

Research on the impact of digital economy on the reduction of the rural-urban gap

Guohui Wang¹

¹Taiyuan Normal University, Jinzhong 030619, Shanxi, China

Abstract:

INTRODUCTION: Through the research on the relationship between digital economy and urban-rural gap, we can find out the important factors affecting the urban-rural gap, so as to promote the development of urban-rural integration and urban-rural economic growth.

OBJECTIVES: Based on regression analysis and mediating effect test, this paper analyzes the impact of digital economy on the reduction of urban-rural gap and whether new urbanization plays a mediating role. Robustness test was added in the analysis process to determine the accuracy and stability of the research conclusion.

METHODS: This paper adopts the methods of literature research and quantitative analysis. The article selects the panel data of 31 provinces in China, which belong to from 2011 to 2020. After Hausmann test, this paper establishes a fixed effect pattern. Then the paper empirically analyzes the relationship between new-type urbanization construction and digital economy and narrowing of the urban-rural gap through combining regression analysis, four robustness tests and mediation effect tests.

RESULTS: The research indicates the following results (1) The new urbanization and digital economy have a remarkable propelling effect on reducing the gap between town and country areas. (2) There is the mediating role of new urbanization between the narrowing of the urban-rural gap and digital economy. And the mesomeric effect constitutes approximately 37.1%.

CONCLUSION: Digital economy can further reduce the gap between town and country areas through the growth of new-type urbanization. The level of education development has a remarkable role in improving the narrowing of the gap between urban-rural areas.

Keywords: Digital Economy, Urban-rural gap, New Urbanization

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*Corresponding Author G. Wang Email: 13994283640@163.com

1. Introduction

Digital technology has penetrated into various industries and sectors. The integration of data economy and traditional industries is gradually deepening. This has established the data economy as a dominant force in national economic development, enhancing international industrial competitiveness and fostering advanced industrial clusters. Concurrently, the thriving digital economy has narrowed the urban-rural digital divide, created diverse job opportunities, enhanced the sharing of premium resources and facilitated the equal provision of public services. It can be seen that China's advancement of new urbanization and narrowing the rural-urban gap are inseparable from the new opportunity and

power of data economy. The high quality growth of digital economy will comprehensively empower China's journey towards narrowing of the rural-urban gap and new urbanization.

Thus, to thoroughly examine the mechanisms and logical connections among the digital economy, new urbanization and narrowing of the rural-urban gap. This study conducts an empirical analysis about the digital economy's impact on narrowing the rural-urban gap. At the same time, it analyzes the mediating effect of new urbanization. This paper is based on the panel data of 31 provinces in China from 2011-2020.

2. Literature Review

In recent years, the relationship between data economy and urban-rural gap has been researched by many savants. Yulan Zhou, Jianjun He et al. (2024)^[1], Xu Bai(2023)^[2]believe that the urban-rural income gap will first increase and then decrease in an inverted "U" shape with the growth of the data economy, and will vary due to the differences in years and regions. At the same time, innovative human factors will affect the inflection point of urban-rural income gap. Zifeng Wang et al.(2023)^[3]are of the opinion that the "U-shaped" influence of the data economy on the income gap between urban and rural residents has remarkable areal differences, and rural human capital and urbanization play a moderating role in it. Longlong Duan et al.(2023)^[4] Feng Deng et al.(2024)^[5] are of the opinion that the relationship between the data economy and the rural-urban income gap at the provincial level varies in different regions. The relationship between the eastern and western regions is in the right half of the inverted U-shaped structure, while the relationship between the central region is in the left half. Xiaojuan Shi et al.(2023)^[6],Chaofeng Xie(2024)^[7], Yongjun Wei(2024)^[8], believe that the cultural consumption level of rural residents has significantly improved with the growth of the data economy, but it will have a significant inhibitory effect on the cultural consumption of adjacent villagers. With the growth of the digital economy, the rural-urban income gap residents has gone through a process of widening and improving. Yixia Fan et al. (2022)^[9], Tingting Xie et al.(2023)^[10]believe that there is a U-shaped relationship which is positive or negative between the data economy and the rural-urban income gap, which requires further research. Xiaoyan Liu et al. (2024)^[11], Jincai Zhang(2024)^[12]believe that there are significant regional differences and spatial dependencies between the data economy and the consumption gap between rural and urban residents. Wen Zhong et al. (2024)^[13], Xiaohui Jiang et al.(2024)^[14]believe that the relationship between the data economy and the rural-urban income gap has now crossed an inverted "U"-shaped turning point. And the effect of reducing the rural-urban income gap in the eastern region is more pronounced.

