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EVALUATING IMPACTS OF ICT DEVELOPMENT ON WAGES OF WORKERS

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Abstract. At the provincial level, there is a research gap in discussing the causality and internal mechanism between ICT development and wages of workers. The study utilizes the province-level balanced panel data over the period 2006–2021 in China, clarifies the impact and internal mechanism of ICT development on wages of workers, and uses the DID method to identify the causality between the two. This study found that there is a positive correlation between ICT development and workers' wages, and skill level is a mediate transmission channel. Moreover, ICT development has a positive impact on workers' wages in the central and western regions. Besides, compared to low-wage workers, high-wage workers gain more information dividends. The findings of this study have reference significance for policymakers. First, for the central and western provinces in China, it is necessary to actively develop the ICT industry, cultivate high-tech enterprises, and improve local ICT development levels. Second, we should improve the skill level of workers and enhance their competitive advantage in employment. Third, each province should continue to expand the enrollment scale of higher education institutions, and improve the quality of labor force.

Keywords: ICT development, wages, skill level, high-quality and full employment, China.

JEL Classification: J21, J24, J31.

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1. Introduction

Employment is the most basic livelihood, and promoting high-quality and full employment is the mission of the Communist Party of China. The Third Plenary Session of the 20th Central Committee of the CPC pointed out the need to improve the policy of prioritizing employment and establish a mechanism for promoting high-quality and full employment. Since human-beings entered the information age, information and communication technologies (ICTs) has had a profound impact on the economy and society, changing people's way of life and work, and computers and mobile phones have become an essential part of people. In daily life, human-beings are constantly influenced by ICT, such as remote work, online education, telemedicine, video chat, online shopping, etc. As a General Purpose Technology (GPT), the concept of ICT is very broad and constantly changing, including headphones, ETC system, industrial robots, fixed broadband, wireless networks, smart phones, radio and television, personal computers, voice recognition, video conferencing, etc. (Rath et al., 2023;

Shi, 2023). Obtaining wages is the direct purpose of workers, the foundation for maintaining basic living, and the condition for achieving comprehensive development. Wage is also an important factor in measuring the job quality of workers (Cascales Mira, 2021; Myhill et al., 2021). The wages of workers are also one of the most notable social concerns in academia and government. Thus, discussing the impact of ICT development on wages of workers has strong academic and practical significance. Besides, China has a vast territory and a large population, ranking second in GDP for a long time in the world. In 2023, the contribution rate of China's economy to global economic growth reached 32%, making it the largest engine of global economic growth. Taking China as an example, clarifying the impact mechanism of ICT development on workers' wages and proposing relevant policy recommendations can provide reference for other countries.

The relation between ICT development and wages has always been controversial in the academic field. On the one hand, numerous empirical studies have identified a positive correlation between ICT development and wages. For instance, Forman et al. (2012) found that there is a positive correlation between Internet investment and wage growth. Akerman et al. (2015) found that broadband internet raises the wages of workers with abstract tasks. Hunter and Lafkas (2003) found that ICT use is related to positively to wages. Taniguchi and Yamada (2022) found that a rise in ICT equipment is conducive to improving the wages of workers. Alekseeva et al. (2021) found that AI skills carry a wage premium. Namely, high-skilled workers are the biggest beneficiaries of AI development. Similarly, Falck et al. (2021) found that mastering ICT skills is beneficial for improving the income level of workers. Felten et al. (2018) found that new advances in AI have a positive impact on wages in high-income occupations. Fossen and Sorgner (2022) found that digital labor-reinstating technologies are beneficial for promoting individual's wage growth. Nonvide (2023) found that ICTs use improves agricultural households' wages. Shi (2023) matched province-level data with individual data and found that there is a positive correlation between ICT development and workers' wages. Majumdar (2014) found that the diffusion of broadband among the firms has increased the average wage level of firms in the sector. On the other hand, some scholars have found that there is a negative correlation between the two. For instance, Bu and Tang (2023) found that after one percentage point increase in the number of fixed-line users per capita, there is a 0.06% decrease in average wages. Shahiri and Osman (2015) found that no clear evidence exists that Internet job search (IJS) increases individual wages. Acemoglu and Restrepo (2020) found that one more robot per thousand workers reduces the wages by 0.42%. Fossen and Sorgner (2022) found that automation technology has replaced some of the labor force, which is not conducive to increasing the wages of workers. Akerman et al. (2015) found that increasing the availability of broadband internet has reduced the wages of low-skilled workers.

