

Research on the Impact Mechanism of Digital Economy on Urban Rural Integration Development

Yilin Wu¹, Yi Chen², Ting Zhang³, and Xiaohe Wang^{1,*}

¹ School of International Trade and Economics, Anhui University of Finance and Economics, Bengbu, Anhui, 233030, China

² School of Languages and Media, Anhui University of Finance and Economics, Bengbu, Anhui, 233030, China

³ School of Economics, Anhui University of Finance and Economics, Bengbu, Anhui, 233030, China

Abstract

In the era of digital economy, digital technology can break the barriers between urban and rural areas, promote the free flow of various elements between urban and rural areas, and play an important role in the integrated development of urban and rural areas. Based on the era background of the prosperity and development of the digital economy, this paper focuses on the urgency of solving the uncoordinated development of urban and rural areas in China, and uses panel data from 31 provinces and cities in China to empirically study the impact mechanism of the digital economy on the integrated development of urban and rural areas. The results show that: first, digital economy has a significant role in promoting urban-rural integration, which is mainly achieved by affecting urban-rural economy, public services, factors and ecological integration. Second, the urban-rural income gap plays an intermediary role in the promotion of digital economy on urban-rural integration. Third, the impact of digital economy on the development of urban-rural integration is provincial heterogeneity. The impact of digital economy on the development of urban-rural integration is stronger in the provinces with higher economic development level in the East. Finally, according to the research results, the paper puts forward policy recommendations to promote the integrated development of urban and rural areas in China, such as strengthening the construction of digital infrastructure, building a digital government, cultivating farmers' information literacy and skills, and implementing differentiated digital economy development strategies in various regions.

Keywords

Digital Economy; Urban Rural Integration; Influence Mechanism.

1. Introduction

As a socialist country, China's fundamental goal is common prosperity, and the urban-rural gap is an important obstacle to the high-quality development of China's economy. The 19th National Congress of the Communist Party of China pointed out that the main contradiction in our society has been transformed into a contradiction between the growing needs of the people for a better life and imbalanced and inadequate development. The biggest imbalance in China is the imbalance in urban-rural relations, and the biggest inadequacy is the inadequate development of rural areas. Therefore, promoting urban-rural integration and fully unleashing the vitality of rural economy plays an important role in achieving high-quality development of China's economy, solving major social contradictions, achieving common prosperity, and comprehensively building a modern country.

The relationship between urban and rural areas in China has always been a hot topic in academic research, and the research on the influencing factors of urban-rural integration development is even more abundant, mainly divided into three categories. Firstly, the impact of factor flow on urban-rural integration and development. Zhang Xiaodong et al. (2018) empirically studied the impact of factor flow on urban-rural integration development from three aspects: human resource elements, material resource elements, and financial capital elements. They found that urban-rural integration development relies on the smooth flow of human resource elements, material resource elements, and financial capital elements.[1] Liu Minghui et al. (2019) used provincial-level panel data from 2000 to 2015 to study the impact of urban-rural factor mismatch on urban-rural integration development. They found that factor mismatch caused by limited urban-rural factor flow plays a certain restrictive role on urban-rural integration in both agricultural and non agricultural sectors.[2] Secondly, the impact of urbanization on the integration of urban and rural development. Zhang Shijie et al. (2019) used Anhui Province as an example to study the impact of new urbanization on the urban-rural income gap, and concluded that urbanization is negatively correlated with the urban-rural income gap, indicating that urbanization is a key factor in narrowing the urban-rural gap.[3] Zhou Hui et al. (2020) used provincial panel data from China from 2006 to 2017 to study the impact of urbanization on urban-rural integration development. They found that in the short term, as factors flow unidirectionally from rural to urban areas, urbanization inhibits urban-rural integration. However, when factor aggregation reaches saturation, production factors flow from urban to rural areas, and urbanization promotes urban-rural integration.[4] Thirdly, the impact of financial development on urban-rural integration development. Gao Zhifu (2022) studied the impact of financial support on urban-rural integration development from multiple dimensions such as financial space, structure, scale, and efficiency by establishing an autoregressive model. The research results showed that financial structure plays a key role in urban-rural integration in the short term, while financial structure, scale, and efficiency have a significant impact on urban-rural income gap in the long term.[5] Wen Tao et al. (2020) used provincial panel data in China to study the impact of social financialization on urban-rural integration development, and concluded that social financialization has a promoting effect on urban-rural economic development, public services, and spatial environment integration, thus contributing to urban-rural integration development [6].

The urban-rural barriers established based on the traditional urban-rural dual system are an important reason for the urban-rural gap. Therefore, the key to promoting urban-rural integration and development is to establish a market system that integrates urban and rural areas, promoting the free flow of various production factors between urban and rural areas. In the era of digital economy, digital technology can break spatial limitations and achieve the exchange of goods, services, information and other elements between urban and rural areas. As a "bridge" between urban and rural areas, it promotes the two-way flow of production factors, improves resource allocation efficiency, and promotes urban-rural integration and development. The Outline of the Digital Rural Development Strategy also clearly states that digital rural areas should be regarded as an important aspect of digital China construction, opening up a new phase of urban-rural integration development. In recent years, as a new economic development trend, the digital economy has played an important role in optimizing industrial structure, improving productivity, and promoting ecological green development. In 2021, the scale of China's digital economy reached 45.5 trillion yuan, accounting for 39.8% of GDP[7]. It can be seen that the digital economy contains enormous development momentum.