Many savants have also conducted research on the relationship between new urbanization and urban-rural disparities. Jing Li et al. (2023)^[15], Hui Zhang et al.(2023)^[16]believe that due to the asynchronous growth of new urbanization and agricultural modernization, there is a non-linear relationship between new urbanization and urban-rural income gap. Yongjing Wang et al. (2021)^[17]believe that there is a significant positive spatial correlation between new urbanization, digital inclusive finance and rural-urban income gap at the provincial level. Huanfeng Ding et al. (2017)^[18], Xiaogang Zhou et al.(2023)^[19] are of the opinion that the implementation of the new urbanization strategy has had a certain influence on reducing the rural-urban income gap, and there is a significant spatial spillover influence on the rural-urban income gap in China. Yongping Zhao et al. (2014)^[20], Bing Chen et al.(2021)^[21], Lan Yao (2023)^[22], Wanwei

Hou et al.(2024)^[23]believe that the new urbanization has a significant effect on reducing the rural-urban income gap, and the reduction of the rural-urban income gap will also bring positive feedback to the new urbanization. Chaoming Wang et al. (2014)^[24], Chunyu Jing(2024)^[25]believe that although equalization of rural-urban education may slow down the pace of urbanization, it can improve the quality of urbanization.

3. Theory analysis and study hypotheses

3.1 Digital Economy and narrowing of the urban-rural gap

The reduction of the gap between town and country areas puts forward higher requirements for the level of productivity. The strengthening and expansion of the digital economy can just endow the productivity with a new power, so that the productivity can be liberated and developed. Firstly, in the digital economy, data elements have become the most critical factor of production. Economic activities can be fully interconnected through data, optimizing or reorganizing traditional labor, capital, and other elements to enhance total factor productivity. Thus, the data economy's empowerment allows the economy to amplify or multiply its effects, facilitating rapid and healthy macroeconomic development. And then, digital economy has obvious innovation and sustainable development effect, which is completely different from traditional economy. As the growing digital economy, it will increasingly transition traditional industries towards ecological and green digital sectors, ensuring the macroeconomy's long-term sustainable development. Lastly, the data economy can promote total factor productivity through digital technology, activate new economic Tables, promote market efficiency, and promote the free flow of market resources in a wider range and in a more equitable way^[26]. This makes the digital economy not only narrow the rural-urban gap, regions and groups for the country, but also makes the economy bigger, stronger and better. Clearly, the rapid growth of digital economy can lay a solid foundation for reducing the gap between town and country areas.

At the same time, data economy has natural advantages and conditions for promoting social development, narrowing the following three major gaps and realizing the integrated development of town and country areas. Regarding the urban-rural divide, the pervasive adoption of digital technology has introduced new business models and industries in rural areas. The rise of rural e-commerce and specialty industries has not only created more job opportunities but also boosted farmers' income. The digital economy has fostered agricultural modernization, expedited urban-rural integration, and reduced disparities. From the perspective of public service gap, whether it is education, health care, ecological environmental protection, smart elderly care and spiritual needs, it can rely on digital technology to eliminate barriers to access to public services and achieve equal sharing. For instance, thanks to 5G networks, now students in remote

mountain villages or vast grasslands have accessed to the same curriculum resources as those in cities. Similarly, digital advancements in healthcare enable people to partake in services like online consultations and health management. The spread of the digital economy can help bridge the rural-urban divide and can also significantly narrow regional disparities in public service equality. For specific groups, those with low literacy, skills, and income can leverage digital public services to expand employment opportunities, enhance their skills and increase income, thus closing the gap with other groups.

Therefore, hypothesis 1 is proposed: The growth degree of digital economy can directly facilitate the reduction of the gap between town and country areas.

3.2 The digital economy indirectly facilitates the reduction of the gap between town and country areas through new-type urbanization advancement

The digital economy has gradually become a major force driving economic development, while new urbanization contains significant potential domestic demand and is also a key driver of economic growth. Therefore, the integration of the new urbanization and growing digital economy is not only aligned in development requirements but also aligns with the trends in urbanization and overall economic growth^[27]. The digital economy can drive innovation for new urbanization through innovation and investment-driven strategies, differing from traditional urbanization pathways. This contributes to addressing issues such as urban-rural disparities, public service disparities, and infrastructure development. These problems are also the difficulties that must be overcome to solve the gap between town and country areas. Consequently, the digital economy can be seen as indirectly affecting the urban-rural gap through the promotion of new urbanization. New urbanization serves as a significant mediator in the relationship between the digital economy and the reduction of the gap between town and country areas.

3.2.1 The digital economy is an important force in promoting new urbanization

The digital economy promotes new urbanization in several ways: Firstly, the digital economy bolsters the momentum of urbanization and positively influences new urbanization by fostering new growth drivers, increasing employment, advancing scientific and technological innovation. Then, the widespread adoption of digital technology for country areas facilitates precise marketing of agricultural and sideline products and expands their market reach; it also empowers farmers to keep abreast of the latest market information to improve production technology; furthermore, it supports farmers in switching jobs or starting businesses, thereby significantly reducing the income divide between town and country areas. And then, the application of digital

technology which is in logistics networks can significantly reduce construction costs and enhance connectivity between town and country areas. Lastly, the expansion of digital economy applications in public services broadens the scope of services, enabling rural areas to enjoy the same public services as urban residents, such as cloud medical services and online smart education. In conclusion, the digital economies takes a vital role in closing the urban-rural gap and advancing new-type urbanization.

