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Research on the Impact of the Digital Economy on the Urban-Rural Income Gap in the Pearl River Delta Region

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Abstract: *With the rapid development of information technology, the digital economy has become an important engine driving global economic growth. The digital economy in the Pearl River Delta region of China is developing rapidly, and its contribution to regional economic growth is becoming more and more significant. The issue of whether the rapid development of the digital economy can narrow the urban-rural income gap has attracted much attention. This paper systematically examines the relationship between the digital economy and the urban-rural income gap through a combination of theoretical and empirical analyses, and takes the Pearl River Delta region as an example for in-depth analysis. Theoretical analysis reveals that the development of the digital economy has a dual impact on the urban-rural income gap, with both narrowing and widening effects. Regression analysis based on mixed OLS indicates that the development of the digital economy in the Pearl River Delta has significantly narrowed the urban-rural income gap, indicating that the narrowing effect of the digital economy on the income gap outweighs the widening effect. Based on the research conclusions, this paper proposes policy recommendations such as strengthening the construction of rural digital infrastructure, cultivating and introducing digital talent in rural areas, promoting rural digital inclusive finance, and driving the deep integration of the digital economy with traditional agriculture. These recommendations aim to narrow the urban-rural income gap in the Pearl River Delta region and promote coordinated development between urban and rural areas.*

Keywords: *Digital economy; Urban-rural income gap; Pearl River Delta region*

1. Introduction

Under the background of the digital transformation of the global economy, the digital economy, as a new economic form, has become a new engine driving global economic growth and is profoundly changing traditional economic structures and social development models. At the same time, with the advancement of China's rural revitalization strategy, the digital economy has broadened income channels for rural residents and promoted two-way flow of urban and rural factors, invigorating the rural economy. However, due to China's dual economic structure of urban and rural separation and a series of historically existing urban-biased policies, the economic development, income growth, and public service levels of rural areas lag behind those of cities, resulting in a significant urban-rural income gap. The expansion of the urban-rural income gap not only affects social equity and justice but may also hinder the sustainable and healthy development of the economy. Whether the development of the digital economy can improve the problem of the urban-rural income gap has important research value. As one of the most active and largest regions in the development of the digital economy in China, the Pearl River Delta region is a typical representative of China's economic development. Studying the impact of the development of the digital economy on the urban-rural income gap in the Pearl River Delta region has important theoretical and practical significance.

Regarding the impact of the digital economy on the urban-rural income gap, different scholars hold different views. Some scholars, after research and analysis, believe that with the development of the digital economy, the urban-rural income gap will narrow. For example, Luo Tingjin (2018) believes that the development of digital technology helps to narrow the gap between urban and rural areas in economic activities, information acquisition, and resource allocation, thus having a positive impact on narrowing the urban-rural income gap [1]. Lu Jiayue (2023) explores how factors such as the level of economic development and the structure of fiscal expenditures affect the actual effect of digital

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inclusive finance in narrowing the urban-rural income gap, taking digital inclusive finance as the starting point. The research results show that there is a significant negative correlation between the development of digital inclusive finance and the urban-rural income gap [2]. Some scholars believe that with the development of the digital economy, the urban-rural income gap will also expand. For example, Jiang Yuexiang and Fu Tao (2020) believe that digital inclusive finance has functions of attracting deposits and providing credit. The former will expand the urban-rural income gap, while the latter will narrow it. Through analysis, they conclude that the effect of attracting deposits of finance is greater than that of providing credit, so the development of digital finance expands the urban-rural income gap [3]. Li Yuxin and Li Zhixuan (2022) analyze the relationship between the digital economy and the urban-rural income gap under the background of rural revitalization: when the level of human capital, innovation vitality, and urbanization rate are poor, the digital economy will expand the urban-rural income gap [4]. Some scholars believe that it is currently impossible to determine whether the digital economy is expanding or narrowing the urban-rural income gap. For example, Ren Xiaogang et al. (2022) believe that the digital economy has both positive and negative impacts on the urban-rural income gap. On the one hand, the digital economy promotes enterprise collaboration, industry collaboration, and industrial collaboration, which helps to narrow regional gaps. However, on the other hand, due to the siphon effect, it will also expand this gap. Ultimately, the impact of the digital economy on the urban-rural income gap depends on the combination of these two factors [5]. Chen Wen and Wu Ying (2021) believe that when the level of digital economy development is low, improving the level of digital economy growth can effectively inhibit the expansion of the income gap between urban and rural residents. However, when the digital economy develops to a certain stage, the further improvement of its level will not only fail to narrow the income gap but may even exacerbate the income gap between these two groups [6]. How does the digital economy affect the urban-rural income gap? As one of the most active regions in the development of the digital economy in China, how does the development of the digital economy affect the urban-rural income gap in the Pearl River Delta region? Research on these issues is of important guiding significance for understanding the income distribution effects in the development of the digital economy and formulating effective regional development policies.