Although many scholars have discussed the relation between ICT development and wages, at the provincial level, there is still a research gap in discussing the causality and internal mechanism between ICT development and wages of workers. Specifically, most scholars only examine the relation between the two from a microscopic perspective. Then, it is necessary to test the applicability of the skill-biased technological change (SBTC) hypothesis in explaining the relation between technological change and wages in the Chinese context. For the measurement indicators of ICT development, some scholars only use a single variable to measure,

including macro indicators such as mobile phone usage, fixed-line telephone installation rate, or Internet access rate, and micro indicators such as whether individuals or enterprises use smart phones, the Internet, ERP systems, OA systems, or industrial robots (Asongu & Le Roux, 2017; Biagi & Falk, 2017; Dzator et al., 2023; Nonvide, 2023; Richmond & Triplett, 2018; Shi, 2022). Due to the different development conditions in each province, the impact of ICT development on workers' wages in different regions may be heterogeneous. Besides, according to the SBTC theory, technological change tends to favor high-skilled workers, and further discussion is needed on whether skill level plays a partial mediation effect between ICT development and wages.

As a result, the research objectives of this article include the following aspects. At the provincial level, we examine the direct impact of ICT development on wages, discuss the indirect impact of ICT development on wages through skill level, attempt to identify the causality between ICT development and wages through "Broadband China" demonstration city construction policy, and analyze the regional heterogeneity. As for the empirical strategy of this article, we utilize the province-level balanced panel data covering the period 2006–2021 in China, use OLS model to examine the direct impact of ICT development on workers' wages, and use a mediation effect model to analyze the internal mechanism. Besides, when tackling the potential endogenous issues and identifying the causality, in addition to using an instrumental variable (IV) approach, we also use the difference-in-differences (DID) method.

The remainder of the article is structured as following. Part I introduces the relevant theories and proposes research hypotheses. Part II provides a detailed introduction to the research design. Part III is the analysis of empirical results. Part IV proposes discussion, conclusion, and policy recommendation.

2. Theoretical analysis and research hypotheses

First of all, ICT development has changed the skill structure of the industry by increasing the proportion of high-skilled workers and reducing the proportion of low-skilled workers. Second, ICT development has promoted the development of high-income industries such as finance (e.g., banking, insurance, security, and trust industries, etc.), information services, and communication, increasing the demand for high-skilled workers. Third, although ICTs (such as computers, artificial intelligence, automation, and cloud computing, etc.) are replacing the labor engaged in procedural work tasks, ICTs have also created new work tasks. These new tasks include industrial robot design, AI development, chip design, etc., creating new careers such as database administrator, virtual reality technicians, network security officer, live streaming salesperson, delivery personnel for online orders, etc. Besides, ICT has raised labour productivity, expanded the scale of e-commerce, increased employment opportunities, promoted wages diversification, increased off-farm income, and increased the proportion of service industry employment (Acemoglu, 2003; Acemoglu & Restrepo, 2019; Bauer, 2018; Behar, 2016; Bloom et al., 2015; Carrera et al., 2021; Chege & Wang, 2020; Falk & Hagsten, 2015; Goos et al., 2014; Ma et al., 2020; Niu et al., 2022; Yang et al., 2021). Based on the above analysis, we propose the following research hypothesis:

H1: *ICT development is conducive to improving the wage level of workers.*

Supporters of the skill-biased technological change (SBTC) hypothesis believe that technological progress benefits high-skilled workers. Technological change has increased the demand for high-skilled workers and reduced the demand for low-skilled workers. ICT development requires workers to possess skills such as abstraction, logic, innovation, leadership, communication, and analysis. Therefore, those who master core skills have more obvious employment advantages and obtain higher skill premiums, while low-skilled workers are at a disadvantage in the job market (Fadinger & Mayr, 2014; Fossen & Sorgner, 2022; Lee et al., 2022; Machin & Van Reenen, 1998; Majumdar, 2014; Michaels et al., 2014). In addition, higher education represents a high level of skills and helps alleviate the negative impact of ICT on wages of workers. In general, if high-educated workers are able to adapt to changes in ICT, they will become the biggest beneficiaries of ICT development (Fossen & Sorgner, 2022). Due to skill barriers, most high-educated workers are engaged in occupations with abstract work tasks, and their wage levels are usually high. However, low-educated workers are mostly engaged in manual tasks, and their wage levels are usually lower than those of high-educated workers (Akerman et al., 2015). Thus, we propose the following research hypothesis:

H2: *ICT development has an indirect impact on wages through skill level.*

The theory of diminishing marginal returns suggests that as an item continues to increase, the utility per unit of continuously increasing item will decrease (Lin & Peng, 2019). As a result, when ICT develops to a very high level, the impact on wages may be reduced. For different regions in China, there is heterogeneity in ICT development due to differences in population changes, geographical location, economic development, and international trade. The development level of ICT in eastern regions such as Beijing, Shanghai, Zhejiang, and Jiangsu is relatively high, ICT has deeply integrated with industries and generated many employment opportunities, and the income promotion effect of ICT development may decrease or disappear. On the contrary, the level of ICT development in central and western regions such as Guizhou, Yunnan, Henan, and Gansu is relatively low, and the impact of ICT development on workers' wages may still be significant. Thus, we propose the following research hypothesis:

H3: *ICT development has a positive impact on the wages of workers in the central and western regions, and the impact on wages in the eastern region is not significant.*

3. Methodology

3.1. Data source

This paper uses provincial panel data to examine the relation between ICT development and wages. China Statistical Yearbook (CSY) is an annual statistical publication collected by the National Bureau of Statistics [NBS], and it covers key statistical data in recent years and some historically important years at the national level and the local levels of provincial level. The China Statistical Yearbook includes indicators such as postal and telecommunications business volume, major telecommunications communication capabilities, postal industry outlets, telecommunications service level, internet development related indicators, software and information service industry main indicators, population size, wage level, GDP, price index, colleges and universities, total imports and exports, etc. (National Bureau of Statistics, 2021).

In this study, the research scope covers 30 provinces in Chinese Mainland (except Tibet, Hong Kong, Macao, and Taiwan Province), and the time span is from 2006 to 2021, with a total of 480 observations (strongly balanced panel data).

3.2. Econometric models

In order to examine the direct impact of ICT development on workers' wages, we construct the following model:

$$\text{Wages}_{it} = \alpha_0 + \alpha \cdot \text{ICT development}_{it} + \beta \cdot \sum_{i=1}^{n} \text{Controls}_{it} + \lambda_i + \varepsilon_{it}. \quad (1)$$

In Equation (1), where α is the effect of the core explanatory variable (i.e. ICT development) on the dependent variable (i.e. wages), β are the effects of all control variables (i.e. GDP, public expenditure, export volume, etc.) on wages. Besides, α_0, ε_{it}, and λ_i denote the constant, the error term and fixed effect, respectively. In Equation (1), we mainly focus on the coefficient and significance of α. If the estimated coefficient α is positive, it means that there is a positive correlation between ICT development and wages of workers; otherwise ICT development decreases wages of workers.

Following the approach of scholars (see Preacher & Hayes, 2004; Shi, 2023; Zhao et al., 2010; Zhou, 2023), when we analyze whether ICT development indirectly affects workers' wages through skill level, we establish the following mediation effect models:

$$\text{Wages}_{it} = c \cdot \text{ICT development}_{it} + \beta \cdot \sum_{i=1}^{n} \text{Controls}_{it} + e_1; \quad (2)$$

$$\text{Skill level}_{it} = \alpha \cdot \text{ICT development}_{it} + \beta \cdot \sum_{i=1}^{n} \text{Controls}_{it} + e_2; \quad (3)$$

$$\text{Wages}_{it} = c' \cdot \text{ICT development}_{it} + b \cdot \text{Skill level}_{it} + \beta \cdot \sum_{i=1}^{n} \text{Controls}_{it} + e_3. \quad (4)$$

In Equation (2), where *c* is the total effect of the core explanatory variable (i.e. ICT development) on the dependent variable (i.e. wages). The *a* in Equation (3) is the direct effect of ICT development on skill level (i.e. mediation variable), *b* in Equation (4) is the direct effect of skill level on wages after controlling the impact of ICT development, and c′ in Equation (4) is the direct effect of ICT development on wages after controlling the impact of skill level. In addition, the relation between different estimated coefficients: $c = a \times b + c'$, and the proportion of mediation effect to total effect is *ab*/*c*.

Besides, in the heterogeneity analysis section, we construct the following quantile regression (QR) model:

$$Y_\tau \equiv Q_{Y_{it}}\left(\tau \mid X_{it}\right) = \alpha_i\left(\tau\right) + X_{it}^{'} \cdot \beta\left(\tau\right). \quad (5)$$

In Equation (5), where *i* represents 480 observations, *t* represents from 2006 to 2021 (16 years), and $\tau \in (0,1)$, $\tau = P\left(Y_{it} \le Y_\tau \mid X_{it}\right) = F_{Y_{it}|X_{it}}\left(Y_\tau\right)$. We determine who is the winner of ICT development by analyzing the difference in the impact of ICT development on workers' wages at different quantile. If the quantile is small, and estimated coefficient is relatively large, which means that low-income workers have gained more information dividends. On the contrary, high-income workers are the biggest winners in the development of ICT.

