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The Impact of the Digital Economy on the Rural-Urban Income Gap—Moderating Effects Based on the Level of Technology Market Development

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Abstract

This paper explores the impact of the digital economy on the income gap between urban and rural residents using panel data from 30 provinces from 2011 to 2021. The study reveals that the digital economy shows a "U"-shaped trend in affecting the income gap between urban and rural residents: initially, it will contribute to the narrowing of the income gap, but over time, the gap is likely to widen. Moreover, this impact is regionally heterogeneous, as it is evident in the eastern and central regions, while in the western region, the development of the digital economy has helped to reduce the income disparity between urban and rural residents. In addition, the level of technology market development plays a moderating role in the "U-shaped" impact of the digital economy on the income gap between urban and rural residents. The conclusions provide policymakers with an indication of how policies should be formulated and adapted in different regions to capitalize on the development of the digital economy for balanced socio-economic development.

Keywords

China, Digital Economy, Urban-Rural Income Gap, Level of Technology Market Development, U-Shaped

1. Introduction

Over the past few decades, China has undergone tremendous changes. The implementation of the policy of reform and opening up, in particular the urban-centered strategy of heavy industrial development, has greatly contributed to the country's economic growth. Urbanization and industrialization have brought

about remarkable economic achievements, but they have also exacerbated the imbalance between urban and rural development, resulting in urban residents having much higher income levels than their rural counterparts. Although China has successfully eliminated absolute poverty by declaring total poverty eradication in 2021, the problem of relative poverty in rural areas still exists. According to the National Bureau of Statistics, between 2011 and 2023, China's income ratio for urban and rural residents fell from 3.13 to 2.39, a reduction of 0.74. The schism between rural and urban communities is sizable with respect to education and healthcare provision, further accentuated by the pronounced income discrepancies existing between these geographically distinct regions, representing an appreciable impediment towards China's ambitions for harmonious development and collective prosperity (Chen et al., 2022).

With the rapid advancement of cutting-edge technologies such as the Internet, big data, and 5G, China is steadily stepping into a new era of digital economy. According to data disclosed by the China Academy of Information and Communication Research in 2023, China's digital economy totals a staggering 50.2 trillion yuan in 2022, accounting for 41.5 percent of its gross domestic product (GDP), marking the central position of the digital economy in driving the country's economic development. The booming development of digital economy not only closely integrates with traditional industries, but also deeply reshapes the allocation of resources, production methods and income distribution patterns, with far-reaching impacts on the employment opportunities of rural and urban residents and their income levels. Consequently, in the pivotal stage of China's economic advancement and evolution, there exists immense pragmatic importance in delving into the repercussions of the digital economy on the disparity in income between urban and rural zones, with a view to ameliorating the configuration of income distribution and comprehending the concept of shared prosperity.

Regarding how the digital economy affects the urban-rural income gap, there are two mainstream views in the academic community, and no unified consensus has been formed. One viewpoint is that the development of the digital economy has a significant "U"-shaped influence on the urban-rural income gap (Wang & Xiao, 2021). Specifically, it suggests that in the initial phases of the digital economy's emergence, its development aids in narrowing the income gap between city dwellers and their rural counterparts (Wang, 2023). Nonetheless, it anticipates that this disparity will become more pronounced over time as the digital economy matures further. Further research, some scholars argue that urbanization and the enhancement of rural human capital are considered to be the key factors moderating this relationship (Wang & Zhang, 2023). Xu et al. (2023) posit that the primary channels by which the digital economy influences the urban-rural income discrepancy are non-agricultural employment and agricultural efficiency enhancement. Educational facilities (Mi & Qu, 2022) and infrastructure advancement (Chen & Wu, 2021) functioning as key regulating factors, play an integral role in the correlation between the digital economy and the urban-rural income divide. Increasing access to education helps to reduce income

disparities because education leads to an increase in one's skills, which in turn leads to increased employment, and employment leads to a stable income that reduces disparities (Khamjalas, 2024). These influencing factors serve a moderating or constraining role across divergent developmental junctures, collaborating in curtailing the income disparate between urban and rural regions in the nascent phases of the digital economy while mitigating the probability of such disparity escalating in the subsequent stages. This finding serves pivotal in amplifying the beneficial impacts of the digital economy whilst managing the progression of the urban-rural income disparity throughout its evolution.