This paper aims to analyze the impact of the digital economy on the urban-rural income gap in the Pearl River Delta region. Through a theoretical discussion of the pathways through which the digital economy affects the urban-rural income gap, combined with the actual conditions of the Pearl River Delta region and using data from 2013 to 2022 for empirical analysis, the paper reveals the extent and mechanisms of the impact of the digital economy on the urban-rural income gap. And then provides useful references for narrowing the urban-rural income gap and promoting the integrated development of urban and rural areas in the Pearl River Delta region and even the whole country.

2. Impact Path Analysis

2.1. The Digital Economy Development Narrows the Urban-Rural Income Gap

1) The development of the digital economy narrows the urban-rural income gap by driving agricultural development

With the rapid development of science and technology, the digital economy is changing the operation mode of every industry worldwide. As the foundation of the national economy, agriculture is also undergoing a digital transformation with the extensive application of advanced technologies such as big data, artificial intelligence, and the Internet of Things. The widespread application of big data technology makes it possible to collect, analyze, and apply agricultural data, thus providing scientific decision-making support for agricultural production. Through data analysis, farmers can better understand crop growth laws and market trends, formulate reasonable planting and sales plans, which not only improves agricultural production efficiency but also enhances the market competitiveness of agricultural products. The application of artificial intelligence technology, such as intelligent planting and breeding, weather forecasting, pest and disease prevention, and product quality testing, is bringing agriculture into the era of intelligence, improving the quality and safety of agricultural products, and enhancing consumer confidence. The application of the Internet of Things technology has realized the remote control and automation of agricultural equipment, saving resources through measures such as precise irrigation and fertilization and improving yields. The development of digital agriculture not only improves production efficiency and product quality but also promotes the transformation and upgrading of agriculture. With the improvement of production efficiency, the demand for agricultural

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labor decreases, leading to some rural residents becoming surplus labor and turning to urban employment. This labor flow helps to eliminate the dual structure of urban and rural areas and narrow the urban-rural income gap, promoting the balanced development of the social economy.

2) The development of the digital economy narrows the urban-rural income gap by promoting non-agricultural employment of rural residents

In the information age, the rapid development of the digital economy has provided rural residents with diversified non-agricultural employment opportunities, optimized the employment structure, and improved the quality of employment. Digital financial services and e-commerce platforms enable rural residents to obtain financing and sales channels conveniently, promoting independent entrepreneurship. Especially the strong growth of e-commerce has brought new income sources to rural residents. At the same time, the popularization of digital technology has broken down traditional barriers to employment, improving the market matching degree and accessibility of financial services for rural residents. The improvement of rural logistics infrastructure and the integration of the digital economy with multiple industries have increased jobs in distribution, transportation, etc., and created low-threshold jobs such as ride-sharing drivers and food delivery workers, further promoting non-agricultural employment. In addition, the digital economy promotes the digital and intelligent upgrading of rural industries. The application of intelligent agricultural technology improves the added value of agricultural products, realizes the standardization and refinement of agricultural production, and promotes the automated upgrading of the industrial chain and the transformation and upgrading of rural industries, thus narrowing the urban-rural income gap.