3.2.2 New urbanization is the necessary approach to narrow the gap between town and country areas

New urbanization is the process centered on people, promoting the orderly transfer of the agricultural population to urban areas, improving the sustainable-development-ability of towns, and achieving ecological livability and harmonious development. With the advancement of new urbanization, the common development of urban and rural areas will be realized. This involves several key aspects: First, the significant shift of agricultural populations to urban areas will substantially boost consumer demand and investment rates, stimulate the economic cycle, and enhance economic vitality; Additionally, the healthy development of new urbanization will drive the development of informatization and industrialization, so that the economy can achieve high-quality development, which is conducive to the common development of urban and rural economy^[28]. Second, new urbanization focuses not only on economic growth but also on cultural enhancement and preservation. Balanced development of material and spiritual civilizations is an intrinsic aspect of new urbanization. Particularly during the process of urbanizing agricultural populations, there's an emphasis on enhancing the spiritual and cultural well-being of migrant workers and ensuring equal access to public cultural services in both town and country areas, thereby supporting the common development of town and country people. Third, new urbanization emphasizes the harmonious coexistence of humans with nature. General Secretary Xi calls for "a green, intensive, low-carbon and intelligent path of new-style urbanization." Consequently, the progression of new urbanization will bring about a substantial improvement in the country's deteriorating ecological environment, and green, low-carbon modes of production, living, and consumption will gradually become the norm in people's everyday lives. By adhering to green development principles, new urbanization achieves the goal of a beautiful China where humans coexist harmoniously with nature, and it also contributes to achieving the common development of town and country areas.

Therefore, hypothesis 2 is proposed: the level of the digital economy growth indirectly promotes reduction of the gap between town and country areas through the advancement of new urbanization.

4. Model design

4.1 Variable selection

4.1.1 Explained variable: Reduction of the gap between town and country areas

The rural-urban gap not only includes the rural-urban income gap and the rural-urban consumption gap but also includes the rural-urban gap in social, spiritual and political aspects. In

assessing the gap between town and country areas, it is essential to consider not only material wealth indicators but also regional disparities, living conditions, and the spiritual well-being of the people. Consequently, this article draws on the classification criteria of Jingkun Zhang^[29], and Zhaofeng Wang et al^[30], and considers the accessibility of data across different years, constructing primary, secondary, and tertiary indicators of rural-urban gap from the two dimensions of overall growth and relative gap, as illustrated which is in Form 1.

Form 1: Evaluation index system of urban-rural gap

variable	Level 1 Indicator	Level2 Indicator	Level3 Indicator	Description
Reduction of the gap between town and country areas	overall development	Material wealth	Per capita GDP	GDP/annual average population
			PCDI	——
			Urbanization rate	Regional town permanent population/total regional Permanent population
		public service	Student teacher ratio in Colleges and Universities	Number of college students/number of College Teachers
			Social security intensity	Social security and employment expenditure/Gross Regional Product
		infrastructure	mass transit cars	Quantity of mass transit cars per 10000 persons
			Number of hygienism technical staffs	Quantity of hygienism technical staffs per thousand persons
		Ecological and environmental protection	Green coverage rate	Forest area/total land area
		Spiritual life	Books per capita	——
			Proportion of education expenditure	Education expenditure/total financial expenditure
	relative gap	Regional disparities	income gap	gini
		the urban-rural gap	consumption gap between town and country	consumption per person expenditure of city dweller / consumption per person expenditure of country dweller
			income gap between town and country	per person income of city dweller/ per person income of country dweller
			Cultural gap between town and country	per person cultural consumption of city dweller / per person cultural consumption of country dweller
			medical gap between town and country	City medical beds/Country medical beds

4.1.2 Core explanatory variable: Development degree of digital economy

With the rapid growth of information technology, digital economy has become an important engine of economic growth. In recent years, numerous research institutions and savants already assessed the growth degree of the digital economy, generally focusing on three dimensions: digital

technology basic facilities, industrial digitalization and digital industrialization. However, there is still no complete consensus on the subdivision of secondary measurement indicators. Drawing on the available literature and data from Huilin Xu^[31], this paper evaluates the digital economy infrastructure across four aspects: smartphone penetration, domain count, Internet penetration, and talent base; Assesses digital industrialization through three metrics: software industry revenue, enterprise website count, and

telecommunications traffic; Measures industrial digitalization in two key areas: digital transactions and digital inclusive finance.