The second view holds the opposite view, that the digital economy will first widen the urban-rural income gap, and then reduce it, presenting an inverted "U"-shaped trend. Xie & Li (2023)'s comprehensive analysis utilizing 29 individual province panel data spanning across China illuminates a consistent inverse "U"-shaped correlation existing between the advancement of the digital economy, and the stark urban-rural disparity in income. This scholarly endeavor implores attention to a critical aspect: the transformative effects of the digital economy can extend beyond immediate geographical confines, potentially enhancing financial access within adjacent provinces, particularly those encompassing extensive developments in digital villages. Revisiting this intricate interplay from unique perspectives that incorporate both income levels and distribution structures, Xing & Su (2023) affirm that the stage of digital economic evolution exerts an inverted "U"-shaped influence on the urban-rural earnings gap, with significant roles being played by urbanization and educational attainment as pivotal thresholds in this dynamic process (Pu & Zhu, 2018). When Huang et al. (2021) study the promotion effect of urbanization on farmers' income, they find that urbanization has a significant promotion effect on farmers' property and transfer incomes, but has a limited effect on wage incomes. Furthermore, Zhong et al. (2023) underscore the pivotal role of network infrastructure construction and rural inclusive finance development in arbitrating the connection between the digital economy and the urban-rural income disparity. Evaluating the degree of provincial digital advancement in China through four parameters, Peng & Zhong, (2022) detect a reverse U-shaped trend linking the digital economy with the urban-rural income discrepancy, noting that increased marketization amplifies this divide. Similarly, Fan et al. (2022) argue that the development of the digital economy contributes to economic empowerment and industrial structure optimization, and its impact on the urban-rural income gap shows an inverted "U-shaped" relationship.

Concurrently, the digital economy can promote the level of technology market development by improving the regional innovation capacity, marketization level and financial development level (Dong et al., 2023), and the level of technology market development can improve rural productivity, which in turn can increase the income of farmers and narrow the income gap between urban and rural areas. From the existing studies, few scholars have explored how the development of technology market water affects the relationship between the digital

economy and the urban-rural income gap. In accordance with extant research, a limited number of researchers have delved into the extent to which the maturation of the technology market landscape influences the connection between the digital economy and the urban-rural income disparity. This paper not only analyzes the influence of the digital economy on the urban-rural income gap, but also examines the moderating role of the level of technology market development in this process. This research provides a valuable reference for the formulation of integrated urban and rural development strategies adapted to the new era and contributes to a better utilization of the potential of the digital economy in order to achieve more balanced and sustainable development.

2. Literature Review and Hypotheses Development

2.1. Mechanisms of the Digital Economy's Impact on the Urban-Rural Income Gap

At the early stage of the development of the digital economy, the digital economy mainly through digital financial inclusion, digital platforms and driving industrial structure upgrading to make the income gap narrow (Gao & Li, 2023; Liu & Chen, 2021). First, entrepreneurship is an important way to increase farmers' income. Digital financial inclusion provides rural residents with a wider range of financial services (Tao, 2020), including credit and insurance, which reduces farmers' financing costs and enables them to invest in entrepreneurship and thus improve agricultural productivity, thereby increasing farmers' incomes (Sun & Liu, 2022). Second, digital platforms such as e-commerce and online labor markets provide rural residents with more direct and broader market channels, reducing intermediate links, shrinking the cost of selling agricultural products and increasing their selling prices, as well as making it easier for farmers to find non-farming jobs and facilitating the off-farm mobility of labor. Furthermore, the evolution of information and communication technology facilitates the structural advancement within the industry (Heo & Lee, 2019; Zhang & Ma, 2022). This digital industrialization stimulates new growth in the entrepreneurial sector, whereas industrial digitization elevates both the productivity and output of conventional industries. Such advancement within emerging sectors widens the job horizons for farmers, providing avenues for attaining more remunerative positions.

