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The Influence and Mechanism of Digital Village Construction on the Urban–Rural Income Gap under the Goal of Common Prosperity

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Abstract: Digital village construction is not only a vital component of the digital China strategy but also a crucial measure by which to realize common prosperity. This study theoretically elaborates the influence of digital village construction on the urban–rural income gap (URIG) and its mechanism and empirically tests it by using a panel fixed-effect model, a mediating-effect model, and a moderating-effect model based on the provincial data of major producing areas from 2011 to 2020. The results show that digital village construction can significantly narrow the URIG, and rural industry revitalization is a vital channel for digital village construction in driving the decline of the URIG. The construction of transportation infrastructure can significantly enhance the inhibition effect of digital village construction on the URIG. Moreover, there is a human capital threshold for the impact of digital village construction on the URIG; after crossing the threshold, digital village construction better suppresses the URIG. So, the government should increase the financial support and technical support for digital village construction, improving the rural production conditions and industrial development environment and establishing a rural digital talent cultivation mechanism so as to achieve the goal of common prosperity.

Keywords: digital village construction; urban–rural income gap; rural industry revitalization; rural human capital

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1. Introduction

Promoting equal access to education, transportation, and other public service resources in urban and rural areas is an important path to achieving common prosperity [1]. Since 1978, China's economic development has focused on urban areas, while ignoring rural areas, leading to serious urban–rural differentiation. On the basis of the data of the National Statistics of China, the URIG has shown an inverted U-shaped evolution (see Figure 1). The absolute difference between urban and rural income is expanding, while the relative difference is narrowing. The existence of this gap shows that China has not balanced interests in the process of rapid development, resulting in the marginalization of some regions and groups. Starting from the balance of resource factors, such as education and public services, improving farmers' knowledge and skills and the rural business environment and effectively narrowing this gap is of great value to realizing the goal of common prosperity in China.

In recent years, the digital economy, spawned by information technology, as an emerging economic industry, has injected new momentum into China's economy and provided new opportunities for the construction of rural society. According to the data compiled in the White Paper on the Development of China's Digital Economy (see Figure 2), the scale of China's digital economy has grown rapidly, and its share of GDP has also grown from to 41.5% in 2022. However, it must be pointed out that the informatization process in China's rural areas is obviously lagging behind that in urban areas. So, China put

forward the Digital Rural Development Strategy, which aims to digitize the countryside by consolidating digital infrastructure and facilitating the in-depth fusion of the Internet and the agricultural industry. With the rapid launch of smart agriculture construction and the emergence of new industry models in rural areas, the advantages of the construction of a digital countryside in promoting the revitalization of rural local resources and upgrading the industrial structure has begun to be highlighted [2]. Currently, all parts of China are actively engaged in promoting the practice of digital village construction in an attempt to alleviate the problem of the low penetration of innate digital resource endowment and digital services into rural areas and to foster integrated development.

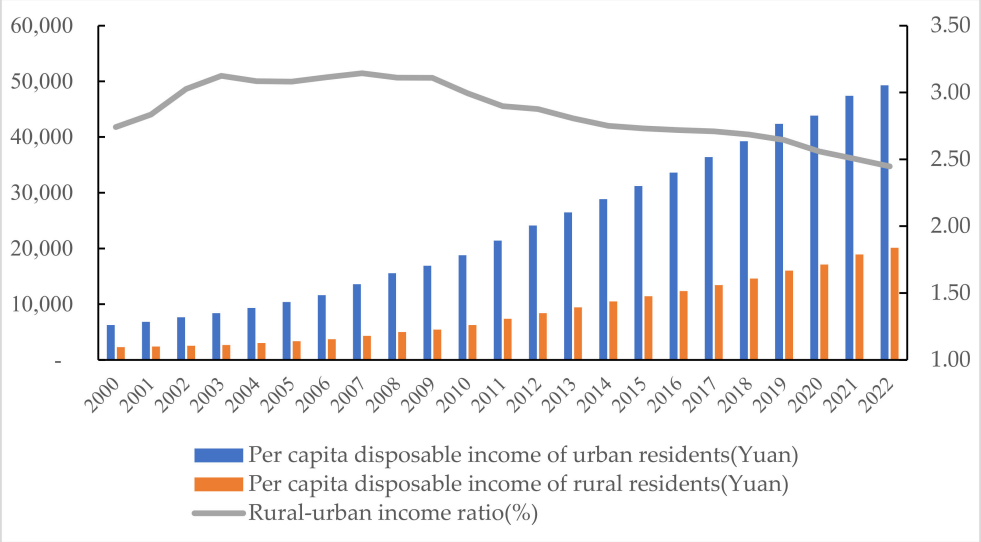

Figure 1. The urban–rural income gap in China.

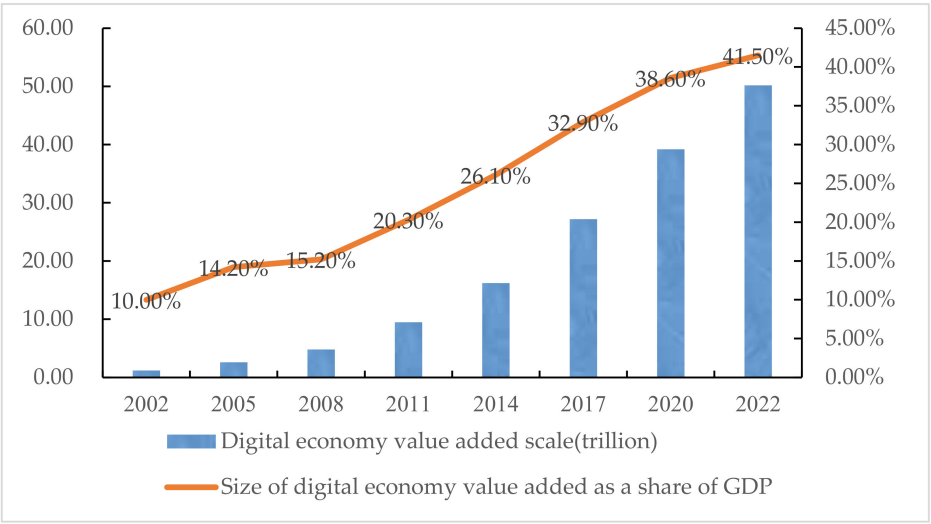

Figure 2. The development of the digital economy.

Specifically, the rural digital economy can promote agricultural production intelligence and intensification through the digitization of production factors, as well as the intelligence of the production process [3,4]. Digital tools such as e-commerce platforms and agricultural apps can also be used to build an information communication mechanism between agricultural producers and consumers, reduce the information asymmetry among production subjects, and realize the docking of agricultural supply and demand markets and the sharing of high-quality resources [5]. As rural Internet and other digital infrastructures undergo continuous enhancement, the digital economy has initiated rural

economic advancement by enhancing the distribution of agricultural resource factors and diversifying the agricultural industry structure [6–8]. Consequently, the establishment of digital villages presents the potential to mitigate the urban–rural dichotomy and diminish the URIG, thus serving as a pivotal driver for fostering shared prosperity.