Form 2: Evaluation indices structure of digital economy growth

variable	Level 1 Indicator	Level2 Indicator	Description
Development degree of digital economy	Digital infrastructure	Smartphone penetration	Annual cellular phone ownership per 100 Households
		Number of Internet domain names	——
		Internet penetration	Broadband access users/total number of households
		Talent base	amount of information transmission employees/number of urban unit employees
	Digital industrialization	Software industry revenue	——
		amount of enterprise websites	Amount of websites per 100 business
		Telecom business volume	——
	Industrial Digitalization	Digital transaction	E-commerce sales
		Numeral Inclusive Finance	Numeral inclusive finance index

4.1.3 Mediating variable: level of new-type urbanization growth

Adopting the measurement approach of Xingcun Fang, the level of new urbanization development is evaluated across five dimensions: demographic urbanization, economic urbanization, territorial urbanization, social urbanization, and ecological urbanization^[32]. This framework comprises 13 specific secondary indicators, as detailed Form 3.

Form 3: Index System of new-type urbanization growth

variable	Level 1 Indicator	Level2 Indicator	Description
Development level of new urbanization	Population urbanization	Urbanization rate	Regional town permanent population/total regional Permanent population
		Urban Employed Population	——
	Economic Urbanization	speed increase of Regional GDP	GDP during the reporting period/ base period GDP
		Per Capita GDP	GDP/annual average population
		Urban per capita disposable income	——
	Land Urbanization	road area per citizen	City Road area/city population
		Urban built-up area	——
	Social urbanization	100000 college students	Number of college students per 100000 population
		amount of medical and health staff	amount of health technicians per thousand people
		Civil vehicle ownership	——
	Ecological Urbanization	Garbage harmless treatment rate	Amount of domestic waste treated harmlessly/total amount of domestic waste
		town green coverage	town greening area/total land area
		The greenery area of per capita park	Park green area/ regional Permanent population

4.1.4 Control variables

By assessing the conditions of the intermediary variable, core explanatory variable, explained variable, and utilizing the approach of variable selection of Jianren Yang et al^[33], we chose four variables which are control variables. They are industrial structure (bgdp-3), labor force level (ldlsp), education development level (jyfszp), and regional disparity (jnxs). We use the proportion of the tertiary sectors in GDP to gauge the industrial structure; The ratio of regional employed population to regional resident population is used to express the labor force level; The level of education development is represented by the ratio of education expenditure to GDP; Drawing on existing literature, The gap between town and country areas has an impact on the development level of new-type urbanization; hence, the Gini coefficient which is a measure of regional disparity is included in the control variables. The relationship between these variables is shown in figure 1

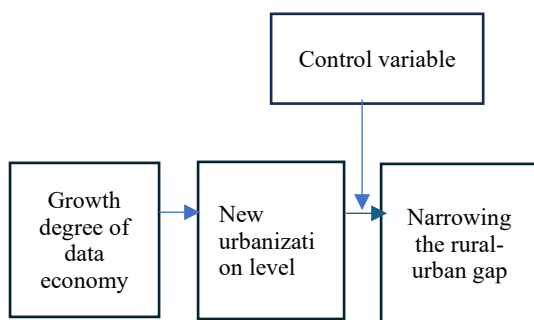


Figure 1: Theoretical model

4.2 Model Settings

To verify the correctness of hypothesis 1, construct a basic econometric model, as shown in formula (1)

$$gongt_{i,t} = a_0 + a_1 shuzi_{i,t} + a_2 control_{i,t} + \theta_i + \delta_i + \varepsilon_{i,t} \quad (1)$$

In formula (1), gongtit is the degree of reduction of the gap between town and country areas, where i is the province and t is the period; shuziit is the degree of digital economic development, where i is the province and t is the period; Controlit, several control variables; θ_i and δ_i represent personal and time utility respectively; and $\varepsilon(i,t)$ denotes a random interference term.

To test the validity of hypothesis (2), a mediation effect model was developed based on model (1), incorporating the development level of new-type urbanization (xczh) as the mediating variable, as presented in formula (2) and (3).

$$xczh_{i,t} = \beta_0 + \beta_1 shuzi_{i,t} + a_2 control_{i,t} + \theta_i + \delta_i + \varepsilon_{i,t} \quad (2)$$

$$gongt_{i,t} = \gamma_0 + \gamma_1 shuzi_{i,t} + \gamma_2 xczh_{i,t} + \gamma_3 control_{i,t} + \theta_i + \delta_i + \varepsilon_{i,t} \quad (3)$$

In formula (2), xczhit signifies the development level of new-type urbanization where i is the province and t is the period.

4.3 Data Sources and Descriptive Statistics of Variables

Owing to data continuity constraints, this study utilizes panel data from 2011 to 2020 covering 31 provinces in China as the research sample. The original data primarily come from the China Statistical Yearbook 2012-2021 and the EPS data platform. The digital inclusive finance index is from the statistical yearbook of Chinese cities. This article initially employs the entropy method to assess the degree of reduction of the gap between town and country areas, the level of new-type urbanization and the digital economy growth. Then the article produces weighted scores that facilitate subsequent panel regression analysis. There are specific descriptive statistics of variables in Form 4.