With the further development of the digital economy, the income gap between urban and rural areas may widen for the following reasons. First, differences in the digital transformation of industries have led to a digital divide between urban and rural areas. Urban areas typically have stronger data infrastructures and higher returns on digital capital, which enables industries in urban areas to achieve digital transformation more quickly. In contrast, traditional industries such as agriculture have low digital penetration rates, especially in the production and supply chain (Wang & Zhou, 2021), meaning that rural areas are unable to fully utilize digital technologies to improve productivity and increase income. Second, the difference in digital literacy between urban and rural residents is also an important factor. Urban residents are more likely to use digital technolo-

gies for human capital investment and online business activities, while farmers primarily use digital technologies for simple social entertainment, and this difference in digital literacy leads to urban residents being able to more effectively capitalize on the opportunities presented by the digital economy, thereby increasing their incomes and gradually widening the urban-rural income gap. In addition, the combination of agricultural products and digital platforms, while promoting rural development in the early years, may encounter transformational bottlenecks over time (Feng & Xu, 2021). Rural areas may be limited in the application of digital technologies by the lack of necessary technical support and educational resources, which restricts their competitiveness in the digital economy, and in turn has the potential to widen the urban-rural income gap. In summary, this paper puts forward hypothesis 1.

Hypothesis 1: the digital economy on the urban-rural income gap has a "U"-shaped characteristics of first narrowing and then expanding.

2.2. The Moderating Effect of the Level of Technology Market Development on the Relationship between the Digital Economy and the Urban-Rural Income Gap

On the one hand, there is a close relationship between the level of development of technology markets and the digital economy. The level of maturity of the technology market tends to promote the innovation and application of digital technologies, thereby facilitating the development of the digital economy. When the technology market is able to provide advanced digital infrastructure and services, it can accelerate digital transformation, promote industrial upgrading and enhance economic vitality and innovation. On the other hand, the level of development of the technology market has both direct and indirect effects on the urban-rural income gap. The direct impact is reflected in the fact that technological innovation and application can improve agricultural productivity and promote rural economic development, thereby increasing farmers' incomes. Specifically, through the introduction of advanced agricultural technologies, farmers can increase crop yields, reduce losses and increase market competitiveness. Indirect impacts, in turn, relate to the educational and training opportunities that arise from the level of development of the technology market. As technology develops, people in rural areas will need to acquire new skills to adapt to market demands, which may facilitate the allocation and quality of educational resources, which in turn may help to reduce the education gap between urban and rural areas. To summarize, this paper puts forward hypothesis 2.

Hypothesis 2: the level of technological market development can regulate the "U"-shaped impact of the digital economy on the income gap between urban and rural residents.

3. Study Design

3.1. Model Construction

To validate Research Hypothesis 1, we have devised and constructed the follow-

ing model:

$$\text{theil}_{it} = \beta_0 + \beta_1 \text{dig}_{it} + \beta_2 \text{dig}_{it}^2 + \beta_3 \sum X_{it} + U_i + \theta_t + \varepsilon_{it}, \quad (1)$$

where theil denotes the urban-rural income gap, dig denotes the level of digital economic development, dig^2 denotes the squared term of the level of digital economic development, X is a series of control variables, i is the region, and t is the year; U_i is the province fixed effect, θ_t is the time fixed effect, and ε_{it} is the error term.

Secondly, in order to test hypothesis 2, this paper constructs the following model to test the moderating effect of the level of technology market development in the digital economy affecting the income gap between urban and rural residents:

$$\begin{aligned} \text{theil}_{it} = {} & \beta_0 + \beta_1 \text{dig}_{it} + \beta_2 \text{dig}_{it}^2 + \beta_3 \left(\text{tech}_{it} \times \text{dig}_{it}\right) + \beta_4 \left(\text{tech}_{it} \times \text{dig}_{it}^2\right) \\ & + \beta_5 tb_{it} + \beta_6 \sum X_{it} + U_i + \theta_t + \varepsilon_{it}, \end{aligned} \quad (2)$$

where tech denotes the level of technology market development and other settings are the same as in model (1), and if β_4 is significant, it means that the moderating effect exists.