In addition, the construction of digital villages is a systematic project involving the cooperation of multiple actors. The participation of government, enterprises, social organizations, and farmers in the construction of digital villages can be regarded as a collective action in pursuit of common interests. However, there are differences in the interests of different subjects, which may lead to the "collective action dilemma" [9]. For example, in the process of digital economy construction, local governments pursue political achievements; enterprises and social organizations pursue profits and reputation; and farmers pursue income growth. Therefore, it is worth thinking about how to avoid collective irrationality caused by the individual subjects' pursuit of rational behaviors, and how to give full play to the role of digital village construction in narrowing the URIG.

The scholarly exploration of the digital economy's influence on the URIG has yielded varied perspectives without a definitive consensus. Some research has substantiated the digital economy's role in fostering the convergence of the URIG. Theoretically, data, as a new type of production factor, can be organically combined with factors of production, such as labor, capital, and land, to promote the intelligentization of rural industries and the continuous extension of new industries and business forms, which promotes the revitalization of rural industries [10]. The proliferation of the Internet in rural locales [11] and the advancement of digital inclusive finance [12,13] can contribute to the expansion of farmers' access to employment information and the increase in non-farming employment opportunities for farmers, as well as to alleviating the financial constraints faced by farmers' production and operation, promoting the upgrading of the structure of the agricultural industry and effectively narrowing the URIG [14,15]. Some scholars have found that digital village construction can promote non-farm employment and family entrepreneurship to realize farmers' income increase based on the micro data of farmers [16,17]. Furthermore, it has been found that transportation infrastructure is able to reduce the urban–rural income gap by driving the development of rural e-commerce and the rise of the logistics industry and promoting the adoption of digital infrastructure [18]. Urbanization [19,20], regional economic development, and innovation intensity [21] can also reduce the urban–rural income gap.

But other scholars believed that the deepening evolution of the digital economy has amplified the asymmetry between urban and rural economic development and may exacerbate the URIG and peasant poverty [22]. The translation of digital technologies into real productivity and wealth opportunities depends on their adoption by farmers. Considering the disparities that exist between urban and rural regions regarding digital infrastructure (inclusive of broadband accessibility) and factor endowments (such as labor and capital), substantial discrepancies persist between urban and rural inhabitants regarding the accessibility to, and application of, digital technologies [23]. The gap between urban and rural areas is further widened by the inability of rural households to fully access and utilize digital technologies due to poor network facilities in their places of residence or their own low incomes and lack of digital skills. Currently, China's rural areas are being rapidly digitized in terms of network infrastructure, but farmers' digital skills and literacy have not been upgraded simultaneously [14]. Digital skills are an important component of human capital, and the enhancement of farmers' digital skills can improve their understanding and practical application of digital technology, promote the optimal allocation of production factors, accelerate the intelligentization of agricultural production, and thus achieve the enhancement of production efficiency and effectiveness [24]. Additionally, the popularization of digital technologies such as the Internet can improve the inequality of educational resources and promote the accumulation of human capital [25]. Furthermore, certain researchers believed that there is a U-shaped relationship between them; they contend that

the digital economy initially aids in diminishing the UIRG, yet upon surpassing a particular threshold, it contributes to the exacerbation of the URIG [26,27].

The current empirical research on digital village construction is still relatively small, there is no uniform standard for evaluating digital village construction. So, to what extent, if at all, can digital village construction narrow the URIG, and through what mechanism does digital village construction affect the URIG? In a more detailed manner, the role of rural human capital in the relationship between digital village construction and the URIG also needs to be explored. In the era of digital economy, exploring these questions will help clarify the role of digital rural construction on the development of rural production and life, find new ideas to narrow the income gap between urban and rural areas, and better utilize the supporting role of digital rural construction on rural industries, thus promoting the realization of the goal of common wealth between urban and rural areas in China.

Therefore, this paper explored and verified the influence and mechanisms of digital village construction on the URIG. The contents and contributions are as shown below: firstly, we theoretically explained and clarified the mechanism of digital village construction on the URIG, analyzed the mediating and moderating role of digital village construction on the URIG in terms of rural industry revitalization and transportation infrastructure, and examined the non-linear impact of the two from the viewpoint of rural human capital, thus improving the transmission mechanism between them; secondly, at the empirical level, we established an assessment system of digital village construction, used entropy method to measure it at the provincial level, and used the Thiel index to measure the URIG in each province; moreover, various mediating effect methods, such as Sobel and Bootstrap, were chosen to confirm the mediating effect of digital village construction on the URIG. Furthermore, we tested their heterogeneity. Based on the analysis of the whole paper, we hope to provide possible ideas at the policy level for digital village construction to better narrow the URIG and promote common prosperity.

Specifically, this paper is divided into four parts: the first part is the introduction, which mainly introduces the background of the study; the second part presents the theoretical analysis and research hypotheses of the paper; the third part presents the empirical design and data description; the fourth part presents the empirical results and discussion; and the fifth part presents the conclusions of the study and feasible policy recommendations.

2. Theoretical Analysis

2.1. Analysis of the Influence of Digital Village Construction on Urban–Rural Income Gap

Digital village construction is a systematic project that uses information technology and intelligent equipment to popularize, and for application in, agricultural production, life, rural governance, and other scenarios to achieve rural digital development [28]. In the field of production, the application of intelligent farm equipment and other technologies can help farmers to accurately predict and supervise the growth and development of crops, which will help farmers to adopt scientific planting methods and agricultural management tools, improve crop yield and agricultural production efficiency, reduce production costs, elevate the quality and value-added attributes of agricultural commodities, and consequently augment farmers' revenue [29]. Moreover, the establishment of rural digital infrastructure can foster the expansion of the rural e-commerce and logistics industry; farmers can show consumers the product environment and quality of agricultural products through e-commerce live streaming, thereby streamlining transactional processes in the agricultural supply chain, thus increasing farmers' income [30]. Digital villages construction can improve basic public services and industrial environment in countryside, thus attracting migrant workers and urban talent dedicated to rural construction back to the countryside to exploit rural resources, innovation, and entrepreneurship, thus creating new jobs and effectively promoting the employment of farmers and increasing their wage income [31]. In addition, digital village construction provides facilities and conditions for the widespread use of the Internet and accelerates the development of inclusive finance in the countryside, thereby providing convenient and inexpensive financial support for farmers and rural

enterprises, effectively promoting the diversification of countryside industries and broadening the sources of income of farmers by means of employment-driven efforts to increase farmers' wages [32]. Taking an in-depth view, "the digital" itself is an economic factor; digital village construction through information technology will be able to the effective integrate and use the land in rural areas; it will promote capital, technology, talent, and other factors in the agricultural industry's agglomeration and integration, form an integrated development pattern of diverse industries, such as agricultural production, processing and manufacturing, and social services, raise the added value of agricultural production, and help farmers increase their incomes. So, we proposed hypothesis 1 as follows:

H1: *Digital village construction can narrow the urban–rural income gap.*

2.2. Analysis of the Mediating Mechanism of Digital Village Construction and the Urban–Rural Income Gap

Digital village construction utilizes digital technology to adjust the direction and scale of rural industry from the demand side and capital side, and it fully explores rural resources and promotes rural industry model innovation and integrated development, thus realizing rural industry revitalization and driving farmers to increase their income, narrowing the URIG [33]. From the point of view of market demand, Internet and mobile payment have accelerated the construction of e-commerce platforms and the development of agricultural e-commerce, allowing farmers to accurately understand consumer demand and consumption trends and targeted agricultural production. Consumers can buy agricultural products directly on the platform, reducing the intermediary links from production to sales, lowering transaction costs, and increasing the farmers' agricultural operating income [34,35]. In addition, characteristic industrial clusters in rural areas are gradually forming, and the financing demand of rural residents is growing rapidly. Digital village construction is conducive to accelerating the depth and breadth of rural digital finance, alleviating the financing difficulties of township enterprises and new agricultural business entities, promoting the expansion of agricultural operation scale, the growth of the agricultural processing industry, and the service industry, extending the agricultural industrial chain, and providing the re-employment of surplus rural labor force [36]. Furthermore, digital village construction is conducive to the innovation of new forms of rural industries and businesses, such as smart agriculture, homestay economy, and rural elderly care, and it promotes the performance of the living and ecological functions of agriculture, as well as attracting the flow of high-quality talent and capital to the rural industry to drive employment through entrepreneurship and expand the channels by which farmers can increase their incomes [37,38]. On the basis of this analysis, we proposed Hypothesis 2 as follows:

H2: *Digital village construction can narrow the urban–rural income gap by promoting rural industry revitalization.*

2.3. Analysis of the Moderate Mechanism of Digital Village Construction Affecting the Urban–Rural Income Gap

Transportation infrastructure construction can affect the URIG by affecting the transfer of rural labor, agricultural means of production, and agricultural products [18,39]. Moreover, transportation infrastructure construction is a prerequisite for the rural e-commerce, and it can also alleviate the problems of short stocking cycles and high logistics costs caused by agricultural products that are not easy to store, thus broadening the scope of sales of agricultural products [40,41]. Furthermore, e-commerce has spawned the prosperity and growth of the rural logistics industry, which has increased the number of new jobs and driven the employment of farmers [42]. Moreover, the improvement of transportation infrastructure reduced the time cost and opportunity cost of transferring rural labor to the non-farm sector, and farmers can realize an increase in their wage income through part-time or non-farm employment. Therefore, with the perfection of transportation infrastructure,

the dampening effect of digital village construction on the URIG will gradually increase. On the basis of this analysis, we proposed Hypothesis 3 as follows:

H3: *Transportation infrastructure can enhance the inhibition influence of digital village construction.*

2.4. The Non-Linear Influence of Digital Village Construction and Urban–Rural Income Gap under the Human Capital Perspective

Rural human capital serves as a pivotal assurance for the advancement of countryside digital development. Digital rural construction can break the barrier of tilting educational resources to cities through Internet popularization and promote the quality and skill of the agricultural labor force by means of online education, etc. In addition, digital rural construction also relies on the accumulation of rural human capital [43,44]. Rural residents with higher education exhibited a swifter grasp and better application of intelligent devices and network technologies; it is easier for them to utilize digital technology and thus increase their chances of choosing new types of employment positions [14]. In the meantime, new rural industries represented by live e-commerce, rural culture and creativity, and leisure agriculture have emerged at an accelerated pace, which has broadened the channels of income generation and employment for the vast number of farmers but has also put forward new requirements for the development of rural human resources and skills. Therefore, rural human capital is directly related to the effectiveness of digital village construction; however, currently, policies in the Chinese countryside are focused on building digital infrastructures and lack the cultivation of farmers' digital literacy, which makes it difficult for the digital infrastructure to fulfill its functions and roles [45]. Additionally, rural human capital needs to be accumulated to a certain extent before it can change from "quantitative change" to "qualitative change" to better promote the construction of the digital village to give full play to its income-generating effect on farmers and narrow the URIG [46,47]. Due to this analysis, we formulated hypothesis 4 as follows:

H4: *The influence of digital economy on the urban–rural income gap has the threshold effect of rural human capital.*

According to these arguments, we believe that the construction of digital villages can affect the URIG through the revitalization of rural industries, and that there is a moderating role and threshold effect of transportation infrastructure and rural human capital between them; so, we constructed the following theoretical framework (see Figure 3).

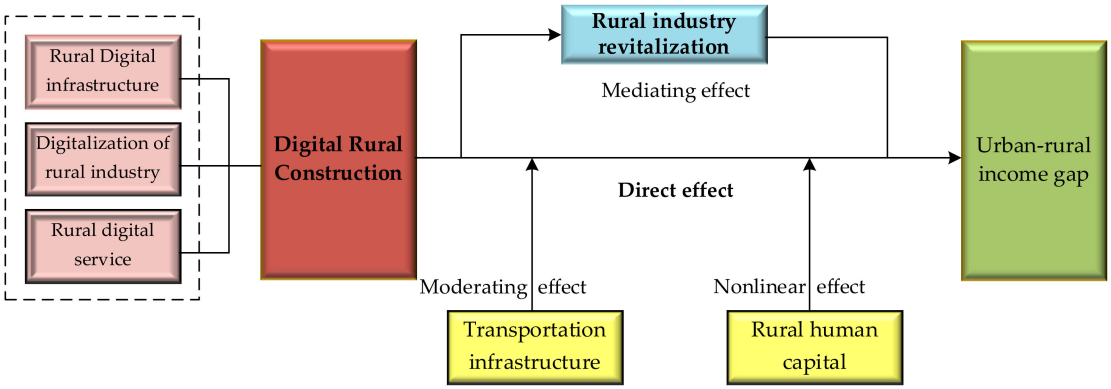

Figure 3. Theoretical framework.

3. Materials and Methods

3.1. Description of Variables

3.1.1. Dependent Variable

China's urban–rural income gap is displaying a trend of polarization, and the Thiel index compared the difference between the actual income distribution and the perfectly

equal distribution based on the cumulative distribution of individual incomes so as to better reflect the degree of inequality [21]. Therefore, we chose to characterize the URIG by using the Thiel index, which is calculated as follows:

$$Gap_{i,t} = \sum_{i=1}^{2}\left(\frac{I_{it}}{I_t}\right) ln \frac{I_{it}/P_{it}}{I_t/P_t} = \left(\frac{I_{1t}}{I_t}\right) ln \frac{I_{1t}/P_{1t}}{I_t/P_t} + \left(\frac{I_{2t}}{I_t}\right) ln \frac{I_{2t}/P_{2t}}{I_t/P_t}. \quad (1)$$

In Equation (1), $Gap_{i,t}$ is the URIG, I_{1t} and I_{2t} denote the total income of urban and rural residents, P_{1t} and P_{2t} denote the population of urban and rural, and I_t and P_t denote the total income and total population.