3) The development of the digital economy narrows the urban-rural income gap by improving the level of human capital of rural residents

The rise of the digital economy has opened up new paths for rural residents to improve their level of human capital. The development of the digital economy provides more education and training opportunities for rural areas. Rural residents can learn remotely through online education platforms and participate in digital training courses, thus obtaining more knowledge and skills, improving their professional ability, and enhancing their employability, thereby narrowing the urban-rural education gap. In the era of big data, data is the key to decision-making. Rural residents can use data for analysis, better understand market demand, predict the price trend of agricultural products, avoid risks, reduce losses, and make more favorable decisions to increase profits. The digital economy also creates new working environments for rural areas. For example, the rise of rural e-commerce provides new sales channels for rural residents, which stimulates their spirit of innovation and desire for knowledge, and encourages them to learn relevant e-commerce skills. It can be seen that the development of the digital economy not only brings tangible economic benefits to rural residents but also greatly improves their knowledge and skills, innovative thinking, and ability to adapt to the new era, thus effectively promoting the modernization transformation and sustainable development of rural human resources.

2.2. The Development of the Digital Economy Expands the Urban-Rural Income Gap

1) The development of the digital economy expands the urban-rural income gap through the "information gap"

The so-called "information gap" refers to the gap in accessing information between different regions and groups, which affects social equity and development. Information asymmetry is an important factor leading to the expansion of the urban-rural income gap. In the development of the digital economy, rural areas, due to a lack of funds, technology, or other resources, lag behind in the construction of digital infrastructure, and rural residents cannot access the Internet or enjoy high-quality digital services, leading to their disadvantageous position in information acquisition and online learning. At the same time, rural residents lack skills in using electronic devices, data analysis, online communication, etc., and have insufficient information acquisition, evaluation, and utilization capabilities, which prevents them from fully understanding and utilizing useful information. On the other hand, urban residents have the advantages of Internet popularity, compulsory education coverage, and infrastructure improvement, and most of them can use the basic functions of electronic devices and apply them well. Over time, the gap between rural residents and urban residents widens. Rural residents cannot quickly and accurately capture information beneficial to their own development on the Internet and obtain greater benefits, resulting in lagging regional economic development and gradually expanding the urban-rural income gap.

2) The development of the digital economy expands the urban-rural income gap through the

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"employment gap"

The disparities in employment opportunities, treatment, and security among different groups form an "employment divide". In the digital age, although the development of the digital economy offers unlimited possibilities for the employment market, there is still an employment gap between urban and rural residents. The development of the digital economy relies on technological innovation, which requires knowledge-based and skilled talents to carry out computer operations, data analysis, online marketing, etc. There is a difference in education level between urban and rural residents, and education level is an important factor affecting personal employability and competitiveness. Due to the inclination of educational resources, urban residents have more access to knowledge than rural residents, which puts them in a dominant position in the job market, while rural residents in a disadvantaged position can only find jobs in manual labor. In addition, there are also differences in employment opportunities and treatment in different industries. Although the development of the digital economy brings about the rise of some emerging industries, it also impacts traditional industries, making them face employment pressure. Most rural residents engaged in traditional industries may face unemployment and a sharp drop in income. Influenced by the inclination of educational resources, most emerging industries choose to settle in cities, accelerating the economic development of cities and increasing residents' income. However, the economic growth rate of rural areas is not as fast as that of cities, which leads to a gradual widening of the income gap between urban and rural residents.