3.2. Variable Measurement

3.2.1. Explanatory Variables

The existing research efforts lack consistency in constructing proxy variables representing the digital economy. In this scholarly article, we adapt the methodology employed by Zhang & Jiao (2017) and Wang et al. (2021). This method involves creating a comprehensive framework consisting of five primary Level 1 indicators: digital economy infrastructure, digital economy development ecosystem, digital industrialization, industrial digitization, and digital innovation, at the broader, macroeconomic scale. These foundational indicators are subsequently subdivided into 14 secondary indicators and a total of 32 tertiary indicators. By utilizing the entropy value method, the development level of digital economy is portrayed in an all-round way. The specific set of indicators is detailed in **Table 1**.

3.2.2. Explained Variables

The Thiel index is used as a proxy variable to measure the urban-rural income gap. And the ratio of urban residents' income to rural income is used as a proxy variable to measure the urban-rural income gap, which is used as a robustness test. The Thiel index is calculated as follows:

$$\text{Theil}_t = \sum_{i=1}^{2} \left(\frac{I_{it}}{I_t}\right) \text{Ln}\left(\frac{I_{it}/P_{it}}{I_t/P_t}\right) = \left(\frac{I_{1t}}{I_t}\right) \text{Ln}\left(\frac{I_{1t}/P_{1t}}{I_t/P_t}\right) + \left(\frac{I_{2t}}{I_t}\right) \text{Ln}\left(\frac{I_{2t}/P_{2t}}{I_t/P_t}\right) \quad (3)$$

where I_{it} is the total income of the residents of region i in period t, calculated by multiplying the respective per capita disposable income by the total population; I_t is the total income of the residents of the whole country in period t, P_{it} is the population data of region i in period t, and P_t is the total population of the whole

country in period *t*. The Thiel index is greater than 0, with larger values indicating a wider gap between urban and rural income distribution.

Table 1. Digital economy indicator system.

Tier 1 indicators	Tier 2 indicators	Tier 3 indicators	Data sources
Digital economy infrastructure	Traditional digital infrastructure	Fiber optic line length	China National Bureau of Statistics (CNBS)
		Telephone penetration (including cell phones)	China Information Yearbook
		Mobile telephone exchange capacity	CNBS
		Cell phone year-end subscribers	CNBS
	New digital infrastructure	Number of Internet broadband access ports	CNBS
		Internet broadband access subscribers	CNBS
		Number of Internet domain names	CNBS
		Websites per 100 businesses	CNBS
		Computers per 100 population	CNBS
Digital economy development environment	Digital talent	Number of general higher education institutions	CNBS
		Number of degrees conferred by general institutions of higher education at the undergraduate level	CNBS
	Digital environment	Employment in the postal sector	CNBS
		Employment in the information transmission, software and information technology services industry	CNBS
Industrial digitization	Agriculture	Rural broadband access subscribers	CNBS
		Value added of agriculture, forestry, livestock and fisheries	CNBS
	Industries	Value added by industry	CNBS
		Share of enterprises with e-commerce trading activities	CNBS
		E-commerce turnover of industrial enterprises	CNBS
		Revenue from sales of new products	CNBS
	Tertiary sector of industry	Value added of tertiary industry	CNBS
		Express mail volume	CNBS

