: the total amount of imports and exports is measured by logarithm.

Table 3. Variable selection and variable description

	variable	index	symbol	unit
Explained variable	Skill structure of labor force	Educational ratio	lab	-
Explanatory variable	Digital economy	See Evaluation index system for details	dig	-
Regulating variable	Urbanization rate	Urban population accounts for the total population	urb	%
Control variable	Regional development level	Per capita GDP	gdp	Ten thousand yuan
	Salary of employed personnel	Average wage of employed persons	sal	Ten thousand yuan
	Government support	Education is part of government expenditure	gov	Hundred million yuan
	International direct investment	Foreign direct investment by province	fdi	Hundred million yuan
	Open to the outside world	Total import and export value	open	Hundred million yuan

3.3. Data Selection

This paper selects provincial panel data from 2013 to 2021 for empirical analysis. The data comes from the EPS database and the statistical yearbooks of each province, and the statistical table of variables is shown as follows.

Table 4. Descriptive statistics of variables

Variable	Obs	Mean	Std. Dev.	Min	Max
lab	270	0.306	0.26	0.091	1.698
dig	270	0.223	0.156	0.021	0.927
urb	270	60.883	11.48	37.89	89.6
gdp	270	6.223	2.943	2.315	18.398
sal	270	7.4	2.544	3.83	19.465
gov	270	6.66	0.655	4.727	8.242
fdi	270	5.446	1.799	-1.575	7.63
open	270	8.129	1.582	3.134	11.321

4. EMPIRICAL ANALYSIS

4.1. Baseline Regression

The regression results of model (1) are shown in the following table. At the significance level of 5%, the regression coefficient of the digital economy is 0.312, indicating that the digital economy has a positive promoting effect on the skill structure of the labor force. In short, the vigorous development of the digital economy is promoting the optimization and upgrading of the skill structure of the labor force. The widespread adoption of digital technologies, such as big data analytics, cloud computing, and artificial intelligence, has not only changed traditional ways of working, but also had a profound

impact on the skill needs of the workforce. In this context, in order to adapt to the development of the digital economy, the labor force must constantly improve its professional skills and knowledge level, which promotes the upgrading of the skill structure of the entire labor market.

4.2. Adjustment Effect Test

The regression results after the introduction of interaction terms are shown in the following table. The results show that at the significance level of 10%, the interaction coefficient between digital economy and urbanization rate is positive, that is, with the increase of urbanization rate, the promotion effect of digital economy on the skill structure of labor force will be further enhanced. The acceleration of the urbanization process provides a broad market and more application scenarios for the development of the digital economy, and also provides more employment and development opportunities for the labor force. With the increase of urbanization rate, the workforce has more access to advanced digital technologies and concepts, so that it can adapt to the development needs of the digital economy more quickly. Therefore, the increase of urbanization rate not only promotes the vigorous development of the digital economy, but also further strengthens the positive impact of the digital economy on the skill structure of the labor force.

Table 5. Empirical results

	(1)	(2)	(3)	(4)
Variables	lab	lab	lab	lab
sz	0.312**	-0.008	0.363***	0.363**
	(2.36)	(-0.04)	(2.89)	(2.18)
city		-0.009*		
		(-1.81)		
sz_city		0.005*		
		(1.99)		
gdp	0.008	0.006	0.002	-0.002
	(1.05)	(0.89)	(0.23)	(-0.20)
sal	0.051***	0.027*	0.049**	0.078***
	(3.96)	(1.79)	(2.64)	(5.63)
gov	-0.217***	-0.085	-0.200***	-0.136**
	(-5.70)	(-1.38)	(-3.34)	(-2.24)
fdi	0.004	0.003	0.003	-0.004
	(0.66)	(0.75)	(0.66)	(-0.49)
open	0.001	-0.005	0.018	0.031
	(0.10)	(-0.47)	(1.36)	(1.25)
Constant	1.247***	1.105***	1.073***	0.470
	(4.72)	(3.84)	(2.86)	(1.06)
Observations	270	270	210	135
Number of id	30	30	30	15
R-squared	0.812	0.836	0.752	0.868
id FE	YES	YES	YES	YES
year FE	YES	YES	YES	YES
F test	0	0	0	0
r2_a	0.802	0.825	0.737	0.852
F	35.97	84.16	25.34	5358

4.3. Robustness Test

In order to test the robustness of regression results, this paper adopts two methods to test the robustness. First, taking 2015 as the time node, data from 2015 to 2021 are selected for robustness test. The regression results are shown in column (3) of Table 5. The regression results are consistent with the baseline regression results and pass the robustness test. Secondly, the robustness test is carried out with the northern provinces as sub-samples. The regression results are shown in column (4) of Table 5, which shows that the coefficient of digital economy is still significantly positive and passes the robustness test. This indicates that the positive impact of the digital economy on the skill structure of the labor force is significant in both the national scale and in specific regions, and also shows that the enhancement effect of the digital economy on the skill structure of the labor force is universal and robust.

5. CONCLUSIONS AND SUGGESTIONS

Through empirical analysis, this paper finds that the digital economy has a significant positive promoting effect on the skill structure of the labor force, and with the increase of urbanization rate, this promoting effect will be further enhanced. This conclusion shows that in the context of the rapid development of digital economy and urbanization, strengthening the construction of digital economy and improving the level of urbanization is an important way to promote the upgrading of labor skill structure. Based on the above research conclusions, this paper puts forward the following policy recommendations: First, strengthen the construction of digital economy and promote the development and application of digital technology. The government should increase investment in the construction of digital infrastructure to improve the innovation capacity and competitiveness of the digital industry. At the same time, we encourage enterprises to increase investment in research and development, and promote the innovation and development of new technologies, new business forms and new models. Second, promote urbanization and optimize the distribution of population and industries. The government should formulate a scientific and reasonable urbanization development plan to promote the agglomeration of population and industries to cities and towns. At the same time, strengthen the construction of urban infrastructure, improve the comprehensive carrying capacity of the city, and provide strong support for the upgrading of the labor force skill structure; Third, strengthen education and training to upgrade the skills of the workforce. The government should increase the investment in education and improve the allocation efficiency of educational resources. At the same time, enterprises and social organizations are encouraged to participate in education and training, and provide diversified training programs and services to help the workforce upgrade their skills and adapt to the needs of the development of the digital economy.

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