3.3. Variable selection and description

(1) Dependent variable. In this study, based on the availability of data, we use the average annual wage (CNY) of workers as a substitute variable for wages, and we standardize wages (0–1).

(2) Core explanatory variables. Following the research of scholars (Dzator et al., 2023; Njangang et al., 2022; Ofori et al., 2022; Shi, 2023), we use the following indicators to measure: (i) Internet access rate, (ii) mobile phone usage rate, (iii) ICT output value, and (iv) technical level. Among them, the number of Internet broadband access port per 100 people, the number of mobile phones per 100 people, per capita telecommunications business volume, and per capita technology market transaction volume are substitute variables for Internet access rate, mobile phone usage rate, ICT output value, and technical level, respectively. To obtain more objective results when measuring ICT in various provinces, following the approach of Qiu et al. (2021), we use entropy weight method to determine the weight of indicators, and we get the score of ICT development (between 0 and 1).

(3) Mediation variable. Based on existing research experience (Akerman et al., 2015; Autor & Dorn, 2013; Cortes, 2008; Luo et al., 2022; Zou et al., 2009), we use the proportion of college student in a region to the total population as a substitute variable for skill level. According to the human capital theory, educational background affects the skill level of workers. Herrera et al. (2023) found that there is an interactive effect between education and ICTs. Therefore, using the proportion of college student as a substitute for skill level is feasible.

Table 1. Variable description and definitions

Variables	Definitions	Obs.	Mean	Std. dev.	Min.	Max.
Wages	Average annual wage of workers	480	57,263	30,243	15,590	201,504
ICT development	It is calculated from four indicators (i.e., Internet access rate, mobile phone usage rate, ICT output value, and technical level)	480	0.152	0.186	0.007	1.000
Skill level	The proportion of college student to the total population	480	0.019	0.006	0.006	0.042
Gdp	GDP per head	480	46,430	29,368	6,103	187,526
Tertiary industry	The proportion of tertiary industry to the total GDP	480	46.972	9.495	29.700	83.700
Public expenditure	Per capita public financial expenditure	480	106.144	67.167	15.333	340.895
Export volume	Per capita foreign-invested enterprises export volume	480	611.210	1,115	0.125	6,043
Real estate sales	Per capita real estate sales	480	66.742	55.644	3.602	291.319
Unemployment rate	The registered urban unemployment rate	480	3.392	0.660	1.210	5.100

(4) Control variables. We control the heterogeneity of provinces, including GDP per head, the proportion of tertiary industry to the total GDP, per capita public financial expenditure, per capita foreign-invested enterprises export volume, per capita real estate sales, and the registered urban unemployment rate. Consistent with dependent and independent variables, we standardize all control variables (0–1). According to the results of collinearity test, the mean VIF of all variables is 4.8, indicating that there is no multicollinearity issue. Descriptive statistics and definitions of variables, please see Table 1.

4. Empirical results

4.1. Impacts of ICT development on wages of workers

First of all, to analyze the dynamic changes in wages and ICT development, we drew a kernel density figure (see Figure 1). In Figure 1, the left figure represents 2006 and the right figure represents 2021; the blue line represents wages, while the red line represents ICT development. The Figure 1 shows that wages of workers are showing an upward trend, and the wage gap among workers in different provinces is showing a narrowing trend. Moreover, the level of ICT development is increasing, and there is a trend of widening the information gap in different provinces.

According to the Hausman test results, the fixed-effect model is applicable to the balanced panel data of this study, and the estimated results are shown in Table 2. Columns 1, 2, 3, and 4 are fixed-effects (FE) and Column 5 is random-effect (RE). Column 1 indicates that ICT development has a significant positive impact on workers' wages without adding any control variables. Columns 2, 3, and 4 indicate that the impact of ICT development on workers' wages remains significantly positive, even with the addition of control variables.

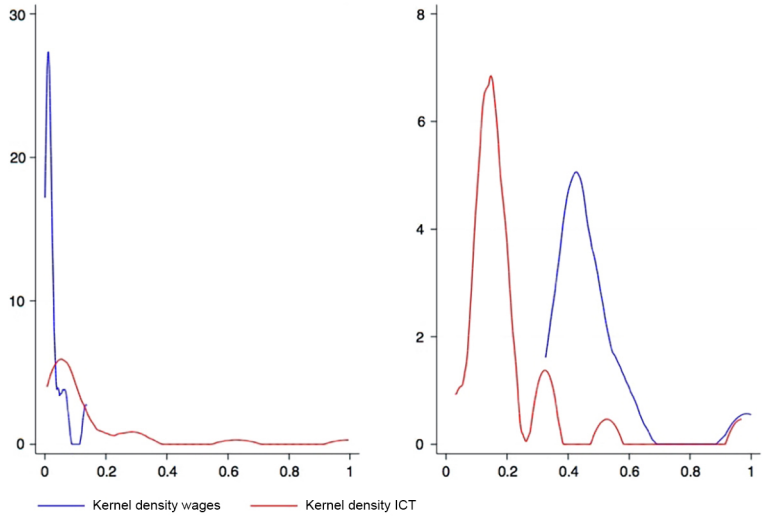

Figure 1. Kernel density (left – 2006 and right – 2021)