Continued

		Revenue from express delivery operations	CNBS
Digital industrialization	Telecommunications industry	Volume of telecommunication services	CNBS
	Postal industry	Total postal operations	CNBS
		Postal service outlets	CNBS
	Software and information technology services	Revenue from software operations	China Electronic Information Industry Statistical Yearbook (CEIISY)
		Income from information technology services	CEIISY
	Electronic information manufacturing	Main business income of the manufacturing industry of communications equipment, computers and other electronic equipment	Statistical Yearbook of China's Industrial Economy
Digital innovation	R&D investment and number of projects	R&D expenditures of industrial enterprises above scale	China Science and Technology Statistical Yearbook (CSTSY)
		Number of R&D projects (topics) of industrial enterprises above large scale	CSTSY
	R&D efficiency	Ratio of domestic patent applications authorized to full-time equivalents of R&D personnel in industrial enterprises above scale	CSTSY
	Patents and intellectual property	Number of active patents	CSTSY

3.2.3. Regulating Variables

The level of technology market development is measured by the proportion of technology market turnover to GDP in this paper. That is, a macro perspective is used to observe the scale and development trend of the technology market.

3.2.4. Control Variables

This paper chooses economic growth, marketization level, government intervention, industrial structure, cultural capital, transportation accessibility, and future labor force as control variables. Economic growth (egro) is measured by the growth rate of GDP (previous year = 100); marketization level (mar) is measured by the marketization index of Fan et al. (2011); government intervention (gov) is measured by the ratio of fiscal expenditure to upper GDP; industrial structure (is) is measured by the ratio of tertiary value added to GDP; cultural capital (cul)

is measured by the per capita ownership of the public library collection (volumes per capita); accessibility (road) is measured by the per capita area of urban roads (m2); and the future workforce (labor) is measured by the child and adolescent dependency ratio.

3.3. Data Sources

The sample consists of 30 provinces in China (excluding Tibet, Hong Kong, Macao and Taiwan) and spans the period from 2011 to 2021. The data is obtained from the National Bureau of Statistics database, EPS Global database, and provincial statistical yearbooks. The descriptive statistics are shown in Table 2.

4. Results and Robustness Test

4.1. Benchmark Regression

Table 3 presents the results of the benchmark regressions. Column (1) presents only the original regression results without any control variables and fixed effects. Column (2) introduces control variables but does not consider fixed effects. Column (3) further incorporates individual fixed effects on top of the inclusion of control variables. Column (4) is based on the inclusion of control variables and considers both individual and time fixed effects. In these four columns, the estimated coefficients of the first term of digital economy are −0.068, −0.055, −0.066, and −0.079 respectively, all of which are significantly negative at the 1% level; the estimated coefficients of the square term of digital economy are 0.022, 0.016, 0.018, and 0.044 respectively, all of which are significantly positive at the 5% level. The results of the benchmark regression illustrate that the impact of the digital economy on the income gap between urban and rural residents is in the shape of a "U", narrowing first and then widening, and Hypothesis 1 is verified.

Table 2. Descriptive statistics.

Var	Mean	SD	Min	p50	Max
theil	0.0870	0.0390	0.0180	0.0820	0.202
dig	0.405	0.261	0	0.360	0.906
tech	1.669	2.796	0.0190	0.691	17.57
egro	107.8	2.832	94.60	107.9	116.4
ti	2.137	1.488	0.389	1.434	6.757
mar	6.933	2.086	2.330	6.815	12.63
gov	0.261	0.113	0.105	0.233	0.758
is	0.495	0.0900	0.327	0.488	0.837
cul	0.738	0.534	0.230	0.585	3.320
road	16.22	4.923	4.040	15.85	26.78
labor	22.76	6.190	9.900	22.80	36.40

Table 3. Benchmark regression results.