Form 4: Descriptive statistics of variables

Variable Symbol	Variable	standard deviation	Maximum	minimum value	mean value	sample size
gtong	Urban-rural gap	0.082	0.623	0.188	0.334	310
shuzi	Development degree of digital economy	0.129	0.734	0.007	0.135	310
xczh	Development level of new urbanization	0.139	0.868	0.085	0.355	310
bgdp_3	Proportion of tertiary industry in GDP	9.653	83.9	29.7	47.319	310
ldlsp	Labor level	0.147	0.641	0.069	0.210	310
jyfszp	Educational development level	0.024	0.173	0.021	0.043	310
jnxs	gini	0.045	0.509	0.350	0.430	310

5. Empirical analysis

5.1 Hausmann test

The Hausman test employs chi-square statistics to compare and select the best model among two or more economic models, aiming to determine which of the fixed or random effect models is more applicable. The null hypothesis of the Hausman test assumes no significant difference between the fixed and random effect models, implying no selection bias and acceptance of the random effect model as the correct one. If the chi-square statistics indicate significant differences in the estimated results, it should reject the original hypothesis and using fixed effect model. Conversely, if the original hypothesis is true, it should adopt the random effect model. As Form 5 reveals, the Hausman test for model (1) yielded a $\chi^2(5)$ value of 31.37 and the p value is 0.0000, which significantly rejects the original hypothesis. Hence, the fixed effect model, not the random effect model, should be used. Additionally, employing the fixed effect model, as suggested by the Hausman test, can mitigate endogenous issues to a certain degree.

Form 5: Hausmann Test Results

The measure of Shuzi in model (1)	Hausman statistics	Corresponding p value
	31.37***	0.0000

*** means significant at 1% significance level

5.2 Multicollinearity test

In order to prevent the correlation between independent variables from affecting the effectiveness of regression results, we conducted a multicollinearity test. This article uses the Vif test to measure whether the multicollinearity is serious. In general, if the value of Vif is greater than 10, it indicates that there is a multicollinearity problem. The larger the Vif value, the greater the correlation between variables. It can be seen from Form 6 that the Vif values of all variables are less than 5, indicating that there is no multicollinearity problem in the model.

Form 6 : Variance inflation factor

	VIF	1/VIF
shuzi	4.789	0.209
xczh	3.986	0.251
bgdp_3	2.271	0.44
ldlsp	1.812	0.552
jyfszp	1.471	0.68
jnxs	1.028	0.973
Mean VIF	2.559	

5.3 benchmark regression

To examine the influence of the data economy's growth on rural-urban gap, we conducted an empirical test for formula (1) using Stata 15.0 software. From 7 shows the benchmark regression results of the influence of growth degree of digital economy with control variables on the reduction of rural-urban gap. After accounting for time and regional effects, As the core explanatory variable, the coefficient of digital economy is 0.1274, which is significantly positive. At the same time, it is significantly positive on the level of 1%. It shows that the reduction of the gap between town and country areas is significantly improves with the digital economy's development. These regression findings support Hypothesis 1. which states that the digital economy growth can directly promote the reduction of rural-urban gap.

The regression coefficient for the tertiary industry's share in GDP is 0.0024, regarding the control variables, and it is significantly positive on the level of 1%. It shows that the proportion of the tertiary industry has an obvious positive role in facilitating the reduction of the gap between town and country areas. Based on the experiences of developed nations, the tertiary industry's share in the gross national product is expected to persistently rise. Concurrently, the tertiary industry plays an irreplaceable role in advancing industrialization and modernization, broadening employment opportunities across society, preserving social stability, enhancing living standards and fostering cultural and ethical progress. These functions are exactly the different aspects of promoting the reduction of the gap between town and country areas; The regression coefficient of labor force level is 0.1182, which is significant on the level of 1%. It shows that the level of labor force can significantly improve the level of narrowing the rural-urban gap. In this study, the labor force level refers to the ratio of the regional employed population to the total regional permanent population. A higher labor force level indicates a larger proportion of employed individuals, correlating with fewer unemployed individuals in the region. And the empirical data show that the stable employment situation is highly consistent and coordinated with the steady improvement of residents' income level, so the higher the labor level, the more conducive to narrowing the regional gap, thus promoting the reduction of the rural-urban gap; The education development level's regression coefficient of 0.6467, significant on the 5% level. It shows that the level of education development can significantly promote the reduction of the gap between town and country areas. In this study, education development is measured by the ratio of education funding to GDP. Education serves as a fundamental strategy to break the intergenerational cycle of poverty, and increasing investment in education and enhancing access to education at all stages are crucial for achieving educational equity. The regression coefficient of Gini coefficient is -0.6066, which is significant at the level of 1%. It shows that the higher the Gini coefficient, the more restrained the narrowing of the gap between town and country areas. The Gini coefficient measures income inequality within a region. The lower the Gini coefficient,

the higher the reduction of the gap between town and country areas.