Regarding the impact of the digital economy on urban-rural integration development, scholars' research perspectives mainly focus on the internal mechanism of the impact of the digital economy on urban-rural integration development and the implementation path of the digital economy promoting urban-rural integration development. Xie Lu et al. (2022) believe that the

four links of social reproduction - production, circulation, distribution, and consumption - have gradually achieved digital transformation, providing new impetus for the integration of urban and rural development.[8] Liu Xian et al. (2021) believe that the digital economy has fully utilized the matching effect, multiplier effect, trickle down effect, and synergistic effect of production factors and technological innovation, thereby empowering the development of urban-rural integration.[9] Li Haoxiang (2022) believes that the digital economy promotes the development of urban-rural integration through the integration of enabling factors, infrastructure services, overall urban-rural governance, and urban-rural humanities and digital technology.[10] Regarding the implementation path of promoting urban-rural integration in the digital economy, Xie Lu et al. believe that agricultural operators should fully utilize digital technology to develop digital agriculture, strengthen rural infrastructure construction through financial investment, build a digital public service system for urban-rural integration, and an integrated digital governance platform.[8] Hua Xingshun (2021) believes that urban and rural planning should be coordinated, new rural infrastructure construction should be increased, and digital technology should be fully utilized to achieve urban-rural spatial integration, development environment integration, and industrial integration. In addition, farmers should be encouraged to return to their hometowns to start businesses and cultivate a group of information talents to promote rural economic development.[11] Wang Shilong et al. (2022) believe that promoting innovative development of urban-rural integration should focus on strengthening digital infrastructure, improving farmers' information literacy, promoting bidirectional flow of factors between urban and rural areas, and promoting digital transformation of traditional rural industries [12].

In summary, the academic community has conducted extensive research on the digital economy and urban-rural integration, but it cannot be denied that there are still certain blind spots in their research field. These studies mainly focus on explaining the mechanism of the impact of the digital economy on urban-rural integration development at a qualitative level. At a quantitative level, research on the impact of the digital economy rarely involves urban-rural integration, and there is also little mention of the digital economy in the research on the influencing factors of urban-rural integration development. Based on this, this paper will use the panel data of 31 provinces and cities in China from 2011-2021, use the entropy method to build the digital economy and urban-rural integration development level index, establish an econometric model, and empirically study the impact of digital economy on urban-rural integration development and its mechanism. Based on the research results, relevant suggestions are proposed for China to fully unleash the potential of the digital economy and promote high-quality development of urban-rural integration.

2. Literature Review and Hypothesis Proposal

(1) The impact of digital economy on urban-rural integration development

Through a review of existing literature, it can be seen that in the digital economy era, digital technology is gradually participating as a new production factor in urban-rural integration development. Compared to traditional production factors such as land, labor, and capital, its advantages of replicability, sharability, reusability, and unlimited supply can improve the availability of resources, thereby promoting economic development. Moreover, in the era of digital economy, the development of internet technology can connect various innovative entities, gather innovative resources, and promote technological innovation in various fields. Technological innovation is the driving force for high-quality economic development.[13] The level of economic development is a key factor affecting urban-rural integration development. In addition, Diewert and Fox (2016) believe that the development of the digital economy can improve the information access ability of the entire social group, especially rural residents,

thereby facilitating farmers to seize development opportunities, promoting rural economic development, and promoting urban-rural integration. Based on this, this article proposes the following assumptions:

H1: Under the same other conditions, the digital economy can promote urban-rural integration and development.

(2) The Mechanism of the Impact of Digital Economy on the Integration of Urban and Rural Development

According to the theory of resource allocation and a review of existing literature, firstly, in promoting the integration of urban and rural economies, with the gradual improvement of rural internet infrastructure, rural e-commerce has shown explosive growth. Taobao Village, Taobao Town, digital agricultural parks, and other e-commerce platforms have flourished. Alibaba, JD, and other e-commerce platforms have relied on their big data and internet advantages to layout rural bases and extend their business areas to the front-end of the agricultural product supply chain.[9] The e-commerce platforms generated by the digital economy have broken through the information barriers between urban and rural supply and demand. Urban residents can purchase various agricultural products, and rural residents can also purchase products from the same perspective as urban consumers through various e-commerce platforms[14], which promotes the formation of a unified large market for urban-rural consumption and promote the integration of urban-rural consumption. Secondly, in promoting the integration of urban and rural public services, the development of the Internet in the digital economy era has broken the constraints of traditional public services on time and space. Through remote technology, public services such as education and healthcare in rural and urban areas can be developed hand in hand.[10] Rural students can enjoy urban education resources through the internet, and rural patients can also receive real-time remote consultations from urban doctors through the internet. What's more, in promoting urban-rural ecological integration, digital technology can be used for ecological area management, environmental and ecological monitoring, allowing the government to better coordinate planning and unified scheduling of urban-rural ecological resources. Secondly, the digital economy has changed the unreasonable development mode of high pollution and high consumption in the industrial era. As a new factor of production, digital participation in social production can effectively improve the utilization rate of resources.[11] Finally, in promoting the integration of urban and rural factors, for a long time, the channels for the two-way flow of factors between cities and rural areas have not been fully opened, and talent and human resources have flowed unidirectionally from rural areas to cities, which causes the widening gap in urban-rural development. In the digital economy era, factors of production such as information, technology, and population are constantly being digitized, and the advantages of shared and unlimited supply of digital elements enable them to flow in both directions between urban and rural areas. Moreover, the supply and demand sides of factors can achieve rapid matching of supply and demand information through the network, reduce the circulation time of factors between urban and rural areas, and reduce circulation costs[8] to promote the integration of urban and rural factors. Based on this, this article proposes the following assumptions:

H2: Under the same other conditions, the digital economy promotes the integration of urban and rural economy, public services, ecology, and factors to promote the development of urban-rural integration.