	(1)	(2)	(3)	(4)
dig	−0.068***	−0.055***	−0.066***	−0.079***
	(−13.199)	(−7.176)	(−9.448)	(−4.593)
dig^2	0.022***	0.016**	0.018***	0.044***
	(3.930)	(2.212)	(2.807)	(2.752)
egro		0.001***	0.001***	0.001***
		(2.860)	(3.083)	(3.857)
mar		−0.000	0.001	0.001**
		(−0.079)	(0.967)	(2.165)
gov		0.067***	0.040***	0.032**
		(4.781)	(2.916)	(2.314)
is		−0.003	0.026*	0.031*
		(−0.181)	(1.856)	(1.824)
cul		0.010***	0.018***	0.021***
		(2.688)	(5.336)	(5.811)
road		−0.001***	−0.002***	−0.001***
		(−7.337)	(−8.305)	(−7.673)
labor		0.001***	0.000**	0.001***
		(4.156)	(2.152)	(2.787)
_cons	0.109***	0.002	0.001	−0.033
	(18.742)	(0.065)	(0.018)	(−1.173)
province	no	no	yes	yes
year	no	no	no	yes
N	330.000	300.000	300.000	300.000
R^2	0.834	0.902	0.910	0.924
F	217.58	786.74	261.960	160.943

Note: t-statistics in parentheses, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

4.2. Robustness Tests

In order to test the reliability of hypothesis 1, this paper does the following robustness tests:

1) Change the sample. Given the significant differences between municipalities and other provinces in terms of economy and society, the data of Beijing, Shanghai, Tianjin and Chongqing municipalities are excluded from the analysis, and the regression results after this adjustment are shown in column (1) of Table 4. In addition, due to the significant impact of the New Crown outbreak in 2020 on China's economy, data from that year are excluded and the regression results after this change are shown in column (2) of Table 4.

2) Replace the explanatory variables. The ratio of urban residents' income to

rural income is used as a proxy variable to measure the urban-rural income gap, and the results are shown in column (3) of Table 4.

3) Replace of explanatory variables. Referring to the research method of Zhang et al. (2020), the digital financial inclusion index (dfi) is replaced by the digital economy index, and the results are shown in column (4) of Table 4.

Table 4. Robustness test results.

	(1)	(2)	(3)	(4)
	theil	theil	gap1	theil
dig	−0.079***	−0.072***	−0.654***	
	(−4.593)	(−4.111)	(−4.003)	
dig^2	0.044***	0.042**	0.471***	
	(2.752)	(2.551)	(3.085)	
dfi				−0.033***
				(−4.647)
dfi^2				0.006***
				(7.714)
egro	0.001***	0.001***	0.003	0.000*
	(3.857)	(3.670)	(1.496)	(1.730)
mar	0.001**	0.001	0.023***	0.001
	(2.165)	(1.059)	(3.568)	(1.236)
gov	0.032**	0.030**	0.291**	0.038***
	(2.314)	(2.085)	(2.231)	(2.963)
is	0.031*	0.064***	0.258	0.047***
	(1.824)	(3.328)	(1.586)	(3.047)
cul	0.021***	0.019***	0.176***	0.014***
	(5.811)	(5.046)	(5.044)	(3.814)
road	−0.001***	−0.001***	−0.006***	−0.001***
	(−7.673)	(−4.948)	(−3.777)	(−3.876)
labor	0.001***	0.000*	0.007***	0.000
	(2.787)	(1.938)	(3.513)	(1.114)
_cons	−0.033	−0.052	1.854***	0.038
	(−1.173)	(−1.559)	(6.980)	(1.373)
province	Yes	Yes	Yes	Yes
year	Yes	Yes	Yes	Yes
N	300.000	260.000	300.000	300.000
R^2	0.924	0.931	0.905	0.933
F	160.943	153.499	125.908	183.760

Note: t-statistics in parentheses, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

In these four columns, the estimated coefficients of the primary term of the digital economy are −0.079, −0.072, −0.654, −0.033, all significantly negative at the 1% level, and the estimated coefficients of the squared term of the digital economy are 0.044, 0.042, 0.471, 0.006, all significantly positive at the 5% level, which once again verifies the "U"-shaped influence of the digital economy on the income gap between urban and rural residents.