Column 5 indicates that when we examine the relation between the two using random-effects, the research conclusions of this article remain unchanged, hence, the research hypothesis H1 has been confirmed. ICT development has improved labour productivity and individual performance, given birth to new industries (such as the Internet, electronic commerce, and information service, etc.), emerged new careers (such as food/drug delivery courier, K12 lecturer, software engineers, database administrators, and web designers, etc.), provided a large number of high-quality employment positions, increased the proportion of non-agricultural employment (such as transportation, tourism, catering, and accommodation, etc.), increased employment rates, and thus increased the wages of workers.

Table 2. The direct impact of ICT development on workers' wages

	(1)	(2)	(3)	(4)	(5)
ICT development	1.929*** (0.169)	1.865*** (0.177)	1.677*** (0.171)	1.245*** (0.173)	0.451*** (0.093)
Gdp		0.261 (0.183)	–0.085 (0.185)	–0.232 (0.188)	–0.332*** (0.076)
Tertiary industry		–0.045 (0.122)	0.043 (0.116)	0.017 (0.111)	–0.269*** (0.057)
Public expenditure			0.615*** (0.084)	0.445*** (0.083)	0.190*** (0.032)
Export volume			0.161 (0.203)	–0.071 (0.195)	0.148*** (0.051)
Real estate sales				0.181*** (0.050)	0.252*** (0.039)
Unemployment rate				0.230*** (0.041)	0.129*** (0.029)
Constant	–0.069*** (0.026)	–0.120 (0.074)	–0.197*** (0.071)	–0.143** (0.072)	0.127*** (0.015)
Observations	480	480	480	480	480
R-squared	0.224	0.230	0.313	0.387	0.339
FE	Yes	Yes	Yes	Yes	No
RE	No	No	No	No	Yes

Notes: Standard errors in parentheses. Columns 1, 2, 3, and 4 are fixed-effects. Column 5 is random-effect. ***, **, and * denote significance level of 1%, 5% and 10%, respectively (the same below, no more repeated explanations).

4.2. Mediation effect results

To examine the internal mechanism of ICT development on workers' wages, we use skill level as the mediation variable to estimate. Table 3 shows that the total effect of ICT development on wages (c) is positive, and the direct effect of ICT development on skill level (a) is positive. After controlling the effect of ICT development, the direct effect of skill level on wages (b) is positive; after controlling the effect of skill level, the direct effect (c') of ICT development on wages is positive. Hence, ICT development has an indirect impact on wages through skill level, with a mediation effect contribution rate of 31.65% (i.e., *ab*/*c*), and the research hypothesis

Table 3. Mediation effect results

	(1) Wages	(2) Skill level	(3) Wages
ICT development (c)	0.451*** (0.093)		
ICT development (a)		0.018*** (0.004)	
Skill level (b)			7.929*** (1.087)
ICT development (*c'*)			0.306*** (0.091)
Control variables	Yes	Yes	Yes
Constant	0.127*** (0.015)	0.017*** (0.001)	–0.007 (0.023)
Observations	480	480	480

H2 has been confirmed. If workers have higher skill levels, they have a higher probability of using ICTs, are more likely to search for jobs through the Internet, engage in high-end service industries, and have higher wages (Shi, 2023); if workers have low skill levels, they are more likely to engage in low-end service industries (such as catering, accommodation, tourism, and transportation, etc.), and have lower wages.