3.1.2. Independent Variable

Digital village construction emphasizes the application of digital technology to promote the innovation of new agricultural business forms and industrial modes, thus generating information, technology, and capital dividends, promoting the integration of agricultural industries and the play of multi-functionality in agriculture, and realizing the goals of agricultural efficiency, added industrial value, and farmers' income increase [48]. Therefore, this paper selected three dimensions, namely, rural digital infrastructure construction (including rural Internet and fixed and mobile equipment ownership), rural industry digitization (including Taobao village construction, broadband construction, and financial popularization), and rural digital service (including rural e-commerce and mobile payment), to measure the digital village construction [6,8,26,36,49]. Specific indicators can be seen in Table 1. The entropy value method is used to standardize the indicators and calculate the digital village construction.

Table 1. Index system of digital village construction.

Dimension	Index	Definition and Unit	Sources
Rural digital infrastructure	Internet popularity	Internet access per capita in countryside	Peng and Dan (2023) [26]
	Fixed digital device popularity	Average year-end computer possession per 100 rural inhabitants	Zhao et al. (2023) [6]
	Mobile digital device popularity	Average year-end cell phone possession per 100 rural inhabitants	Zhao et al. (2023) [6]; Peng and Dan (2023) [26]; Hao et al. (2022) [49]
Digitalization of rural industry	Sales digitization	Taobao village accounts for the proportion of administrative villages (%)	Hao et al. (2022) [49]
	Digitalization of agricultural production	Share of administrative villages with Internet broadband service (%)	Hao et al. (2022) [49]
	Financial industry digitization	Digital finance digitization index	Chang (2022) [8]; Xiong et al. (2022) [36]
Rural digital service	Digital financial services	Breadth of digital finance coverage index	Xiong et al. (2022) [36]; Hao et al. (2022) [49]
	Mobile payment level	Mobile payment index	Xiong et al. (2022) [36]
	E-commerce service	Average number of rural deliveries per week	Hao et al. (2022) [49]

3.1.3. Core Explanatory Variable

Mediating variable: The rural industry revitalization is a key path to increasing farmers' incomes. Only rural industry revitalization can promote the agglomeration and optimal allocation of local factors in the countryside, effectively enhance agricultural production efficiency, and attract the mobility of high-quality urban talent and capital, promoting rural industry integration and innovation, expanding the employment channels of farmers, and narrowing the URIG [50,51]. Combined with the theoretical analysis, this paper

draws on the studies of Geng et al. [52] and Liu et al. [53], selecting three dimensions—agricultural production capacity, agricultural industry chain extension, and agricultural multifunctionality expansion—to measure the rural industry revitalization, with detailed indicators in Table 2. Additionally, the entropy method was employed to preprocess and evaluate the primary data and then obtain the rural industrial revitalization variables.

Table 2. Index system of digital economy.

Dimension	Index	Definition and Unit	Sources
Agricultural production capacity	Level of agricultural mechanization	Gross power of agricultural machinery/sown area of crops (kW/hm^2)	Shi and Yang (2022) [54] Liu et al. (2021) [55]
	Labor productivity	Gross output value of agriculture, forestry, livestock, and fisheries/sown area of crops (Million/hm^2)	Liu et al. (2021) [55]
	Land productivity	Gross output value of agriculture, forestry, livestock, and fisheries/employment in primary industry (Million per person)	Liu et al. (2021) [55]
	Grain output	Total grain output/sown area of grain crops (t/hm^2)	Luo et al. (2023) [37]; Tian et al. (2023) [38]
Agricultural industry chain extension	Share of value added in primary sector	Value added in primary sector/GDP (%)	Luo et al. (2023) [37]
	Percentage of output value of agro-processing industry	Main business income of agro-processing industry/gross output value of agriculture, forestry, animal husbandry, and fisheries (%)	Wang et al. (2021) [56]
	Rural cooperative situation	Number of rural farmers' cooperatives/rural population	Wang et al. (2021) [56]
Agricultural multifunctionality expansion	Leisure agriculture development	Leisure agriculture business income/gross agricultural output (%)	Wang et al. (2021) [56]
	Facility agriculture development	Facility agricultural area/crop sown area (%)	Wang et al. (2021) [56]
	Percentage of agricultural services output	Output of agriculture, forestry, and fishery services/total (%)	Wang et al. (2021) [56]

Moderate variable: Drawing upon preceding theoretical deliberations, transportation infrastructure has the potential to amplify the mitigating impact of digital rural development on the URIG. So, we used the ratio of the sum of highway and railroad mileage to the area of provincial administrative divisions to characterize transportation infrastructure [57].

Threshold variable: Rural human capital also deeply affected the influence of digital village construction and the URIG, so the average education years rural residents is used to measure it.

3.1.4. Control Variables

The formation of the URIG involves multiple factors, such as government, market, industry, etc. To mitigate the interference of omitted variables on the empirical results and assure the stability and reliability of results, we took urbanization rate, foreign trade of agricultural products, industrial structure, financial development, and social security as the control variables [15,18,19,58], as shown in Table 3. In the process of empirical demonstration, for the sake of avoiding the influence of outliers and endeavor, all variables are logarithmically treated.

Table 3. Descriptive statistics of study variables.

Variables	Symbol	Definition and Unit	Mean	Std. Dev.
Urban–rural income gap	Gap	Theil index	0.091	0.040
digital village construction	Digital	This value is calculated by the entropy method	0.153	0.112
Rural industry revitalization	RIR	This value is calculated on the basis of indicators	0.227	0.084
Urbanization rate	Urban	Urban permanent population/total population (%)	0.581	0.131
Industrial structure	Indus	Output value of tertiary industry/output value of secondary industry	1.225	0.686
Foreign trade of agricultural products	Trade	Total imports and exports of agricultural products/GDP (%)	0.271	0.288
Financial development	Fin	Loan balance of financial institutions/GDP (%)	1.571	0.539
Social security	Social	Social security and employment expenditure of local finance/general budget expenditure of local finance (%)	0.130	0.034
Transportation infrastructure development	Trans	Road and rail mileage/administrative area(km/km^2)	0.943	0.535
Rural human capital	Rhc	Average years of schooling in the primary sector (years)	7.544	0.871

3.2. Model Setting

3.2.1. Panel Data Models

For the sake of verifying the influence of digital village construction on the URIG, the following panel model is first constructed for the regression test.

$$Gap_{i,t} = \propto_0 + \propto_1 Digital_{i,t} + \delta \sum x_{i,t} + \varepsilon_{i,t} \quad (2)$$

In Equation (1), $Gap_{i,t}$ is the URIG, $Digital_{i,t}$ represents digital village construction, $x_{i,t}$ represents the control variables, $\propto_0$ represents the intercept term, $\propto_1$ and δ represent the estimate parameters, while $\varepsilon_{i,t}$ is the random error term.