(3) The mediating role of urban-rural income gap

The key to urban-rural integration development is to narrow the gap between urban and rural areas. The gap in urban-rural development in China is reflected in multiple aspects such as residents' income, consumption, public services, social welfare, etc.,[15] which can be summarized as income gap and non income gap.[16] The increase in income is the prerequisite

and foundation for achieving other aspects of development, and the increase in resident income is the key to stimulate domestic demand, stimulate consumption, transform economic development forms, promote high-quality economic development and achieve synchronous growth of residents' income and economic development. Therefore, forming a reasonable income distribution pattern, improving the income level of rural residents, and narrowing the urban-rural income gap are key measures to promote urban-rural integration and development. The development of the digital economy can alleviate information poverty[17], improve agricultural production efficiency, increase employment opportunities for farmers[18] and other aspects to improve the income of rural residents and narrow the urban-rural income gap. The development of the Internet in the digital economy era has broadened the channels for farmers to access external information and reduced the cost of obtaining information for farmers, which alleviated the technical and knowledge-based economic poverty caused by information poverty[17]. Farmers can use the available information to understand the latest market conditions, arrange their production activities reasonably, improve production efficiency, and increase income levels. The rise of smart agriculture with the development of the digital economy has greatly improved agricultural production technology. Farmers can use advanced breeding technology, irrigation technology, agricultural machinery technology, and other agricultural production activities. These technologies can not only improve agricultural production efficiency, but also increase the yield of agricultural products, achieve agricultural income increase, and increase farmers' income. The development of the digital economy has created more new employment opportunities for farmers through e-commerce and short video platforms. Many farmers have doubled their income by selling their unique agricultural products on e-commerce platforms, while others have gained countless followers and likes by showcasing their talents and skills on short video platforms, thereby monetizing traffic and improving their income levels. It can be seen that the digital economy plays a crucial role in reducing poverty[19], increasing farmers' income, and narrowing the urban-rural income gap. Based on this, this article proposes the following assumptions:

H3: Under the same other conditions, the digital economy promotes urban-rural integration development by narrowing the urban-rural income gap. The urban-rural income gap plays a mediating role in the process of digital economy promoting urban-rural integration and development.

3. Research Design

(1) Model building

On the basis of existing research, this article comprehensively considers time effects and individual effects, and constructs a model (1) to test the impact and mechanism of the digital economy on urban-rural integration development. According to the "three step method of intermediary testing", model (1), (2), and (3) is used to test the intermediary effect of urban-rural income gap in the impact of digital economy on urban-rural integration development.

$$\ln \text{URI}_{it} = \alpha_0 + \alpha_1 \ln \text{DE}_{it} + \alpha_2 \ln \text{control}_{it} + \beta_i + \beta_t + \varepsilon \quad (1)$$

$$\text{revenue}_{it} = \beta_0 + \beta_1 \ln \text{DE}_{it} + \beta_2 \ln \text{control}_{it} + \beta_i + \beta_t + \varepsilon \quad (2)$$

$$\ln \text{URI}_{it} = \gamma_0 + \gamma_1 \ln \text{DE}_{it} + \gamma_2 \text{revenue}_{it} + \gamma_3 \ln \text{control}_{it} + \beta_i + \beta_t + \varepsilon \quad (3)$$

Among them, $\ln \text{URI}_{it}$ represents the logarithm of the urban-rural integration development index of province i in period t , $\ln \text{DE}_{it}$ represents the logarithm of the digital economy

development index of province i in period t , $\ln \text{control}_{it}$ represents the set of logarithms of various control variables of province i in period t , revenue_{it} represents the ratio of urban-rural per capita disposable income of province i in period t , β_i , β_t represents individual effects and time effects, respectively, and ε is a random perturbation term.

Determine whether the impact of the digital economy on urban-rural integration development is significant by observing the significance of α_1 in equation (1). Equation (2) is used to test whether the impact of the digital economy on urban-rural income gap (intermediary variable) is significant. Equation (3) is used to test the joint impact of the digital economy and urban-rural income gap on urban-rural integration. Determine whether the intermediary effect exists by observing the significance of β_1 , γ_2 , Determine whether it is partially mediated or completely mediated by observing the significance of γ_1 .

(2) Variable selection

Table 1. Indicator System for Urban Rural Integration Development Level

Variable name	Measurement indicators				Indicator attribute	Data sources
	Primary indicators	Primary indicators weight	Secondary indicators	Secondary indicators weight		
Urban Rural Integration Development Index(URI)	Economic integration (URIECONOMIC)	0.188	The proportion of the second and third industries	0.034	+	China National Bureau of Statistics
			Comparison coefficient of urban and rural consumption levels	0.028	-	China National Bureau of Statistics
			Ratio of urban and rural fixed assets investment	0.008	-	China National Bureau of Statistics
			Rural household cultural, educational, and entertainment expenses	0.118	+	China National Bureau of Statistics
	Public services Integration (URISERVICE)	0.479	Education funding investment	0.154	+	China National Bureau of Statistics
			Number of beds in hospitals and health centers per 10000 people	0.062	+	Ministry of Science and Technology of China; China National Bureau of Statistics
			The registered urban unemployment rate	0.064	-	China National Bureau of Statistics
			Total length of operating lines	0.199	+	Ministry of Transport of China
	Ecological integration (URIECOLOGY)	0.287	Comprehensive utilization rate of industrial solid waste	0.045	+	China National Bureau of Statistics
			Urban artificial forest area	0.197	+	Ministry of Environmental Protection of China; China National Bureau of Statistics
			Harmless treatment rate of household waste	0.023	+	China National Bureau of Statistics
			Green coverage rate in built-up areas	0.012	+	China National Bureau of Statistics
			Sewage treatment rate	0.010	+	Ministry of Housing and Urban- Rural Development of China
	Factor integration (URIELEMENT)	0.046	Population urbanization rate (urban population/total population)	0.046	+	China National Bureau of Statistics