4.3. Moderating Effects

This paper uses a moderated model to test the moderating utility of the level of technological market development in the impact of the digital economy on the income gap between urban and rural residents, and the results are presented in Table 5. In column (1) of Table 5, no control variables are added; in column (2) of Table 5, all control variables are added, and it is found that the coefficients of the squared term of the digital economy and the interaction term of the level of technological development in both columns are −0.004, and are significant at the 10% and 5% levels, respectively, which suggests that the level of technological development plays a moderating role in the process of the digital economy affecting the income gap between urban and rural residents. Specifically, by raising the level of technology market development, it is possible to effectively reduce the income gap between urban and rural residents in the early stages of the development of the digital economy, and to slow down the trend of widening this gap in the later stages. In addition, increasing the level of technology market development may delay the timing of the lowest point of the "U" curve, thus delaying the point at which the digital economy widens the urban-rural income gap, which means that at higher levels of digital economy development, the urban-rural income gap may reach its minimum value and then gradually widen.

4.4. Heterogeneity Analysis

In this paper, 30 provinces are divided into eastern, central and western regions to test for heterogeneity, and the estimation results are shown in Table 6 below. It can be seen that the "U" shaped impact relationship estimated by the baseline model is very significant in the eastern and central regions, but in the western region, the squared term of the digital economy is not significant, which indicates that the digital economy in the western region will reduce the local urban-rural income gap. This heterogeneous impact may be related to the stage of digital economy development and infrastructure in each region. In the eastern and central regions, the initial development of the digital economy may reduce the urban-rural income gap by providing new employment opportunities and increasing the accessibility of services. However, over time, with higher levels of digital economy development in the eastern and central regions, digital economy infrastructure may become more concentrated in urban areas, thus widening the income gap between urban and rural areas. In contrast, the western region may be at an earlier stage of digital economy development, and increased infrastructure development and human capital investment may contribute more directly

to digital economy growth in rural areas, thus helping to narrow the urban-rural income gap. In addition, policy support and resource allocation may have different impacts in different regions. If the western region receives more policy support and resource inputs, it can help accelerate the development of infrastructure and the diffusion of technology in the west, thus promoting the development of the digital economy in rural areas and narrowing the gap with urban areas.

Table 5. Results of moderating effects.

	(1)	(2)
dig	−0.048***	−0.029**
	(−3.064)	(−2.330)
dig^2	0.048**	0.031*
	(2.483)	(1.957)
dig*tb	0.002***	0.002**
	(3.999)	(2.483)
dig^2*tb	−0.004*	−0.004**
	(−1.791)	(−2.247)
tb	0.002**	0.000
	(2.391)	(0.057)
egro		0.001*
		(2.004)
mar		0.001
		(1.122)
gov		0.031
		(1.048)
is		0.051
		(1.333)
cul		0.021***
		(3.625)
road		−0.001***
		(−3.673)
labor		0.000
		(1.388)
_cons	0.083***	−0.049
	(11.453)	(−1.011)
Year	Yes	Yes
Province	Yes	Yes
N	330	300
F	48.152	118.756
adj. R^2	0.890	0.928

Note: t-statistics in parentheses, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 6. Heterogeneity regression results.

	(1) east	(2) middle	(3) west
dig	−0.070***	−0.042*	−0.074**
	(−2.849)	(−1.752)	(−2.501)
dig^2	0.056**	0.042**	0.039
	(2.408)	(2.035)	(1.365)
egro	0.001***	−0.000	−0.000
	(3.407)	(−0.689)	(−0.518)
ti	−0.002**	0.002*	0.001
	(−2.391)	(1.886)	(0.363)
mar	0.002***	0.002	0.001
	(3.037)	(1.338)	(0.729)
gov	−0.011	0.079***	−0.002
	(−0.437)	(2.761)	(−0.106)
is	−0.010	−0.076***	0.054
	(−0.346)	(−3.829)	(1.648)
cul	0.013***	0.016	0.011
	(3.214)	(1.402)	(1.176)
road	−0.001***	−0.001***	−0.000
	(−5.564)	(−2.868)	(−0.887)
labor	−0.001*	−0.001	0.001
	(−1.961)	(−1.657)	(1.583)
_cons	−0.039	0.141***	0.138**
	(−0.895)	(3.584)	(2.279)
Province	Yes	Yes	Yes
Year	Yes	Yes	Yes
N	110	80	110
F	39.061	89.777	129.616
adj. R^2	0.867	0.955	0.957

Note: t-statistics in parentheses, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.