3.2.2. Mediating-Effect Model

For verifying the mechanism of rural industry revitalization, we adopted a three-step mediation effect to prove the hypotheses. The first step is consistent with Equation (2), and the remaining steps are demonstrated in Equations (3) and (4).

$$M_{i,t} = \propto_0 + \propto_1 Digital_{i,t} + \delta x_{i,t} + \varepsilon_{i,t} \quad (3)$$

$$Gap_{i,t} = \propto_0 + \propto_2 Digital_{i,t} + \theta M_{i,t} + \delta x_{i,t} + \varepsilon_{i,t} \quad (4)$$

In Equations (3) and (4), $\propto_1$ is the coefficient of the $Digital_{i,t}$ on $M_{i,t}$, $\propto_2$ is the coefficient of the $Digital_{i,t}$ on $Gap_{i,t}$ after controlling for the variable of $M_{i,t}$,θ is the coefficient of the $M_{i,t}$ on $Gap_{i,t}$ after controlling for the $Digital_{i,t}$, the definitions of $\varepsilon_{i,t}$ and δ are the same as in Equation (2).

3.2.3. Moderate Effect Model

Furthermore, to verify the moderating influence of transportation infrastructure, the moderate effect model shown in Formula (5) is further constructed.

$$Gap_{i,t} = \propto_0 + \propto_1 Digital_{i,t} + \propto_2 Trans_{i,t} + \propto_3 Digital_{i,t} * Trans_{i,t} + \propto_4 \sum x_{i,t} + \varepsilon_{i,t} \quad (5)$$

In Equation (5), $Gap_{i,t}$ is the URIG, $Digital_{i,t}$ represents digital village construction, $x_{i,t}$ represents the control variables, $\propto_0$ denotes the intercept term, $\propto_1, \propto_2, \propto_3$, and $\propto_4$ represent the estimate parameters, while $\varepsilon_{i,t}$ is random error term.

3.2.4. Threshold Model

For the sake of verifying the non-linear relationship between the core explanatory variable of digital village construction and the explained variable of the URIG, rural human capital is adopted as the threshold variable, and the threshold panel model is set as follows:

$$Gap_{i,t} = \propto_1 Digital_{i,t} I(Rhc_{i.t} \leq \gamma_1) + \propto_2 Digital_{i,t} I(\gamma_1 < Rhc_{i.t} \leq \gamma_2) + \propto_3 Digital_{i,t} I(Rhcl_{i.t} > \gamma_2) + \propto_4 \sum x_{i,t} + \varepsilon_{i,t}. \quad (6)$$

Formula (6) is a double threshold model. γ_1 and γ_2 are the threshold values, $x_{i,t}$ is the control variable, $\propto_1, \propto_2, \propto_3$, and $\propto_4$ are coefficients to be estimated, and the definition of $Gap_{i,t}$, $Digital_{i,t}$, and $\varepsilon_{i,t}$ are the same as in Equation (2).

3.3. Data Sources

This paper investigated the timeframe spanning from 2011 to 2020 across 31 Chinese provinces as its sample. Data sources include the China Statistical Yearbook (http://www.stats.gov.cn, accessed on 9 October 2023), the China Rural Statistical Yearbook, the China Agriculture Yearbook, the National Compilation of Agricultural Cost–benefit Data, and EPS databases (https://www.epsnet.com.cn, accessed on 10 October 2023). Supplementary data are obtained from the statistical yearbooks and bulletins published by different province. The digital-related indicators come from the Digital Financial Inclusion Index released by Peking University.

4. Results and Discussion

4.1. Annual Change Characteristics of Digital Village Construction and Urban–Rural Income Gap

We designated the years 2011, 2015, and 2020 as temporal reference points to capture the characteristics of digital village construction and the URIG by utilizing ArcGIS 10.2 software, as depicted in Figures 4 and 5. Generally, China's digital village construction exhibited the overall pattern of regional development imbalance from strong to weak in the east, center, and west, with Beijing, Zhejiang, Jiangsu, Fujian, and Guangdong as the representatives of the eastern coastal provinces; their digital village development is much higher than that of many western provinces. The reason may be that there are differences in the financial support and industrial structure of the different provinces, leading to differences in the degree of e-commerce and industrial structure developed in the countryside.

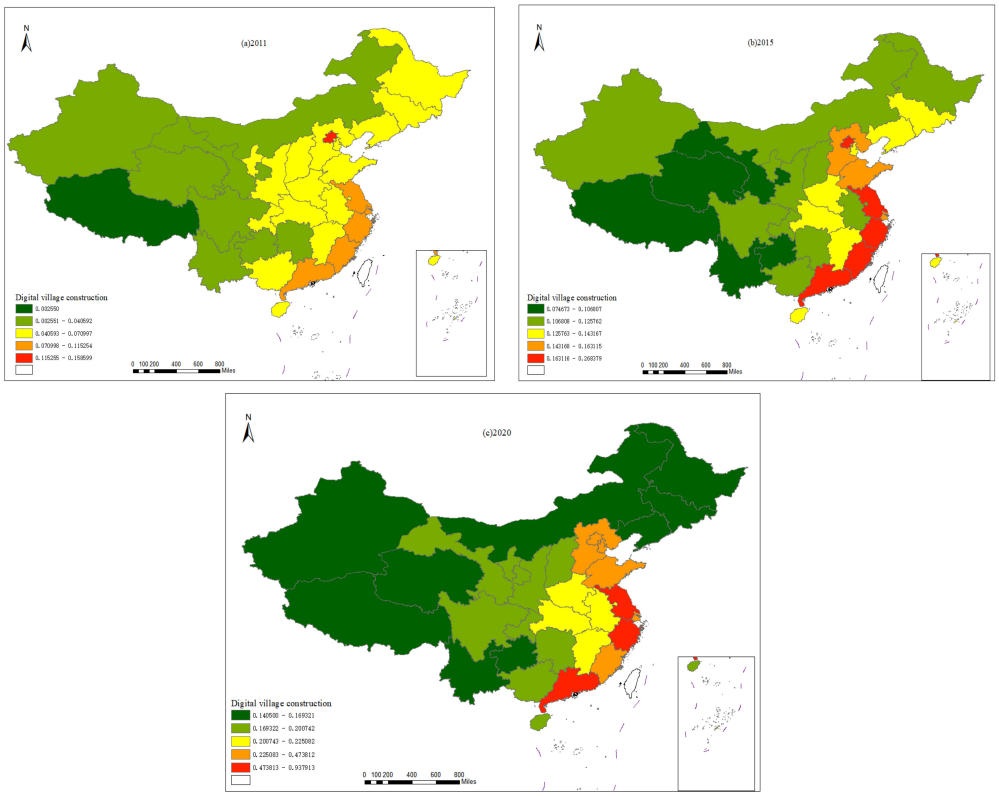

Figure 4. Spatiotemporal evolution characteristics of digital village construction.