In China, many college graduates prioritize employment in their province. Taking Peking University (located in Beijing, China) in 2021 as an example, the proportion of undergraduate students employed in Beijing is 42.33%, master's students employed in Beijing is 45.63%, and doctoral students employed in Beijing is 53.10% (Peking University, 2021). Even in underdeveloped western provinces, employment is mainly within the province. Taking Lanzhou University (located in Lanzhou, Gansu, China) in 2021 as an example, the proportion of undergraduate students employed in Gansu is 32.18%, master's students employed in Gansu is 31.81%, and doctoral students employed in Gansu is 51.74% (Lanzhou University, 2021). On the one hand, if there are more college graduates in a province, it means that the proportion of high-skilled workers is higher, the likelihood of employment in high-end service industries is greater, and their wages are higher; on the other hand, if the development of ICT in a province improves and the demand for high-skilled labor increases, the local government will expand the enrollment scale of universities, increase the proportion of high-skilled labor, and thus increase the average wage level. Therefore, how to attract and retain high-skilled talents is one of the ways to increase the wages of workers in each province. For individuals, knowledge changes destiny, while skills lead to life. Workers should adhere to the concept of lifelong learning, improve skill levels, and strengthen competitive advantages in employment through various methods such as on-the-job training, skill competitions, and micro courses.

4.3. Robustness test

We use four methods for robustness testing (see Table 4). First, we use new ICT development (i.e., the equal weight method) to estimate (see Column 1); Second, we use L.ICT development (lag one-period) to estimate (see Column 2); Third, we only use Internet access rate to

estimate (see Column 3); Finally, we only use ICT output value to estimate (see Column 4). Taken together, all the results show that ICT development has a positive impact on workers' wages, and the estimated results of this study are valid.

Table 4. Robustness results

Variables	(1) ICT development	(2) L.ICT development	(3) Internet access rate	(4) ICT output value
	1.782*** (0.385)	1.125*** (0.188)	0.450*** (0.041)	0.189*** (0.054)
Control variables	Yes	Yes	Yes	Yes
Constant	–0.125* (0.070)	–0.059 (0.076)	–0.073 (0.063)	–0.007 (0.071)
Observations	480	450	480	480
R-squared	0.389	0.380	0.462	0.334

4.4. Tackling endogeneity

The benchmark regression results may have endogenous issues. ICT development has promoted industrial development, provided many employment opportunities, and increased wages for workers. In turn, the increase in wages for workers will also lead to the purchase of electronic products such as headphones, game consoles, smart phones, and computers, promoting the development of ICT. We use an instrumental variable (IV) approach (i.e., 2SLS method) to tackle potential endogenous issues. Specifically, we use the number of patent licenses per 10,000 people as the instrumental variable of ICT development. On the one hand, patents reflect the level of technological innovation in a region and are related to ICT. On the other hand, there is no correlation between patents and wages. Therefore, the instrumental variable meets the two assumptions of exogenous and relevance. Table 5 presents the estimated results, it shows that the instrumental variable passed the validity test, and we find that after adding the instrumental variable, there is still a positive correlation between ICT development and wages, which is consistent with the results of benchmark regression.

Table 5. Instrumental variables estimation results

	(1) First-stage	(2) IV_2SLS
ICT development		14.159*** (4.603)
Instrumental variable	0.001*** (0.0003)	
Control variables	Yes	Yes
KP rk LM		8.972{0.003}
CD Wald F		23.280[16.38]
Observations	480	480

Notes: P-value is in curly bracket; Stock-Yogo weak ID test critical value (10% maximal IV size) is in square bracket.

4.5. Identifying causality

We examine the impact of "Broadband China" demonstration city policy on wages to identify whether there is a causal relation between the two. In order to accelerate the popularization of broadband, the Chinese government announced the first batch of "Broadband China" demonstration cities in 2014, including three municipalities directly under the central government (province-level cities): Beijing, Tianjin, and Shanghai. The "Broadband China" demonstration city construction policy provides a unique quasi-natural experimental setting to identify the causality between ICT development and wages (see Nie & Wan, 2023). We used the difference-in-differences (DID) method to examine the impact of this policy on wages, using three provincial level cities as the experimental group and 27 other provinces as the control group. The policy is related to ICT development, is an exogenous shock, and does not have endogenous issues. Table 6 presents the impact of "Broadband China" demonstration city policy on wages. The results show that this policy has a positive impact on wages. After parallel trend testing and placebo testing (see Figure 2 and Figure 3), we find that this policy is valid and identify the causality.