Dependent variable: The dependent variable of this article is the level of urban-rural integration development. Due to the numerous measurement indicators involved, based on a large number of references and the connotation of urban-rural integration development, four primary indicators, namely urban-rural economic integration, urban-rural public service integration, urban-rural ecological integration, and urban-rural factor integration, are selected and refined into 14 secondary indicators for measurement. The specific indicators are shown in Table 1.

Table 2. Index System of Digital Economy Development Level

Variable name	Measurement indicators				Data sources
	Primary indicators	Primary indicators weight	Secondary indicators	Secondary indicators weight	
Digital Economy Development Index (DE)	Level of information technology development (DEINFOR)	0.461	Fiber optic cable line length	0.101	China National Bureau of Statistics
			Number of mobile phone base stations	0.080	China National Bureau of Statistics
			Asset value of information technology equipment	0.092	Ministry of Education of China, China National Bureau of Statistics
			Total telecommunications business volume	0.188	China National Bureau of Statistics
	Level of internet development (DEINTERNET)	0.434	Internet broadband access port	0.098	China National Bureau of Statistics
			Mobile Internet Access Traffic	0.174	China National Bureau of Statistics
			Number of broadband internet access users	0.099	China National Bureau of Statistics
			Number of mobile internet users	0.063	China National Bureau of Statistics
	Level of digital transactions development (DEDT)	0.104	Number of websites owned by every hundred enterprises	0.015	China National Bureau of Statistics
			Number of computers used per hundred people	0.058	China National Bureau of Statistics
			Proportion of enterprises with e-commerce transaction activities	0.016	China National Bureau of Statistics
			E-commerce sales	0.015	China National Bureau of Statistics

Independent variable: The independent variable of this article is the level of digital economy development. Based on the indicators selected by previous scholars to measure the digital economy, this article selects three primary indicators: information technology development level, internet development level, and digital transaction development level, and refines them into 12 secondary indicators to measure the level of digital economy development. The specific indicators are shown in Table 2.

Control variable: In addition to the digital economy, there are other factors that may have an impact on the level of urban-rural integration development. Based on a large number of references, this article introduces four control variables: economic development level,

government financial expenditure level, marketization level, and degree of openness to the outside world. And they are represented in terms of per capita GDP, government fiscal expenditure, the proportion of non-state-owned economy fixed assets investment in the whole society fixed assets investment, and the proportion of total imports and exports in GDP.

Mediating variable: This article selects the urban-rural income gap as the intermediary variable, drawing on the approach of Wang Jun et al. (2021), and uses the per capita disposable income ratio of urban and rural residents (revenue) as the proxy variable for the urban-rural income gap [20].

(3) Data description

This article uses panel data from 31 provinces in China from 2011 to 2020 as the sample for empirical research, and fills in missing values using methods such as linear interpolation and mean supplementation. For indicators with different data dimensions, standardization processing is required, and the specific processing methods for each indicator are shown in Table 3.

Table 3. Indicator Processing Methods

Variable type	Variable name	Variable Symbol	Processing method	
Dependent variable	Development level of urban-rural integration (URI)	Urban-rural economic integration index	URIECONOMIC	Entropy method
		Urban-rural public services integration index	URISERVICE	Entropy method
		Urban-rural ecological integration index	URIECOLOGY	Entropy method
		Urban-rural factor integration index	URIELEMENT	Entropy method
Independent variables	Development level of digital economy (DE)	Level of information technology development	DEINFOR	Entropy method
		Level of internet development	DEINTERNET	Entropy method
		Level of digital transactions development	DEDT	Entropy method
Control variables	Economic development level	GDP	min-max standardization	
	Government fiscal expenditure level	GE	min-max standardization	
	Degree of openness to the outside world	OPEN	min-max standardization	
	Degree of marketization	MAR	\	
Mediating variable	Urban-rural income gap	revenue	\	
Substitution variable	Digital Inclusive Finance Index	DF	min-max standardization	

The specific steps of the entropy method for objective weighting are as follows:

Step 1, standardize the indicators:

$$\text{Positive indicators: } X'_{\gamma ij} = \frac{(X_{\gamma ij} - X_{\min})}{(X_{\max} - X_{\min})} \quad (4)$$

$$\text{Negative indicator: } X'_{\gamma ij} = \frac{(X_{\max} - X_{\gamma ij})}{(X_{\max} - X_{\min})} \quad (5)$$

Among them, $X_{\gamma ij}$ represents the numerical value of the indicator j of province i in year γ , X_{\max} , X_{\min} represent the maximum and minimum values of different indicators j among all evaluation objects, and $X'_{\gamma ij}$ represents the standardized indicator value of $X_{\gamma ij}$.