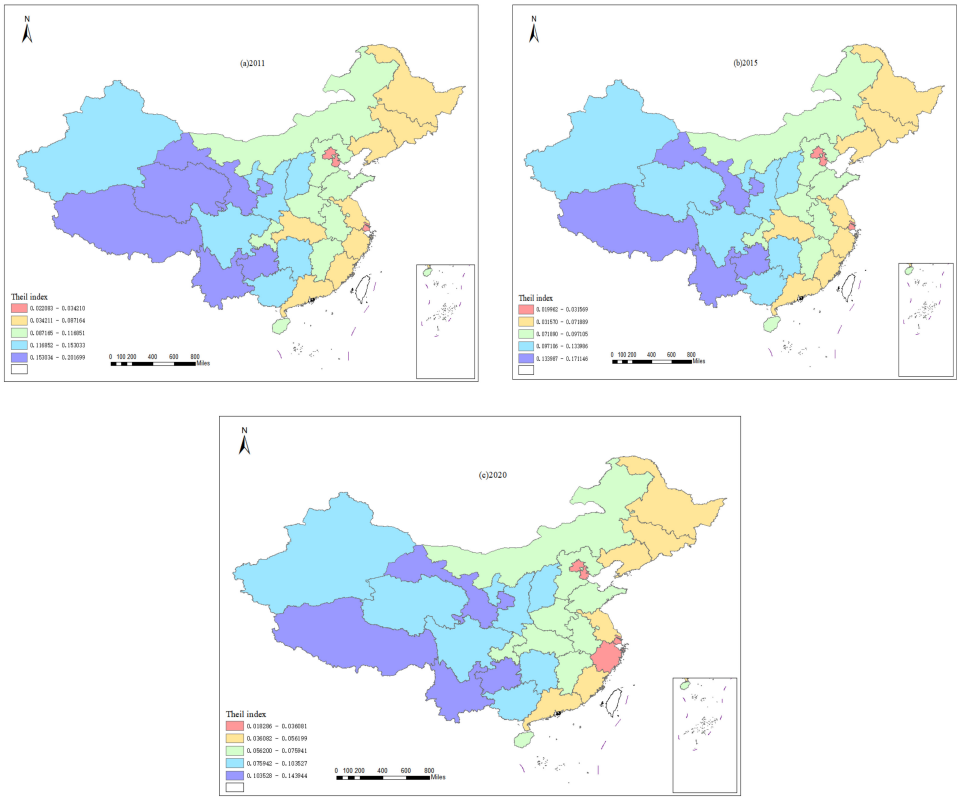

Figure 5. Spatiotemporal evolution characteristics of the URIG.

Moreover, the distribution of the URIG in China has not changed significantly over time, and the spatial distribution is relatively stable. Overall, the value of the URIG has

widened sequentially in the eastern, central, and western regions, with the largest value of the URIG being in economically poor provinces, such as Guizhou, Gansu, Yunnan, and the Tibet, and the smallest value of the URIG being in economically rich provinces, such as Beijing, Shanghai, and Tianjin.

4.2. Benchmark Regression Results

Prior to the formal regression analysis, we undertook a unit root cointegration test on the panel data using the Kao and Pedroni tests (see Table 4) to check whether the data are smooth. The test results indicated that the panel data passed the cointegration test, and, on this basis, the regression analysis on the original equation was more accurate. In addition, the results of the Huasman test (see Table 5) indicated a chi-square statistic of 31.36, which means that the estimation of the random effect model is biased, so the panel fixed-effects model should be chosen. Table 5 showed the benchmark regression results and robustness tests. Using a progressive regression approach, the difference of column (1) and (2) is the inclusion of control variables, but the coefficients of the digital village construction are −0.217 and −0.094, both of which are significant at the 1% level. These findings provide preliminary evidence for digital village construction being able to significantly reduce the URIG, thus confirming H1.

Table 4. Panel cointegration test results.

Type		Statistic	*p*-Value
Kao test	Modified Dickey–Fuller t	2.029	0.021
	Dickey–Fuller t	3.386	0.000
	Augmented Dickey–Fuller t	−2.812	0.003
	Unadjusted Modified Dickey–Fuller t	1.396	0.081
	Unadjusted Dickey–Fuller t	2.724	0.003
Pedroni test	Modified Phillips–Perron t	10.100	0.000
	Phillips–Perron t	−25.992	0.000
	Augmented Dickey–Fuller t	−20.047	0.000

Table 5. Benchmark regression results and robust test.

Variables	lnGap			
	(1)	(2)	(3)	(4)
lnDigital	−0.217 ***	−0.094 ***	−0.025 ***	−0.046 ***
	0.028	0.014	0.007	0.010
lnUrban	N	−0.604 ***	−0.231 ***	−0.747 ***
		0.100	0.036	0.116
lnIndus	N	−0.185 ***	−0.038 ***	−0.169 ***
		0.051	0.009	0.043
lnTrade	N	0.003	0.000	0.015
		0.0136	0.00558	0.01376
lnFin	N	0.138 ***	0.027 ***	0.113 ***
		0.036	0.009	0.029
lnSocial	N	−0.107 *	0.002	−0.158 **
		0.055	0.020	0.062
Constant	−2.965 ***	−3.300 ***	0.760 ***	−2.988 ***
	0.059	0.144	0.049	0.218
R-squared	0.752	0.880	0.788	0.870
Province fixed-effect	Y	Y	Y	Y
Hausman	31.16 ***		-	-
F value	58.13 ***	166.09 ***	89.21 ***	137.84 ***

Note: *, ** and *** respectively indicate significant at 10%, 5% and 1% levels.

From the perspective of control variables, urbanization, industry structure, and social security can dampen the URIG, while regional financial development, on the contrary, can exacerbate the URIG. This is consistent with the findings of Yao and Jiang [19] and Su et al. [20]. China's urbanization is still mainly a process of providing citizenship to farmers, urbanizing the city to provide labor force and consumer power, and promoting urban economic development, while farmers also gain labor skills and wages. Furthermore, the city can feed the countryside through increased investment in rural digital infrastructure and rural vocational skills training, and we can consolidate rural public facilities and basic public services to achieve benign interaction between city and countryside, narrowing the URIG [59].

Upgrading the industrial structure can create more high-paying jobs, absorbing farmers into the processing industry, service industry, and other high-value-added industries, realizing the upgrading of farmers' wages and skills, and narrowing the URIG [15]. In addition, as farmers are at a relative competitive disadvantage in the job market, more local financial expenditure on social security and employment, more direct transfer subsidies, and indirect preferential policies for low-income groups, such as farmers, can narrow the URIG. Furthermore, capital is a scarce resource in rural areas, but it is profit-driven, and the seasonality and weak nature of agricultural production mean that it is characterized by high risks and low returns. Coupled with the imperfect infrastructure in rural areas, financial institutions may form higher entry thresholds for middle- and rural-area residents and enterprises and other weaker groups, thus increasing the cost of financing for farmers and aggravating urban–rural income inequality [60].

From an in-depth analysis, the urban–rural income gap in China is affected by multidimensional factors, such as the economy, society, technology, and the system, and shows obvious stage characteristics. In the era of the digital economy, the development of digital technology may become a new force through which to narrow the URIG. Therefore, taking digital village construction as a means to drive farmers to apply digital technology in the field of rural production and life is an important path to realizing the goal of common prosperity. On the one hand, digital village construction promotes the universal use of the Internet in the rural context, enabling farmers to learn about market demand and price changes in a timely manner through Internet e-commerce platforms and social platforms such as Taobao, WeChat, and other Internet e-commerce platforms, carrying out targeted production and marketing to broaden the sales channels of agricultural products [11]. On the other hand, it also provides space for the development of rural inclusive finance, effectively reduces the threshold of farmers' financing, and provides financial support for the expansion of the scale of farmers' production and operation and the entrepreneurship of farmers returning to their hometowns, which, in turn, leads to an increase in rural jobs and reduces the income gap between urban and rural areas. The research of Li and Yang also proved that digital countryside construction can promote family entrepreneurship to increase the income of farmers [17].