3) The development of the digital economy expands the urban-rural income gap through the "profit distribution gap"

In the development of the digital economy, differences in factors such as data, technology, and capital lead to uneven distribution of profits among different groups and enterprises, forming a "profit distribution gap". Some emerging industries and high-tech enterprises in the digital economy rely on technological innovation and market monopoly positions to obtain huge profits, achieving rapid growth in a relatively short period of time, and their profitability often exceeds that of traditional industries. This limits the competitiveness of other enterprises, leading to rising market concentration and unequal profit distribution. In the labor market, the development of the digital economy changes the structure of demand and supply, making some jobs in the digital economy easier to be automated, resulting in an increase in the demand for high-skilled jobs and a decrease in the demand for low-skilled labor, leading to unequal income and employment opportunities. At the same time, in the digital economy, data is regarded as an important asset. Enterprises with a large amount of data resources may obtain more profits from it, which leads to the concentration of data ownership in a few large enterprises and exacerbates the unequal distribution of profits.

3. Empirical Analysis

3.1. Variable Selection and Data Description

1) Variable Selection

Table 1: Variable Definition.

Variable Category	Variable Symbol	Variable Definition
Dependent Variable	gap	Urban-rural income gap = per capita disposable income of urban residents / per capita disposable income of rural residents
Explanatory Variable	dig	Digital economy = calculated by using the entropy method based on indicators such as the volume of telecommunications business, mobile phone subscribers, total social fixed asset investment, R&D personnel, and internal expenditure of R&D funds
Control Variable	open	Degree of opening-up = total import and export volume / GDP
	urb	Level of urbanization = urban permanent population / total population
	gdp	Level of economic development = GDP of the city in that year
	rd	R&D investment = scientific and technological expenditure of the city / general public budget expenditure
	edu	Educational investment = fiscal educational expenditure of the city / general public budget expenditure

This paper selects the urban-rural income gap as the dependent variable, expressed as the ratio of the per capita disposable income of urban residents to the per capita disposable income of rural

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residents. The explanatory variable is the digital economy, calculated by using the entropy method based on indicators such as the volume of telecommunications business (billion yuan), mobile phone subscribers (ten thousand), total social fixed asset investment (billion yuan), R&D personnel (person), and internal expenditure of R&D funds (billion yuan). The control variables include the degree of opening-up, the level of urbanization, the level of economic development, R&D investment, and educational investment. The detailed definitions of each variable are shown in Table 1.

2) Data Description

This paper selects the data on the digital economy and urban-rural income of cities in the Pearl River Delta region from 2013 to 2022 as the research samples, and the data are all from the Guangdong Provincial Statistical Yearbook. In the process of data collection and cleaning, linear interpolation method is used to fill in missing values, and in order to exclude the impact of outliers on the experimental results, this paper truncates the continuous variable data at the 1% and 99% quantiles.

3.2. Model Construction

This paper constructs the following model to verify the impact of the digital economy on the urban-rural income gap.

$$gap_{it} = \pi_0 + \pi_1 dig_{it} + \pi_2 open_{it} + \pi_3 urb_{it} + \pi_4 gdp_{it} + \pi_5 rd_{it} + \pi_6 edu_{it} + year_t + \varepsilon_{it} \quad (1)$$

In the model, the comprehensive index of the digital economy (dig) is the explanatory variable; the urban-rural income gap (gap) is the dependent variable; the degree of opening-up (open), the level of urbanization (urb), the level of economic development (gdp), R&D investment (rd), and educational investment (edu) are the control variables, and $year_t$ is the time fixed effect.

3.3. Collinearity Test

If there is multicollinearity among the variables in the model, it will affect the research results. Therefore, multicollinearity test should be conducted before regression analysis. In statistics and linear regression models, the variance inflation factor (VIF) is an indicator used to detect multicollinearity. The size of the VIF value can accurately determine whether the model has multicollinearity. The VIF values of each variable are shown in Table 2. The VIF values of the explanatory variables and control variables are all less than 10, indicating that there is no serious multicollinearity problem between the explanatory variables and control variables, and the stability and predictive ability of the model will not be affected by multicollinearity, so regression analysis can be performed.

Table 2: Results of Collinearity Test.

Variables	VIF
dig	5.17
open	2.27
urb	6.26
gdp	4.04
rd	3.33
edu	1.43

3.4. Analysis of Regression Results

We conducted a regression analysis of the data of cities in the Pearl River Delta region using the constructed model, and the results are shown in Table 3.