Form 7: baseline regression results

variable	model
shuzi	0.1274*** (2.84)
bgdp_3	0.0024*** (6.85)
ldlsp	0.1182*** (10.01)
jyfszp	0.6467** (2.27)
jnxss	-0.6066*** (-34.65)
_cons	0.4121*** (24.76)
N	310
r ²	0.8948
F	434.47

**And * * * are significant at the significance level of 5% and 1% respectively, and t value is in brackets. The following table is the same.

5.4 Robustness Tests

To ensure the stability of the regression results, this article conducts the following four robustness tests:

5.4.1 Excluding the First Two Years of Underdeveloped Digital Economy

After entering the 21st century, digital technology gradually became an important factor of production and was applied across various industries. Consequently, the digital economy based on digital technology has rapidly developed and been widely applied in the past decade. Additionally, the statistical yearbook data shows data gaps for certain variables related to the digital economy in the years 2011-2012, during which the national digital economy was relatively underdeveloped. Therefore, the robustness test initially excludes all samples from these two years, with the test results presented in model (1) of Form 8. The results show that the digital economy takes a direct and relatively robust promoting influence on the reduction of the rural-urban gap. However, compared with the regression results of the two years before the removal, the regression coefficient after the removal is lower than that before the removal, suggesting the direct promotion influence of the digital economy on the reduction of the rural-urban gap is reduced after the removal. The likely reasons are that the digital economy is not yet fully matured and its coverage is not extensive enough^[34]. On one hand, the information industries and digital industries are currently high-paying sectors. On the other hand, small and medium-sized enterprises face greater challenges in upgrading their digital technology compared to large

enterprises, potentially exacerbating income inequality among different industries or enterprises. The higher regression coefficient before exclusion could be attributed to the significant multiplier effect from the integration of the digital economy with the real economy during its initial development stage.

5.4.2 Test Results Excluding Samples from Central Government Directly Administered Municipalities

Compared to other provinces, municipalities directly under the central government typically exhibit higher levels of digital economy growth, urbanization, and the reduction of the gap between town and country areas than the national average. Including these municipalities in the overall sample could amplify the direct promotional influence of the digital economy, potentially rendering the results less accurate. Consequently, We removed Chongqing, Tianjin, Shanghai and Beijing from the overall sample, with the test results presented in model (2) with Form8. The results show that the regression coefficient remains positive at 0.1198, albeit slightly reduced from before exclusion. It shows that these four municipalities directly under the central government have indeed promoted the reduction of the gap between town and country areas to a certain extent due to the high level of digital economy growth and urbanization, further validating the robustness of the test results.

5.4.3 Excluding the top four digital economy provinces of 2020

Compared to previous years, 2020 marked the most rapid growth in the digital economy. That year, four provinces (municipalities directly under the central government)—Guangdong, Shanghai, Beijing, and Jiangsu—showed notably advanced levels of digital economy growth. To assess whether a higher degree of digital economy development significantly influences the final outcomes, the four provinces (municipalities) with the highest digital economy growth in 2020 were excluded from the analysis and retested. The results are presented in Form8, model (3). The results indicate that the regression coefficient for the digital economy is 0.2257. It confirms that the digital economy can still directly promote the reduction of the gap between town and country areas. Additionally, the slight increase in this coefficient compared to the baseline regression indirectly supports the notion that during the stage when the digital economy is not fully mature, temporary income disparities may arise due to industrial or sectoral imbalances. However, the minimal increase in the coefficient reaffirms the robustness of the test results.

5.4.4 Excluding the four provinces with the lowest digital economy levels in 2020

Similarly, in 2020—the year with the fastest growth in the digital economy—four provinces demonstrated significantly lower levels of digital economy growth: Qinghai, Tibet, Gansu, and Ningxia. To assess whether a lower level of digital economy growth significantly affects the final outcomes, these four provinces with the lowest digital economy growth in 2020 were excluded from the analysis and retested. The results are presented in the model (4) in Form8. The results suggest that the regression coefficient for the digital economy is 0.1207. It proves that the digital economy still has a remarkable direct promoting influence on the reduction of the rural-urban gap. And the slight decrease in the regression coefficient compared to the baseline regression indicates that the four provinces with the lowest digital economy development do not significantly impact the promotion of reduction of urban-rural gap, further attesting to the robustness of the test results.