However, we must recognize that in the context of the rapid updating and iteration of advanced digital science and technology, the weak rural digital technology infrastructure and the lack of human capital will exacerbate the information inequality between urban and rural areas, even leading to the further widening of the URIG [27]. Therefore, to mitigate the development of digital technology leading to the exacerbation of urban–rural resources and information inequality, the government must reduce the cost of digital technology application for farmers through reasonable scientific means, such as improving the subsidies and preferential policies for smart agriculture and facility agriculture and increasing investment in the construction of transportation infrastructure and warehousing and distribution facilities in rural areas so as to create the basic conditions for the development of rural industries and an increase in the income and wealth of farmers [61].

4.3. Robustness Tests

To test the explanatory power of the indicators and the stability of the research conclusions, methods such as replacing the core variables are used to conduct robustness tests. Replacing the explanatory variable with the urban–rural residents' income ratio and the explanatory variable with the digital financial inclusion index, the results (see Table 5) indicated that the direction and significance level of the regression coefficients of core variables were accordance with the benchmark results, which verified that the results are reliable.

4.4. Mechanism Analysis

The results of the moderated-effects model indicated (see Table 6) that the coefficient of the transportation infrastructure and its interaction term with the digital village construction are significantly negative, suggesting that the transportation infrastructure not only has a direct inhibiting influence on the URIG but also has an indirect effect of enhancing the inhibiting influence of the digital village construction on the URIG. This means that improving transportation infrastructure is an important mechanism path by which digital village construction can promote urban–rural common wealth.

Table 6. Results of mechanism test.

Variables	(5)	(6)	(7)	(8)
	lnGap	**lnGap**	**lnRIR**	**lnGap**
lnDigital	−0.088 ***	−0.112 ***	0.174 ***	−0.099 ***
	0.015	0.021	0.048	0.016
lnTrans	−0.175 **	−0.271 ***		
	0.085	0.078		
lnUrban	−0.481 ***	−0.446 ***	−0.35	−0.682 ***
	0.115	0.129	0.216	0.115
lnIndus	−0.176 ***	−0.139 ***	0.176 **	−0.079 **
	0.055	0.032	0.085	0.037
lnTrade	−0.003	0.011	−0.017	0.021
	0.014	0.016	0.032	0.017
lnFin	0.133 ***	0.093 ***	0.054	0.074 **
	0.035	0.024	0.096	0.029
lnSocial	−0.115 **	−0.085	0.408 ***	−0.129 **
	0.055	0.055	0.109	0.058
lnTrans*lnDigital		−0.029 ***		
		0.006		
lnRIR				−0.042 ***
				0.011
Cons	−3.317 ***	−3.211 ***	−0.612 **	−3.365 ***
	0.137	0.146	0.305	0.165
N	310	310	300	300
adj. R2	0.881	0.895	0.373	0.897
Soble test	-	-	0.015 *	
			0.009	
Bootstrap test	-	-	0.015 *	
			0.009	

Note: *, ** and *** respectively indicate significant at 10%, 5% and 1% levels.

The study selected the three-step method to test the mediating effect of rural industry revitalization. The results of the three-step method (see columns (7) and (8) of Table 6) indicated that the coefficient of digital village construction on rural industry revitalization is 0.174, and when both of them are included in the regression model, the influence coefficient of digital village construction on the URIG is reduced to −0.099, and the influence coefficient of rural industry revitalization on the URIG is −0.042; the above findings are all found to be at the 1% percent confidence level. Furthermore, the study adopted Sobel and Bootstrap tests for further analysis. With 1000-times random sampling of the sample, the Soble test

showed that the mediating effect accounts for 33.5% of the total effect. The Bootstrap test also confirmed the existence of intermediary effects. From this, it can be determined that rural industry revitalization is an important path by which digital rural construction can inhibit the expansion of the URIG, which proves that H2 is valid.

In summary, if rural areas want to enhance the effectiveness of digital rural construction, promote the diversification of countryside industrial structure, and drive economic development, they should make efforts along the lines of the following points. First of all, county-level agricultural departments and grass-roots village collectives should be based on the local characteristics of agricultural industries, actively introduce intelligent management systems, scientific management of food planting, and breeding, build standardized demonstration bases, carry out production and marketing docking through agricultural product promotion meetings, and develop order agriculture.

Second, efforts should be made to develop the e-commerce brand of special agricultural products, increasing the added value and market recognition of special agricultural products. Specifically, at the production end, the traceability function of big data can be used to connect the whole-process information of agricultural product variety selection, origin environment, farming operations, harvesting, and processing. At the sales end, a platform for connecting agriculture and commerce should be built, the supply chain of agricultural products should be opened up, efforts should be made to help good products find a good market, to sell them at a good price, and to drive farmers to increase income and become rich [5]. Moreover, the e-commerce platform should not only show the economic value and edible value of agricultural products but, based on the historical and humanistic attributes of agricultural products, it should excavate the deep value behind them and focus on the careful planning of product exhibition, trade negotiation, marketing promotion, etc., to enrich regional cultural elements and expand and extend the process from product docking and industrial docking to emotional docking and cultural docking, then expanding the brand premium space and agricultural product sales.

Furthermore, we should focus on promoting the network coverage of administrative villages, improving the transportation, power grid, and other smart rural infrastructure systems in rural areas, and building a rural smart logistics system to provide a solid foundation for the development of rural e-commerce, ensuring that high-quality agricultural products can be smoothly transferred to consumers.

4.5. Threshold Model Analysis

The threshold model results in Table 7 show that there is only a single-threshold effect, with a threshold value of 1.9954, and the restraining effect of digital village construction on the URIG is restricted and influenced by rural human capital. The threshold regression results in Table 8 show that when lnRhc $\leq$ 1.9954, the coefficient of the digital rural construction is -0.083; when lnRhc > 1.9954, the coefficient increased to -0.104. This demonstrates that after crossing the threshold of rural human capital, the dampening effect of digital village construction on the URIG is able to increase at the margin, showing the phenomenon of threshold strengthening, and H4 is confirmed.

Table 7. Test results of threshold effect.

Threshold	RSS	MSE	Fstat	Prob	Crit10	Crit5	Crit1	BS Degree
Single	0.564	0.002	24.680	0.020	17.415	20.729	27.332	300
Double	0.547	0.002	9.180	0.453	17.482	23.568	32.096	300
Triple	0.530	0.002	9.910	0.623	31.884	38.460	50.007	300

Table 8. Results of threshold regression analysis.