5. Conclusion, Policy Recommendations and Future Outlook

5.1. Conclusion

Using the panel data of 30 provinces in China from 2011 to 2021, this study constructs digital economy indicator and examines its impact on the income gap between urban and rural residents, and draws the following conclusions:

1) The digital economy has a significant "U"-shaped impact on the income

gap between urban and rural residents. In the early stage of the development of the digital economy, the urban-rural income gap will narrow, but as the development process progresses, the gap will gradually widen. This conclusion still holds even after a series of robustness tests.

2) The level of technological market development plays an important regulatory role in narrowing the urban-rural income gap in the context of the digital economy. By raising the level of technological development and penetration, farmers can receive better education and training, thereby improving their digital technological capabilities, enabling them to take full advantage of the opportunities presented by the growth of the digital economy, effectively reducing the income disparity between urban and rural areas in the early stages of the development of the digital economy, and mitigating the negative impacts that may arise over time.

3) There are regional differences in the U-shaped impact of the digital economy on the income gap between urban and rural residents. In the eastern and central regions, the relationship between the development of the digital economy and the urban-rural income gap is consistent with the "U" shape, while in the western region, the development of the digital economy helps to narrow the urban-rural income gap.

5.2. Policy Recommendations

Based on the findings of the study, this paper proposes corresponding policy recommendations:

1) In order to reduce the urban-rural income gap in the early stages of the development of the digital economy and to prevent the gap from widening in the later stages, the Government can take the following measures. Promote digital skills education in rural areas and provide online educational resources and training courses to improve farmers' digital literacy; encourage and support the construction of rural e-commerce platforms to help farmers sell their products and increase their incomes through digital channels; and invest in improving Internet access and mobile network coverage in rural areas to ensure that farmers can use digital services without barriers.

2) Governments can promote the establishment of digital technology training centers in rural areas and provide free or low-cost training courses to improve farmers' technological knowledge and application capabilities; and increase investment in rural Internet infrastructure to ensure that farmers have access to high-speed and stable network services for better access to the digital economy; setting up a special fund to support farmers' entrepreneurial projects in the digital economy, especially those that can promote the upward mobility of agricultural products and increase farmers' incomes; simplify the market access process for agricultural products and utilize digital platforms to provide farmers with broader markets and more sales channels; formulate relevant laws and regulations to protect farmers' data rights and interests in the digital economy and

prevent data abuse.

3) Considering the differences between different regions, the Government should formulate differentiated policies. For eastern and central regions, support for high-tech enterprises should be strengthened to promote industrial upgrading and innovation, while attention should be paid to the digital transformation of rural areas. For western regions, the focus should be on developing a digital economy model suited to local conditions, increasing the added value of agricultural products and promoting the growth of farmers' incomes.

5.3. Future Outlook

Based on theoretical analysis and empirical research, this paper analyzes the impact of digital economy on the urban-rural income gap, but it still has the following limitations:

1) Constraints on time horizon: This study relies on data from 2011 to 2021, which may not fully reveal the full picture of the long-term impact of digital economy development on the income gap between urban and rural residents. Future studies may consider incorporating updated data sets to better understand these dynamic changes.

2) Limitations of indicator construction: The constructed digital economy development level indicator may not be applicable to all countries or regions, so its applicability in different contexts may be limited.

3) Methodological limitations: Although OLS regression analysis was adopted in this study, this method is based on specific assumptions, which may limit the universality and explanatory power of the research results. Future research may consider using more diverse models, such as panel threshold models and structural equation models, to enhance the depth and breadth of research.

4) Consideration of regional differences: The study finds that the impact of the digital economy on the urban-rural income gap varies from region to region, but it fails to analyze the specific reasons for these differences in depth. Further studies can use spatial econometric models to further explore the root causes of this phenomenon.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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