Step 2, calculate the objective weights of each indicator:

$$P_{\gamma ij} = \frac{X'_{\gamma ij}}{\sum_{\gamma=1}^h \sum_{i=1}^m X'_{\gamma ij}} \quad (6)$$

h and m represent h years and m cities, respectively.

Step 3, calculate the entropy values of each indicator:

$$E_j = -k \sum_{\gamma=1}^h \sum_{i=1}^m P_{\gamma ij} \ln P_{\gamma ij} \quad (7)$$

$$k = \frac{1}{\ln(h \times m)}$$

Step 4, calculate the redundancy of entropy values for each indicator:

$$D_j = 1 - E_j \quad (8)$$

Step 5, calculate the weights of each indicator:

$$W_j = \frac{D_j}{\sum_{j=1}^n D_j} \quad (9)$$

Step 6: Calculate the urban-rural integration development index and its four major primary indicators, as well as the digital economy development index and its three major primary indicators for each province in each year:

$$S_{\gamma i} = W_j \times X'_{\gamma ij} \quad (10)$$

(4) Descriptive statistics

Table 4 shows the descriptive statistical results of the main variables. The mean of the level of digital economy development (DE) is 0.191, the standard deviation is 0.139, the minimum value is 0.022, and the maximum value is 0.917, indicating significant differences in the level of digital economy development among different provinces. The average level of urban-rural integration development (URI) is 0.346, the standard deviation is 0.104, the maximum and minimum values are 0.724 and 0.076, respectively, indicating that there are also significant differences in the level of urban-rural integration development among different provinces. Among the four

primary indicators that constitute urban-rural integration, The average of the public service integration index (URISERVICE) and ecological integration index (URIECOLOGY) in each province is much higher than the average of the economic integration index (URIECONOMIC) and factor integration index (URIELEMENT), indicating that the level of economic integration and factor integration between urban and rural areas needs to be improved in the process of promoting urban-rural integration. In the control variables, the maximum and minimum values of marketization degree (MAR) also differ significantly, indicating significant differences in marketization degree among different provinces.

Table 4. Descriptive Statistical Results of Main Variables

Variable	Number of samples	mean	Median	Standard deviation	Min	Max
DEINFOR	310	0.078	0.060	0.067	0.003	0.420
DEINTERNET	310	0.078	0.056	0.068	0.007	0.435
DEDT	310	0.034	0.032	0.013	0.012	0.095
DE	310	0.191	0.149	0.139	0.022	0.917
GDP	310	0.253	0.208	0.175	0	1
GE	310	0.254	0.225	0.170	0	1
MAR	310	0.315	0.329	0.109	0.065	0.564
OPEN	310	0.161	0.082	0.189	0	1
URIECONOMIC	310	0.055	0.055	0.009	0.032	0.071
URISERVICE	310	0.122	0.108	0.058	0.024	0.363
URIECOLOGY	310	0.126	0.124	0.049	0.014	0.261
URIELEMENT	310	0.024	0.023	0.009	0	0.046
URI	310	0.346	0.337	0.104	0.076	0.724

4. Empirical Analysis

(1) Correlation analysis

Table 5. Correlation coefficient matrix

Correlation coefficient	URI	DE	GDP	GE	MAR	OPEN	URIECONOMIC	URISERVICE	URIECOLOGY	URIELEMENT
URI	1									
DE	0.853***	1								
GDP	0.451***	0.465***	1							
GE	0.880***	0.930***	0.443***	1						
MAR	0.420***	0.332***	0.058	0.372***	1					
OPEN	0.366***	0.212***	0.597***	0.277***	-0.036	1				
URIECONOMIC	0.559***	0.520***	0.727***	0.472***	0.311***	0.416***	1			
URISERVICE	0.891***	0.922***	0.405***	0.910***	0.349***	0.266***	0.522***	1		
URIECOLOGY	0.744***	0.479***	-0.024	0.548***	0.350***	0.011	0.083	0.478***	1	
URIELEMENT	0.457***	0.365***	0.862***	0.352***	0.145**	0.706***	0.703***	0.345***	0.018	1

Table 5 lists the correlation coefficients between the main variables. The correlation coefficients between the level of urban-rural integration development (URI) and the explanatory variable digital economy (DE), as well as various control variables, are significant at the 1% level and are positive values greater than 0.3, indicating that the variables selected in

this article are more reasonable. The correlation coefficient between the digital economy and urban-rural integration is 0.853, which is significant at the 1% level, indicating that the digital economy has a positive promoting effect on urban-rural integration development. The correlation coefficients between the digital economy and the four primary indicators of urban-rural integration are significant at the 1% level, and the correlation coefficient with public service integration (URISERVICE) is 0.891, indicating that the digital economy has a significant promoting effect on urban-rural economy, public services, ecology, and factor integration. However, the above relationship still needs further testing.