Table 6. The impact of the "Broadband China" demonstration city policy on wages

	(1)
Policy (treat*time)	0.151*** (0.039)
Control variables	Yes
Constant	0.171*** (0.028)
Observations	480
R-squared	0.975

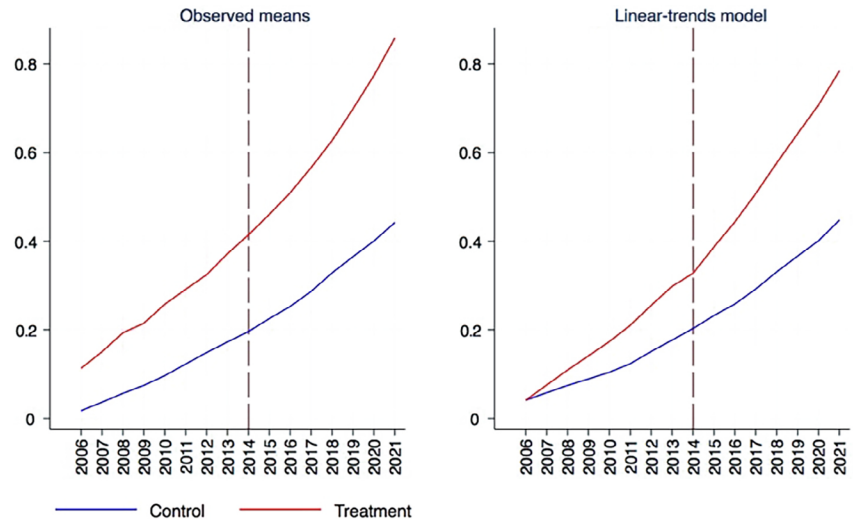

Figure 2. Parallel trend test

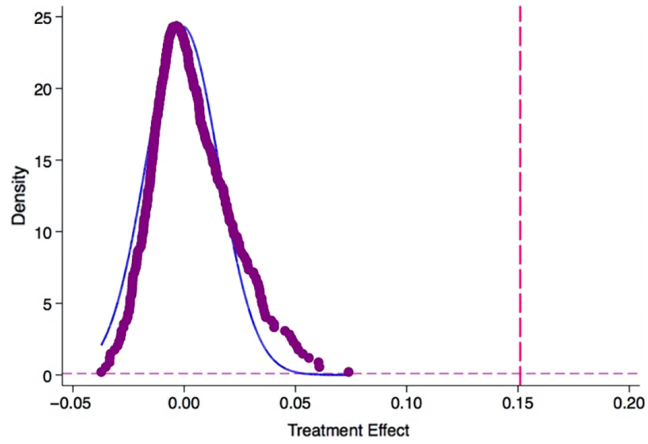

Figure 3. Placebo test

4.6. Heterogeneity results

Due to differences in development levels among provinces, the impact of ICT development on wages may be different, and we analyze the heterogeneity of different regions (see Table 7). According to the classification standards of the National Bureau of Statistics (NBS) and most scholars, there are a total of 11 provinces in eastern China: Beijing, Tianjin, and Zhejiang, etc.; there are a total of 8 provinces in central China: Shanxi, Jiangxi, and Henan, etc.; there are a total of 11 provinces in western China: Inner Mongoria, Guangxi, Chongqing, and Sichuan, etc. We get an interesting and noteworthy conclusion that ICT development has a positive impact on the wages of workers in the central and western regions, while there is no impact on the wages of workers in the eastern regions. According to the law of diminishing marginal utility, when ICT develops to a very high level, the impact on wages will be reduced. Especially in developed regions such as Beijing and Shanghai, the development of ICT has almost reached saturation, and the impact on wages has disappeared. The current level of ICT development in the central and western provinces is lower than that in the eastern regions, which has a significant impact on wages. As a result, in the current and future period, central and western provinces need to accelerate the development of ICT, and fully leverage the positive role of ICT in raising wages. Hence, the research hypothesis H3 has been confirmed.

Table 7. Heterogeneity results: eastern, central, and western

	(1) Eastern provinces	(2) Central provinces	(3) Western provinces
ICT development	0.488 (0.316)	1.031*** (0.295)	1.616*** (0.165)
Control variables	Yes	Yes	Yes
Constant	0.025 (0.242)	–0.095* (0.054)	0.004 (0.055)
Observations	176	128	176
R-squared	0.252	0.826	0.809

The quantile regression method helps to explore the heterogeneity, and quantile functions provide more accurate results on the impact of independent variables on dependent variables. Table 8 reports the heterogeneity of the impact of ICT development on workers of different wages. It is found that ICT development has a positive impact on wages at any quantile, and with the increase of the quantile, the impact of ICT development on wages has gradually increased. In other words, compared to low-wage workers, high-wage workers gain more information dividends. ICT development has promoted the development of the service industry and created many employment opportunities. For workers, if they can seize the opportunity of the information age, they may enter the high-income class. Due to the skill threshold, high-skilled workers are more likely to engage in high-end service industries such as finance and information services, and their income levels are relatively high. Low-skilled workers are more likely to engage in traditional service industries such as accommodation, catering, and domestic services, with lower income levels than high-skilled workers. The research findings suggest that while developing ICT, we should also pay attention to narrowing the income gap among different groups in order to achieve the goal of common prosperity.