Form 8: robustness of regression results

variable	Pattern (1)	Pattern (2)	Pattern (3)	Pattern (4)
shuzi	0.0967** (2.65)	0.1198** (2.36)	0.2257*** (3.81)	0.1207** (2.77)
bgdp_3	0.0027*** (7.65)	0.0023*** (5.97)	0.0019*** (4.73)	0.0026*** (7.21)
ldlsp	0.1119*** (10.15)	0.1141*** (9.01)	0.1023*** (9.68)	0.1118*** (9.01)
jyfszp	0.0324 (0.08)	0.8253*** (3.37)	0.8921*** (4.46)	0.1934 (0.63)
jnxss	-0.6090*** (-28.16)	-0.6067*** (-31.85)	-0.6026*** (-33.51)	-0.6230*** (-37.86)
_cons	0.4314*** (23.64)	0.4030*** (23.65)	0.4110*** (25.78)	0.4396*** (29.04)
N	248	270	270	270
R2	0.9001	0.9066	0.9182	0.9085
F	332.25	408.49	556.31	458.86

5.4.5 Lag effect analysis

In order to further verify whether the influence of digital economy on the rural-urban gap has a long-term effect, we conducted a lag effect test. We lag the core explanatory variable by one period, and the results are shown in Form 9. It can be seen from the results that under the fixed effect model, the coefficient of the core explanatory variable data economy is still significantly positive. It shows that in the long run, the reduction of the rural-urban gap will increase with the improvement of the level of data economy. And the coefficients of other control variables are consistent with the results of benchmark regression. It shows that the growth level of data economy has a long-term influence on reducing the rural-urban gap.

Form 9: Data economy lags behind phase I test results

variable	model
L1_shuzi	0.0926*** (4.63)
xczh	0.1109*** (3.57)
bgdp_3	0.0016*** (5.98)
ldlsp	0.1019*** (12.06)
jyfszp	0.2966** (1.47)
jnxss	-0.6201*** (-33.5)
_cons	0.4424*** (29.9)
N	279
F	425.2

5.5. mediating effect test

Based on the previous robustness test, we can see that the digital economy has a remarkably positive promoting influence on the reduction of the gap between town and country areas, so we can further test the mediating effect. To examine the operational mechanism of the new urbanization development, specifically whether the digital economy can reduce the gap between town and country areas by promoting new urbanization, this study employs a mediating effect model to assess equations (2) and (3), with the regression results presented in Form 10. As indicated by the inspection results of equation (2) in Form 10, the regression coefficient of the digital economy on new urbanization stands at 0.3115, apparent at the level 1%, suggesting a substantial positive influence of the digital economy's development on the level of new-type urbanization, thereby fulfilling the criteria for further mediation effect testing. The test results of equation (3) in Form 10 reveal that the regression coefficient of the digital economy on reduction of rural-urban gap is 0.0871, and the regression coefficient of new urbanization on the reduction of urban-rural gap is 0.1296, which are apparent at the level 1%, and Sobel test also verifies the existence of mediation effect. Overall, the mediating effect of the digital economy in promoting reduction of urban-rural gap through new urbanization constitutes approximately 31.71%, while the direct effect accounts for about 68.29%. The direct effect is 2.15 times that of the indirect effect. This suggests that while the direct impact of the data economy on reduction of urban-rural gap is predominant, the indirect effect is also significant. Consequently, it is evident that the new urbanization serves as a significant mediating variable, playing a crucial intermediary role in the way of the digital

economy advancing the reduction of the gap between town and country areas., thereby supporting hypothesis 2.

Form 10: Mediating effect test results

	equation 1 gongt	equation 2 xczh	equation 3 gongt
shuzi	0.1274*** (6.94)	0.3115*** (8.71)	0.0871*** (4.33)
xczh			0.1296*** (4.31)
bgdp_3	0.0024*** (10.17)	0.0042*** (9.20)	0.0018*** (7.07)
ldlsp	0.1182*** (13.23)	0.1000*** (5.76)	0.1052*** (11.48)
jyfbzsp	0.6467*** (3.14)	0.7582** (1.89)	0.5485** (2.73)
jnxss	-0.6066*** (-30.06)	0.0517 (1.32)	-0.6133*** (-31.25)
_cons	0.4121*** (27.71)	0.0378 (1.31)	0.4072*** (28.16)
R2	0.8965	0.7503	0.9031
F	474.53	164.65	423.85
Sobel inspect	Z=3.86***; P=0.0001		

6. Article conclusions and policy recommendations

6.1 Article conclusion

The article Utilizes the panel data of 31 provinces in China, which belong to 2011-2020. This article employs the entropy method to assess the development degree of reduction of rural-urban gap, new-type urbanization and the digital economy. It utilizes fixed and mediating effect models to investigate how the growth of the new-type urbanization and digital economy contribute to the reduction of urban-rural gap. The main conclusions are as follows: First of all, the foundational regression analysis make known that the growth of the digital economy can encourage the realization of the reduction of urban-rural gap. Then, by removing the first two years of under developed digital economy, the four municipalities directly under the central government with high levels of economic development, the four samples with the highest level of data economy in 2020, the four samples with the lowest level of digital economy in 2020, four robustness tests were carried out in detail. The results were significant at the level of 1%, which proved that there was a stable positive impact on the reduction of the gap between town and country areas

enabled by digital economy. Lastly, the digital economy can indirectly yet apparently enhance the reduction of rural-urban gap through the advancement of new urbanization, with new urbanization development serving as a significant intermediary. In the existing literature, there are few articles discussing the impact of new urbanization on the relationship between digital economy and the reduction of rural-urban gap, so this study theoretically makes up for the lack of research on the reduction of rural-urban gap.