Table 6. Basic Regression Results

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	lnURI	lnURI	lnURI	lnURIECONOMIC	lnURISERVICE	lnURIECOLOGY	lnURIELEMENT
lnDE	0.380*** (9.61)	0.422*** (10.44)	-	0.170*** (4.89)	0.543*** (7.24)	0.311*** (4.87)	0.901*** (4.60)
lnGDP	-	0.044** (2.52)	0.105*** (5.50)	0.042*** (2.83)	0.109*** (3.39)	-0.030 (-1.11)	0.041 (0.50)
lnGE	-	0.112*** (5.99)	0.049** (2.08)	0.074*** (4.61)	-0.027 (-0.78)	0.154*** (5.22)	0.584*** (5.48)
lnMAR	-	0.003 (0.09)	-0.022 (-0.66)	-0.038 (-1.34)	0.155** (2.57)	-0.094* (-1.83)	-0.484*** (-3.15)
lnOPEN	-	-0.029** (-2.49)	0.006 (0.47)	0.008 (0.82)	0.045** (2.13)	-0.130*** (-7.13)	-0.399*** (-7.36)
lnDEDT	-	-	0.222*** (6.35)	-	-	-	-
lnDEINTERNET	-	-	0.072 (1.42)	-	-	-	-
lnDEINFOR	-	-	0.177*** (3.46)	-	-	-	-
_cons	- 0.307*** (-2.95)	0.108 (0.88)	0.843*** (3.73)	-2.362*** (-22.22)	-0.782*** (-3.41)	-1.583*** (-8.12)	-1.777*** (-2.83)
N	310	307	307	307	307	307	306
r2_a	0.814	0.867	0.853	0.733	0.890	0.523	0.484
Year/Province	Yes	Yes	Yes	Yes	Yes	Yes	Yes
F	139.06 3	145.54 2	113.53 3	63.265	180.455	27.150	23.543

(2) Basic regression analysis

The (1) column of Table 6 shows the empirical results of a separate study on the impact of the digital economy on urban-rural integration development. The coefficient of the development level of the digital economy is 0.380, which is significant at the 1% level. The (2) column shows the empirical results after adding control variables. The coefficient of the development level of the digital economy is 0.422, which is significant at the 1% level. This indicates that the digital economy does indeed have a positive promoting effect on urban-rural integration development, and H1 has been verified. In terms of the influence of various control variables on the development of urban-rural integration, the coefficients of economic development level and government fiscal expenditure level are 0.044 and 0.112, which are significant at the 5% and 1% levels, respectively. This indicates that economic development level and government fiscal expenditure level also play a certain promoting role in urban-rural integration. The coefficient of the degree of openness to the outside world is -0.029, which is significant at the 5% level, indicating that the degree of openness to the outside world in a region has a significant reverse

effect on the integration of urban and rural development. The reason for this may be that the increase in the degree of openness to the outside world has indeed promoted economic growth, but due to unreasonable distribution policies, balanced development between urban and rural areas has not been achieved in this process, and urban and rural areas have benefited differently, thus widening the gap between urban and rural development.

The (3) column is an empirical result of studying the impact of the three primary indicators of the digital economy on the development of urban-rural integration. Among the three primary indicators of the digital economy, the level of information technology development and digital trading have a significant promoting effect on urban-rural integration at the 1% level, while the level of internet development has no significant impact on it. This may be because the development of the internet promotes the development of information technology and digital trading, There may be multicollinearity issues among the three, resulting in insignificant impact of internet development level on urban-rural integration.

The empirical results of the impact of the digital economy on the four primary indicators of urban-rural integration are presented in columns (4) (5), (6), and (7). It can be seen that the coefficients of the digital economy on the four primary indicators of urban-rural integration are 0.170, 0.543, 0.311, and 0.901, respectively, and all have been tested at the 1% significance level, indicating that the digital economy mainly promotes urban-rural integration development by influencing the integration of urban-rural economy, public services, ecology, factors, and other aspects, H2 has been validated.

(3) Heterogeneity test

From the above research, it can be seen that the digital economy has a significant promoting effect on urban-rural integration development. However, due to significant differences in economic development levels and geographical locations among different provinces in China, the impact of the digital economy on urban-rural integration development may be different for different provinces, indicating heterogeneity in the impact of the digital economy on urban-rural integration development. Therefore, this article will divide the 31 provinces studied into eastern, central, and western provinces, as well as provinces with high, medium, and low economic development levels, based on geographical location and economic development level differences.[21] Grouping regression will be conducted to observe whether there is heterogeneity in the promotion effect of digital economy on urban-rural integration development.

Table 7 presents the results of heterogeneity testing, indicating significant heterogeneity in the impact of digital economy on urban-rural integration development in eastern, central, and western provinces. In the eastern and western provinces of China, the promotion effect of digital economy on urban-rural integration development is significant at the 1% level. However, the regression coefficient of western provinces is lower than that of eastern provinces. This may be due to the generally high level of economic development in eastern provinces, which is the foundation of urban-rural integration development. Moreover, in areas with higher levels of economic development, digital infrastructure construction is relatively complete, the development level of the digital economy is relatively high, and the promotion effect of the digital economy on urban-rural integration is also more significant. In the central provinces, the impact of the digital economy on urban-rural integration development is significant at a 5% level, which is lower than the significance of the western region. This may be due to the fact that the development level of the central and western regions is relatively backward compared to the eastern region. However, the western region has rich resource advantages, and government policies are inclined towards the western region. The western region actively undertakes industrial transfer from the eastern region and seizes policy opportunities, Therefore, in the era of digital economy, it has shown enormous development potential.

Observing provinces with different levels of economic development, the impact of the digital economy on urban-rural integration development is significant at the 1% level, but the regression coefficient from large to small is in the order of medium provinces>higher provinces>lower provinces. This may be because although provinces with high levels of economic development have a relatively high level of digital economy, their own rural population is relatively small, and the population is mostly concentrated in cities or suburbs. Therefore, they face less pressure on urban-rural integration development, and the progress space driven by digital economy for urban-rural integration development is relatively small, resulting in a lower regression coefficient than provinces with medium economic development levels. In lower level provinces with underdeveloped economic development, there is a huge gap between urban and rural development, and digital infrastructure is lagging behind. As a result, the driving effect of the digital economy on urban-rural integration is limited, resulting in the smallest correlation coefficient.