Variables	lnGap	
	Coefficient	Standard Error
lnUrban	−0.638 ***	0.074
lnIndus	−0.164 ***	0.020
lnTrade	−0.001	0.013
lnFin	0.152 ***	0.022
lnSocial	−0.100 ***	0.030
lnRhc ≤ 1.9954	−0.083 ***	0.013
lnRhc > 1.9954	−0.104 ***	0.013
Constant	−3.334 ***	0.092
adj. R2	0.874	
N	310	

*** indicate significant at 1%.

Farmers are the beneficiaries of digital village construction and the main participants in digital technology application. On account of the constraints of cultural level and skill quality, it is difficult for the local rural workforce to make use of all kinds of digital platforms to obtain and release information on rural industries, not to mention their being unable to realize the deep application of rural digital resources and technologies in the field of industrial integration, thus hindering the rural industry revitalization; this is not conducive to the activation and utilization of rural factors and the optimization of the combination of such factors [45]. Therefore, the formulation of policies to attract the return of quality labor and the establishment of a mechanism for the cultivation of digital farmers are important ways with which to realize the effectiveness of digital rural construction.

There are differences between urban and rural areas in terms of digital infrastructure and Internet-use skills, making the extent to which urban and rural residents benefit from the development of the digital economy different, which, in turn, affects changes to the URIG. The digital economy, with the Internet as its main manifestation, has weakened the inequality of knowledge acquisition between urban and rural residents, and farmers can enhance their digital skills and digital literacy through their independent learning of online educational resources, thus realizing the accumulation of human capital, broadening the choice of opportunities for non-agricultural employment of farming households, reducing the cost of occupational information search, increasing the wage income of farmers, and narrowing the income gap between urban and rural areas [25]. Therefore, the Chinese government emphasized in the Outline of Digital Rural Development Strategy that the construction of digital villages should focus on the improvement of farmers' modern information skills and should continuously narrow the gap between rural residents and urban residents in terms of digital literacy and digital technology skills. The study of Jiang et al. also proved that improving the ability to apply digital technology in rural areas can effectively narrow the urban–rural digital divide [27].

4.6. Heterogeneity Tests

China has an obvious three-tiered terrain, and there is diversity in the policy environment, industrial structure, and infrastructure between the different geographic regions. In addition, China is divided into grain production functional areas based on inter-provincial grain production and consumption characteristics, resource endowment differences, and agricultural production history, i.e., the main grain production area, the main grain marketing area, and the balance of production and marketing area. Therefore, we used a split-sample regression to examine whether there is a difference between the inhibiting effect of digital village construction and the URIG in different geographic regions and production functional areas.

The results (see Table 9) indicated that the dampening effect of digital rural construction on the URIG is significant only in the eastern and western regions. The may because

the eastern region has a more complete rural digital infrastructure, a high degree of Internet penetration, and a high level of farmers' digital literacy, which accelerated the integration of digital technology and local resources and culture; thus, it is more conducive to promoting the innovation of the rural industrial model and reducing the URIG. Moreover, to realize the goal of common prosperity, the government has begun to gradually tilt its policies in favor of the western region so that western region can receive more policy support and financial investment to put into digital construction; thus, its role in suppressing the URIG is more significant.

Table 9. Results of regional and functional heterogeneity analysis.

Variables	lnGap			lnGap		
	(1)	(2)	(3)	(1)	(2)	(3)
lnDigital	−0.120 ***	−0.0062	−0.085 ***	−0.047	−0.083 **	−0.083 ***
	0.032	0.022	0.014	0.038	0.026	0.016
Constant	−3.235 ***	−4.0977 ***	−3.128 ***	−4.005 ***	−3.555 ***	−3.024 ***
	0.238	0.457	0.183	0.326	0.326	0.158
Control variables	Y	Y	Y	Y	Y	Y
R-squared	0.915	0.920	0.895	0.907	0.929	0.893
F value	266.05 ***	5314.15 ***	87.65 ***	224.04 ***	4147.52 ***	70.25 ***

Note: ** and *** respectively indicate significant at 5% and 1% levels.

Moreover, the inhibitory effect is not significant in the main grain-producing areas and the opposite in the main sales areas and the balanced production and marketing areas. The reason may be that in the industrial structure of the main grain producing areas, the ratio of the primary industry is relatively high, the degree of economic development is relatively low, and it is hard to fully induce the city to feed the countryside; so, digital rural construction is difficult to make effective. China's economically developed provinces, with high population mobility and good resource endowment, have a high degree of urbanization. The development of cities in these regions leads to the prosperity of rural industries. The government also has the financial strength to promote the flow of high-quality resources and the construction of rural digital facilities, thereby narrowing the URIG.

5. Conclusions and Suggestion

As one of the practical paths of the digital economy, empowering urban and rural common wealth, digital rural construction can make up for the shortcomings of the digital infrastructure in the countryside and the insufficient development of rural industries and narrow the URIG. This paper deeply analyzed the influence and mechanism of digital rural construction on the URIG and obtained following conclusions: first, digital rural construction has a negative inhibition effect on URIG, and this inhibition effect is only significant in the eastern and western regions and non-food producing areas; second, the mechanism test showed that rural industry revitalization is a vital path by which digital rural construction can drive the reduction in the URIG, while transportation infrastructure can strengthen the inhibitory effect; third, analyzed with rural human capital as the threshold variable, the inhibitory effect of digital rural construction on the URIG has the non-linear characteristic of increasing marginal effect.

Combined with the findings of this study, we believe that in an attempt to achieve the common prosperity of urban and rural areas, it is essential to start from the following places. First, the government should make up for the insufficient investment in rural digital infrastructure, increase policy inclination and capital investment, improve the construction of rural network base stations and transportation facilities, and increase rural Internet coverage and network speed so as to provide a foundation for the application of big data analysis and intelligent equipment. In addition, it is vital to promote the intelligent transformation of agricultural machinery and equipment and to promote the popularization of automatic navigation systems and drones in field farming and harvesting operations and

agricultural socialization services. Moreover, through tax incentives and financial subsidies, county-level and village-level organizations can be encouraged to build corresponding digital rural application platforms by combining local geographic-location and agricultural-production advantages and to actively carry out demonstration work on smart planting and smart farming to resolve the risks and uncertainties faced in agricultural production, assist farmers to actively participate in e-commerce activities, and expand agricultural product sales channels.

Second, farmers are the main actors and beneficiaries of digital rural construction, and the key to rural digital construction is the rational use of digital technology by farmers. Therefore, government departments should set up special funds to guide agricultural research institutes and agricultural departments in carrying out rural digital talent training; share with farmers the integration of agro-literature and tourism, on-site e-commerce platform construction and operation, and other digital rural construction experiences; and encourage farmers to use Internet technology to improve vocational skills, access market information, and enhance the digital skills and literacy of farmers so as to truly apply digital technology to agricultural production and life and thus reduce the urban–rural digital divide and income gap.

Third, the government should introduce corresponding support measures and policies to deeply tap the technology and digital dividends brought about by the construction of digital rural areas. By improving the construction of rural cold chain logistics, warehousing and distribution, intelligent processing, and other facilities, the development of rural e-commerce will be further energized, and village collectives, farmers, and other diversified subjects will be actively encouraged to participate in digital agriculture, leisure agriculture, e-commerce live broadcasting, etc., to promote the upgrading and transformation of the structure of the agricultural industry and drive the employment of the rural labor force, further narrowing the income gap and forming a trend of common prosperity in urban and rural areas.

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