6.2 Policy suggestions

6.2.1 Enhancing the level of rural digital industrialization and industrial digitalization

Given the distinct developmental characteristics of the primary industry, secondary industry, tertiary industry, and the significant variations in digital empowerment, it is essential to employ varied approaches to enhance digital capabilities during the digital transformation process, tailored to the specific needs of different industries. For example, the service industry has many industries and a large development gap. The key to digital empowerment lies in improving service quality and management level. To this end, efforts should be made to strengthen digital consumption infrastructure and build smart business districts^[35]. The manufacturing industry has a wide variety of products and distinct production processes, so the key to digital transformation is the overall collaborative transformation of the industrial chain. Digital transformation models should be tailored to different industries to achieve digital empowerment throughout the entire product lifecycle. The agricultural production has a wide range and a long cycle. Therefore, the key to digital transformation is to improve the level of agricultural technological innovation and infrastructure construction. To this end, we should facilitate the construction of smart farms, digital farmland, digital irrigation areas, e-commerce platform, etc., so that digital empowerment covers the entire process of agriculture before, during, and after production, and promote efficient connection between farmers and the market.

6.2.2 Accelerate the development of new urbanization

To fulfill our intermediary role in promoting the reduction of the gap between town and country areas, we must innovate our development strategies and accelerate the advancement of new urbanization with the help of digital economy. To achieve this, we must excel in the following key areas. First, deepening the application of data economy in the field of public services. We should promote the digitization of public services with the help of big data mining, analysis and integration. For example, we should increase the integration with big data in tourism, public transport, market regulation, meteorological services and

other fields to improve the quality of public services; Promoting the digitalization of industries in pension, medical care, education and other aspects, and enhance the sharing and co construction of high-quality resources between urban and rural areas; Accelerating the popularization of the Internet of things with the help of digital technology, so as to improve the rural-urban gap in energy structure. Second, accelerating agricultural modernization with the help of data economy. First of all, through the application of digital technology, the traditional agriculture is replaced by a more accurate modern agricultural production mode; Secondly, digital technology has greatly shortened the space and time distance between consumers and agricultural producers. It not only increases the sales of agricultural products, but also improves consumers' understanding of agricultural products; Finally, the wide application of digital economy in agriculture is conducive to information sharing and resource sharing. It can not only make agricultural development more suitable for market demand, but also improve the competitiveness of agricultural producers. Third, we must effectively manage the two critical tasks of industrial agglomeration and population migration. In terms of industrial agglomeration, we should upgrade traditional labor-intensive industries while proactively integrating with industries in developed areas, introducing competitive or advantageous sectors to enhance industrial concentration and Table clusters. Regarding population migration, we must focus on enhancing the quality of rural residents and optimizing the population structure. To this end, we should actively provide vocational education and skill training for rural populations, and develop appropriate household registration policies to lay a solid foundation for labor force transfer^[36].

6.2.3 Accelerate the Development of New Infrastructure

We must expedite the development of new infrastructure to solidly foundation the growth of the digital economy. To this end, we should focus on the following tasks. First, we should expand the number of 5G base stations and establish a collaborative innovation system for the 5G industry chain. Second, construct an industrial internet big data center to facilitate the integration and penetration of information technologies like artificial intelligence into the industrial internet, and develop industrial internet parks. Third, set up a big data platform, exploring various modes of data utilization such as unified collection, collaboration, exchange, and sharing. Develop a comprehensive public data resource platform to enable the seamless application of big data and artificial intelligence across various sectors including industry, transportation, education, telecommunications, healthcare, and finance. Fourth, enhance the green development of ecological, water, and energy resources, promoting sustainable development through improved energy efficiency and stricter environmental standards.

7. Research Deficiencies and Prospects

There are still some deficiencies and flaws in this study, which are mainly reflected in the following aspects: First, due to the limitations of data acquisition, for example, the digital inclusive finance index is only updated to 2021, which may make the conclusion of this study unable to fully reflect the latest actual situation; Second, in quantitative research, the selection of control variables may not be comprehensive enough, which may make the conclusion of this study inaccurate; Third, the research on the influence of independent variables on dependent variables is not deep enough and needs to be further explored.

In the future research, we will analyze and study from more angles, expand and deepen the research on the relationship between digital economy and rural-urban gap.

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