The first column in the table is the regression result of the mixed OLS. The estimated coefficient of the digital economy (dig) is significantly negative at the 1% level (-1.078; t=-5.274), indicating that there is a negative correlation between the development of the digital economy in the Pearl River Delta and the urban-rural income gap. This means that under the condition of keeping other variables unchanged, the digital economy can effectively narrow the income gap between urban and rural residents, and for every unit increase in the level of digital economy development, the overall urban-rural income gap in the Pearl River Delta region will narrow by 1.078 units.

The second column in the table is the estimated result after adding the time fixed effect. The estimated coefficient of the digital economy (dig) variable is significantly negative at the 1% level

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(-1.298; t=-5.319), indicating that the digital economy can significantly narrow the income gap between urban and rural residents. At this time, for every unit increase in the development level of the digital economy in the Pearl River Delta, the overall income gap will narrow by 1.298 units.

Table 3: Regression Results.

Variables	(1) gap	(2) gap
dig	-1.078*** (-5.274)	-1.298*** (-5.319)
open	-0.247 (-0.605)	-0.316 (-0.913)
urb	0.558*** (3.056)	0.599*** (4.808)
gdp	0.458*** (8.416)	0.509*** (6.933)
rd	-1.302 (-1.501)	-0.987 (-1.362)
edu	-1.190*** (-5.764)	-1.228*** (-5.903)
Constant term	1.656*** (20.937)	1.651*** (32.126)
Time effect	Not controlled	Controlled
Observations	200	200
R^2	0.320	0.673

Note: ***, **, and * denote significance levels of 0.01, 0.05, and 0.1, respectively.

From the above results, it can be seen that no matter which model is used for regression, the development of the digital economy can significantly narrow the urban-rural income gap, indicating that the narrowing effect of the digital economy on the urban-rural income gap is more significant than the expansion effect. As mentioned above, the development of the digital economy can provide new economic growth points and development opportunities for rural areas, help narrow the gap in income, education, and employment between urban and rural areas, and thus narrow the urban-rural income gap. However, to fully exert the role of the digital economy in narrowing the urban-rural income gap, it still requires the joint efforts of the government and all sectors of society to narrow various gaps between urban and rural areas and ensure that rural areas can fully access and utilize digital resources.

Among the control variables, the degree of opening-up has a negative relationship with the urban-rural income gap, indicating that the expansion of the economic opening-up in the Pearl River Delta region can narrow the urban-rural income gap, but the impact relationship is not significant. The level of urbanization and the level of economic development have a significant positive impact on the urban-rural income gap. The possible reason is that with the development of the economy, the advancement of industrialization and urbanization, urban areas can provide more employment opportunities and higher income levels due to the concentration of industry and services. The population flows from rural to urban areas has become a common phenomenon. In the short term, this may widen the urban-rural income gap. Rural areas, due to a single industrial structure, mainly engage in agricultural labor, and the income growth rate is relatively slow. The rural residents who are left behind are often the elderly and children, and their production capacity and income are low. All these have led to the expansion of the urban-rural income gap. The impact of R&D investment on the urban-rural income gap is also not significant. The impact of educational investment on the urban-rural income gap is significant and reverses, indicating that the increase in educational investment is conducive to narrowing the urban-rural income gap. The reason may be that the increase in educational investment helps to improve the overall quality and ability of residents, thus narrowing the gap between rural and urban residents in terms of employment, entrepreneurship, production efficiency, etc., and further narrowing the urban-rural income gap.

3.5. Robustness Test

Considering that omitted variables may lead to endogeneity problems, this paper uses the lagged one period digital economy (L.dig) as the instrumental variable of the digital economy and adopts the two-stage least squares method (2SLS) for estimation. The regression results are shown in Table 4.

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Table 4: Regression Results of Instrumental Variables.