(4) Mediation effect test

Table 8 shows the results of empirical testing of the mediating effect of urban-rural income gap using the three-step method and Sobel test. The coefficient of ln DE in column (1) is 0.422, which is significant at the 1% level, indicating that the digital economy has a significant promoting effect on urban-rural integration development.

Table 7. Heterogeneity Test Results

Model	Divided by geographical location			Divided by economic development level		
	Eastern	Central	Western	Higher level of economic development	Medium level of economic development	Low level of economic development
	lnURI	lnURI	lnURI	lnURI	lnURI	lnURI
lnDE	0.451*** (7.69)	0.178** (2.12)	0.269*** (3.78)	0.404*** (5.67)	0.525*** (7.84)	0.253*** (3.78)
lnGDP	0.090** (2.18)	0.002 (0.07)	0.068** (2.32)	0.206** (2.65)	-0.053** (-2.36)	0.063** (2.41)
lnGE	0.068** (2.31)	0.183* (1.99)	0.101*** (3.98)	0.094 (1.20)	0.287*** (6.04)	0.049* (1.96)
lnMAR	0.053 (0.98)	-0.092* (-1.93)	0.003 (0.06)	0.051 (0.99)	0.087 (1.49)	-0.094* (-1.77)
lnOPEN	0.087** (2.42)	0.056** (2.55)	-0.057*** (-4.10)	0.191** (2.60)	0.024 (1.22)	-0.044*** (-2.87)
_cons	0.422*** (2.69)	-0.381 (-1.28)	-0.471* (-1.86)	0.470** (2.45)	0.627*** (3.31)	-0.692*** (-2.73)
N	120	90	97	60.000	120.000	127.000
r2_a	0.816	0.939	0.924	0.799	0.938	0.870
F	39.377	99.872	85.417	18.062	129.290	62.096

The coefficient of ln DE in the column (2) is -0.102, and passing the test at the 1% significance level indicates that the digital economy has a significant inhibitory effect on the urban-rural income gap. The higher the development level of the digital economy, the smaller the urban-rural income gap. The coefficients of ln DE and revenue in the column (3) are 0.404 and -0.175, which are significant at the 1% and 5% levels, respectively. From this, it can be seen that the urban-rural income gap plays a partial mediating role in the positive promotion of digital economy on urban-rural integration development. Moreover, the Goodman-1 test in the Sobel

test passed the significance test at the 10% level, indicating once again that the mediating effect is valid and H3 has been validated. From the Sobel test results, it can be seen that the mediation effect coefficient is 0.0177, the direct effect coefficient is 0.4038, and the total effect coefficient is 0.4215. The mediation effect accounts for a relatively small proportion and has a smaller impact on urban-rural integration than the direct effect.

Table 8. Mediation Effect Test

Model	(1)	(2)	(3)
	lnURI	revenue	lnURI
lnDE	0.422*** (10.44)	-0.102*** (-2.80)	0.404*** (9.96)
lnGDP	0.044** (2.52)	-0.078*** (-5.02)	0.030* (1.67)
lnGE	0.112*** (5.99)	-0.052*** (-3.09)	0.103*** (5.47)
lnMAR	0.003 (0.09)	-0.033 (-1.14)	-0.003 (-0.09)
lnOPEN	-0.029** (-2.49)	-0.024** (-2.34)	-0.033*** (-2.86)
revenue	- -	- -	-0.175** (-2.57)
_cons	0.108 (0.88)	2.116*** (19.12)	0.478** (2.53)
N	307	307	307
r ² _a	0.867	0.828	0.870
F	145.542	108.626	139.171
Sobel test	0.0177*(z=1.892)		
Goodman-1 test	0.0177*(z=1.83)		
Goodman-2 test	0.0177**(z=1.962)		
Mediation effect coefficient	0.0177*(z=1.8925)		
Direct effect coefficient	0.4038***(z= 9.9589)		
Total effect coefficient	0.4215***(z=10.4409)		
Mediation effect proportion	0.0421		

(5) Robust Test

To ensure the reliability of the empirical results, this article uses the following three methods to conduct robustness tests on the model. Firstly, replace variables. This article refers to the approach of Han Yanqi (2022)[22] and uses the Peking University Digital Inclusive Finance Index (DF)[23] as another measure of the digital economy, and substitutes it into the model for robustness testing. Secondly, shorten the sample period. Considering the lack of reference value in premature data and the relatively large number of missing values, this article shortens the study sample period to 2014-2020 and conducts regression again to observe whether the regression results are robust. Thirdly, 1% tail reduction treatment. To avoid significant fluctuations in variables affecting the results, a 1% tail reduction was applied to the sample size, and regression was performed again after removing individual outliers.

Table 9 shows the regression results of the robustness test. From column (1), it can be seen that the regression coefficient of using the digital inclusive finance index instead of the digital economy for regression is 0.073, which is significant at the 1% level. From column (2), it can be

seen that the regression coefficient of the digital economy after shortening the sample period is 0.258, which is significant at the 1% level. Column (3) (4) and (5) show the regression results of the robustness test of the mediation effect using the "mediation effect three-step method" after 1% tailing treatment of the sample. From column (3), it can be seen that the regression coefficient of the digital economy on urban-rural integration after tailing treatment is 0.381, which is significant at the 1% level. From column (4), it can be seen that the regression coefficient of the digital economy on urban-rural income gap is -0.078, which is significant at the 5% level, From column (5), it can be seen that when both the digital economy and the urban-rural income gap are included in the model, the regression coefficient of the digital economy on urban-rural integration decreases, but it is still significant at the 1% level. The regression coefficient of the urban-rural income gap on urban-rural integration passes the test at the 5% significance level, so the mediating effect is still valid. Through robustness testing, it can be seen that the regression results of this article have a certain degree of robustness.