Table 8. Heterogeneity results: different wage levels

	(1) 0.15	(2) 0.30	(3) 0.45	(4) 0.60	(5) 0.75	(6) 0.90
ICT development	0.922** (0.383)	1.032*** (0.310)	1.170*** (0.254)	1.325*** (0.264)	1.491*** (0.352)	1.652*** (0.473)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	480	480	480	480	480	480

5. Discussion

The new generation of ICTs such as artificial intelligence, cloud computing, and high-performance chips are changing the labor market and affecting workers' wages. In the information age, clarifying the impact of ICT development on workers' wages has practical significance and theoretical value. Previous studies have mainly examined the impact of ICT development on workers' wages from a micro perspective, but there are not many studies examining the causality between the two from a macro perspective. Based on theoretical analysis, this study uses province-level balanced panel data from 2006 to 2021 in China, investigates the impact and internal mechanism of ICT development on wages of workers, utilizes the instrumental variable method to address potential endogenous issues, and uses "Broadband China" demonstration city construction policy to identify the causality between the two.

Although many authors have discussed the relation between ICT development and workers' wages, which has promoted academic development (Nonvide, 2023; Felten et al., 2018; Forman et al., 2012), this study still makes contributions to the academia. Specifically, we test the applicability of SBTC theory in explaining the relation between ICT development and wages in the Chinese context, providing theoretical reference for related research. Then, we find that skill level is the mediation transmission mechanism by which ICT development affects workers' wages. In other words, improving skill levels is an important way to increase

the income of workers. Besides, we find that ICT development has a positive impact on the wages of workers in the central and western regions and high-wage workers are the biggest winners in the development of ICT, receiving more information dividends. Finally, on the basis of examining the relation between ICT development and wages, we discuss the impact of "Broadband China" demonstration city policy on wages and identify the causality between the two.

This article also has several limitations that need to be further improved in future research. First, the factors that affect wages are multidimensional and constantly changing, such as legal regulations, international competition and cooperation, technological innovation, demographic changes, labor market institutions, market competition, corporate strategies, COVID-19, war, etc. Moreover, the impact of various factors on wages is not the same, and further analysis is needed to determine whether ICT plays a leading or auxiliary role. Second, from the content of ICT, it also includes indicators such as WIFI, smart phones, 3D printers, and telephone networks, etc. Thus, referring to the definition of the International Telecommunication Union (ITU), we will consider using more effective indicators to measure ICT development. Third, in terms of individual heterogeneity, due to data limitations, the study only examines the impact of ICT development on workers of different incomes, owing to different endowments of workers (such as age, education, IQ, EQ, and gender, etc.), there may be differences in their ability to adapt to the development of ICT, and the impact of ICT development on individual income may be different. Finally, we discuss the impact and internal mechanisms of ICT development on wages, we need to further investigate the impact of ICT development on wages inequality between workers, and put forward policy recommendations to achieve common prosperity.

6. Conclusions and policy recommendations

This paper explores the effects and internal mechanisms of ICT development on workers' wages. As the research findings show, we found that ICT development is an important factor affecting wage increases, skill level is a mediate transmission channel through which ICT development affects wages, and ICT development has a positive impact on the wages of workers in the central and western regions, while there is no impact on the wages of workers in the eastern regions. Besides, compared to low-wage workers, high-wage workers gain more information dividends.

The results of this paper have several implications for policy makers: (1) ICT is the important influencing factor in wages, and thus the government should support the development of the ICT industry. Promote the construction of "Digital China" and "Broadband China", promote digital industrialization and industrial digitization, develop the digital economy, support the development of emerging industries, and incubate high-quality employment opportunities. Especially for the central and western provinces of China, it is necessary to actively develop the ICT industry, cultivate high-tech enterprises, improve local ICT development levels, and give play to the positive role of ICT in wages. (2) Strengthen skills training for low-skilled workers, enhance their ability to adapt to the development of ICT, and share the dividends of ICT development. At the same time, in the development of ICT, narrowing the income

gap between different groups and achieving common prosperity. (3) From a provincial level perspective, in the current and future period, each province should continue to expand the enrollment scale of higher education institutions, improve the quality of labor force, enhance employment advantages, and thus increase wage levels.

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Data availability

Data source for 2021: https://www.stats.gov.cn/sj/ndsj/2021/indexch.htm, if you want to obtain data for other years, simply change 2021 on the website to another year, such as 2006, 2007, etc.

Conflicts of interest

There are no potential conflicts of interest in this article.

Compliance of ethical standard

This article does not involve human ethical issues, adheres to academic norms, and has not been published anywhere.

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