Variables	(1) dig	(2) gap
L.dig	0.949*** (12.349)	--
dig	--	-1.674*** (-6.073)
open	0.146** (2.473)	-0.226 (-0.785)
urb	-0.002 (-0.131)	0.674*** (5.200)
gdp	0.023 (1.145)	0.606*** (7.196)
rd	-0.068 (-0.622)	-1.138 (-1.576)
edu	0.066** (2.461)	-1.096*** (-5.864)
Constant term	0.002 (0.394)	--
Time effect	Controlled	Controlled
Observations	180	180
R2	0.985	0.530
F	152.500	--

Note: ***, **, and * denote significance levels of 0.01, 0.05, and 0.1, respectively.

The first column in the table is the regression result of the first stage. The estimated coefficient of the instrumental variable (L.dig) is significantly positive at the 1% level, indicating that there is a significant correlation between the instrumental variable and the explanatory variable. The F value of the weak instrumental variable test is 152.5, which is far greater than 10, indicating that there is no problem of weak instrumental variable. The second column in the table is the regression result of the second stage. The estimated coefficient of the digital economy (dig) is significantly negative at the 1% level, indicating that after considering the endogeneity problem, the digital economy can still significantly narrow the income gap between urban and rural residents.

4. Policy Suggestions

Combining the theoretical analysis and empirical analysis results of this paper, in order to promote the greater role of the digital economy in narrowing the urban-rural income gap in the Pearl River Delta region, this paper puts forward the following four suggestions:

First, the government should strengthen the construction of digital infrastructure in rural areas. The government should increase financial investment to prioritize the construction of key facilities such as rural broadband networks, mobile communication stations, and data centers, ensuring that rural areas have unimpeded access to the digital economy. This will reduce the cost for rural residents to use digital technology, increase the popularity of digital technology, and provide a foundational guarantee for digital economic activities in rural areas.

Second, the government should cultivate and introduce rural digital talents. The government needs to implement relevant policies and projects to cultivate the digital skills of local rural residents, while attracting and retaining digital technology talents to work and start businesses in rural areas. With the power of talents, improve the digital technology research and development capabilities in rural areas, and promote the incubation and growth of the digital economy industry in rural areas.

Third, the government should promote the development of rural digital inclusive finance. The government can encourage financial institutions to enter the rural market and provide diversified digital financial services such as online loans, insurance, and payments to meet the financial needs of rural residents and agricultural industries. At the same time, the government can activate the vitality of the rural economy through financial policy preferential treatment and entrepreneurship support, encourage farmers to start businesses, help rural revitalization, and effectively narrow the urban-rural income gap.

Fourth, the government should promote the deep integration of the digital economy with traditional

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agriculture. The government should advocate for the development model of modern agriculture, encourage the use of digital technology to transform and upgrade traditional agriculture, such as intelligent agriculture and precision agriculture, improve agricultural production efficiency and the quality of agricultural products, and promote the diversified development of rural industries. Guided by the digital agriculture, expand new growth points of the rural economy, improve the overall competitiveness of agriculture, and thus narrow the gap in the development of urban and rural economies from the source.

5. Conclusion

This paper analyzed the pathways through which the digital economy impacts the urban-rural income gap and then focuses on the cities in the Pearl River Delta, using data from the region between 2013 and 2022 for empirical analysis. The theoretical analysis finds that the development of the digital economy will narrow the urban-rural income gap by improving the level of human capital of rural residents, promoting the digital transformation of agriculture, and increasing the income of rural residents, while also expanding the urban-rural income gap due to the existence of "information gap", "employment gap", and "profit distribution gap". The conclusion of empirical analysis is that under the condition of keeping other variables unchanged, the digital economy can effectively narrow the income gap between urban and rural residents, indicating that the narrowing effect of the digital economy on the urban-rural income gap is more significant than the expansion effect. Based on the research conclusions, this paper puts forward policy suggestions such as strengthening rural digital infrastructure construction, focusing on the cultivation and introduction of rural digital talents, vigorously promoting rural digital inclusive finance, and promoting the deep integration of the digital economy with traditional agriculture to narrow the urban-rural income gap in the Pearl River Delta region.

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