Table 9. Robustness Test Results

	Replace variable	Shorten sample period	Tail reduction treatment(3)		
	(1)	(2)	lnURI	revenue	lnURI
lnDF	0.073***	-	-	-	-
	(5.09)	-	-	-	-
lnGDP	0.107***	0.004	0.047***	-0.092***	0.035*
	(6.15)	(0.25)	(2.75)	(-5.56)	(1.94)
lnGE	0.011	0.122***	0.092***	-0.061**	0.084***
	(0.49)	(4.05)	(3.56)	(-2.39)	(3.24)
lnMAR	-0.059	-0.024	0.044	-0.030	0.040
	(-1.62)	(-0.82)	(1.33)	(-0.94)	(1.22)
lnOPEN	0.010	-0.006	0.002	-0.033***	-0.003
	(0.80)	(-0.57)	(0.14)	(-2.92)	(-0.23)
lnDE	-	0.258***	0.381***	-0.078**	0.371***
	-	(7.61)	(10.10)	(-2.11)	(9.80)
revenue	-	-	-	-	-0.132**
	-	-	-	-	(-2.10)
_cons	-0.844***	-0.444***	0.087	2.117***	0.366**
	(-8.74)	(-4.35)	(0.67)	(16.64)	(1.97)
N	306	216	307	307	307
r2_a	0.825	0.894	0.871	0.827	0.872
F	105.915	168.736	150.133	107.391	142.234

5. Research Conclusion and Policy Recommendations

(1) Conclusions

This article uses panel data from 31 provinces and cities in China from 2011 to 2020 to construct a digital economy and urban-rural integration development index, and empirically analyzes the impact and mechanism of the digital economy on urban-rural integration development. The research results show that:

Firstly, the digital economy has a significant promoting effect on the development of urban-rural integration, which is consistent with hypothesis 1. Moreover, the digital economy mainly affects the development of urban-rural integration through the level of information technology development, internet development, and digital transaction development. Moreover, the digital

economy affects the development of urban-rural integration mainly by affecting the integration of urban and rural economy, public services, ecology, and factors, which is consistent with hypothesis 2.

Secondly, the urban-rural income gap plays a partial mediating role in the impact of the digital economy on urban-rural integration, that is, a portion of the digital economy directly affects urban-rural integration, and a portion affects urban-rural integration by narrowing the urban-rural income gap, consistent with hypothesis 3.

Thirdly, through heterogeneity testing, it can be concluded that the impact of the digital economy on urban-rural integration development varies across different provinces. Overall, in provinces with higher levels of economic development in the eastern region, the impact of digital economy on urban-rural integration development is stronger than in provinces with lower levels of economic development in the central and western regions.

(2) Policy recommendations

Based on the research results, this article proposes the following policy recommendations to promote urban-rural integration development:

Firstly, strengthen the construction of digital infrastructure and promote the development of the digital economy. At present, China is actively promoting the construction of "digital rural", but there are still shortcomings in the construction of digital infrastructure in some remote and backward rural areas. The government should strengthen the construction of digital infrastructure in underdeveloped areas, improve the broadband facilities and internet penetration rate in these areas, provide hardware equipment for the development of the digital economy, and enable rural areas to have a certain amount of information carrying capacity. Only in this way can we better leverage the radiation and driving role of developed digital economy areas in underdeveloped areas.

Secondly, create a digital government and promote the integration of urban and rural management services. A digital government based on informatization, open and transparent government affairs, and efficient office work can enable governments at all levels to communicate and share information with each other, enable the government to listen to the voices of the people, enhance the consciousness of government policy implementation, and promote the improvement of government office efficiency. At the same time, through government transparency, rural governments can understand the management methods of urban governments, actively learn their advanced and suitable management experience based on the characteristics of rural development, align with the city, and promote rural development and urban-rural integration.

Thirdly, cultivate the information literacy and skills of rural residents, and promote the development of rural economy. The development of rural economy is the key to the integration of urban and rural development, and rural residents are the main body promoting rural economic development. However, due to limitations in knowledge level and ability, farmers have a low ability to accept and apply digital information[17], and the development potential of the digital economy in rural areas cannot be fully unleashed. Therefore, it is necessary to enhance farmers' information literacy and digital skills to leverage the driving role of the digital economy in rural areas. One is to educate rural residents in the simplest way through daily promotion, so that more residents can receive and use digital facilities. The second is to strengthen the allocation of digital professional talents, improve human capital in rural areas, drive farmers to seize opportunities, and provide technical support and guarantee for urban-rural integration development.

Fourthly, implement a differentiated digital economy development strategy to fully leverage the advantages of various regions. The impact of the digital economy on urban-rural integration development exhibits heterogeneity in different regions. Therefore, different development

strategies for the digital economy should be formulated based on the development advantages of each region to better leverage the driving role of the digital economy. In the economically developed areas of the eastern region, it is necessary to promote the innovative application of digital economy in rural areas by improving the quality of workers, forming demonstration and driving areas, and providing experience and reference for other regions.[20] In the underdeveloped central and western regions, it is necessary to first improve the relevant policy system, strengthen infrastructure construction, do a good job in the basic work of developing the digital economy, and promote the development of the digital economy.

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