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The Impact of Digital Village Construction on County-Level Economic Growth and Its Driving Mechanisms: Evidence from China

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Abstract: Digital village construction is the key to future rural development in China. This study has empirically examined the impact of digital village construction on county-level economic growth in China, utilizing non-balanced panel data from 16 provinces and 622 counties for the years from 2018 to 2021. The study also investigated the underlying mechanisms and conducted heterogeneity and robustness tests using various analytical methods, including instrumental variables and the difference-in-differences (DID) approach. The findings reveal that digital village construction significantly enhances county-level economic growth, with a more pronounced effect observed in southern regions, eastern regions, and non-agricultural counties. The primary mechanism through which digital village construction drives economic growth at the county level is by promoting entrepreneurship. This study not only points out the key to digital village construction in China, but also enriches the theoretical research on digital village construction for economic growth. However, due to data limitations and the short time span of digital village construction, the results of the study are correct only for the period 2018–2021 in China. As digital village construction continues to progress, its impact on economic growth is likely to be even greater.

Keywords: digital village construction; economic growth; driving mechanism; China

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1. Introduction

Digital technology is an important way to promote the modernization of agriculture and rural areas, and the construction of digital villages has become a new trend in global development [1,2]. With the development of digital technologies such as big data, artificial intelligence, blockchain, etc., digital technologies, with their wide penetration characteristics, have broad application scenarios in the agricultural field and rural areas, and are able to impact the development of rural areas tremendously [3,4]. For instance, smart agriculture, rural e-commerce, live streaming sales, etc., are prevalent combinations of digital technology and agriculture and rural areas. In order to seize the favorable opportunity for the digital economy and promote economic growth, many countries have issued policies related to the construction of digital villages. Specific cases of the application of digital technology in rural areas are the "Rural Broadband Reconnect Program" proposed by the U.S. Department of Agriculture [5], and the "Smart Countryside Initiative" of the European Union [6]. Digital village construction has become a novel global trend.

China has developed a digital village strategy in order to capitalize on the wave of digital economic development and to promote the rapid development of the rural economy. In 2005, Document No. 1 proposed a strengthening of the construction of agricultural informatization and promote the development of agriculture and the rural economy. In 2018, the construction of digital villages was formally proposed in China. 2018's Document No. 1 stated that the digital village strategy should be implemented to accelerate the coverage of broadband networks and fourth-generation mobile communication networks

in rural areas. After 2008, the Chinese government enacted a series of measures aimed at advancing the implementation of the digital village strategy. In 2019, the government announced the "Digital Countryside Development Strategy", outlining the vital objectives and tasks for digital village construction. Building on this foundation, in 2020, the "Notice on Conducting Pilot Projects for National Digital Villages" was disseminated, laying out the roadmap for national-level digital rural pilot projects. The year 2021 witnessed the release of the "Digital Village Construction Guide 1.0", offering guidance for the initiation, operation, and administration of digital village construction endeavors across various regions. In 2022, the "Action Plan for the Development of Digital Villages (2022–2025)" was announced, meticulously charting the course for digital village construction during the Fourteenth Five-Year Plan period [7]. The report of the 20th Party Congress also proposed to "accelerate the development of the digital economy" and emphasized the need to "adhere to the priority development of agriculture and rural areas" and "comprehensively promote rural revitalization", which is a major strategic deployment of the CPC Central Committee and Comrade Xi Jinping, at the core of how to make use of digital technology to solve the problem of the "Three Rural Issues". But, it is also the strategy for the new era of comprehensively promoting the construction of digital villages; helping the high-quality development of the rural economy points out the way forward [8].

Digital village construction can empower rural development through a variety of channels, and the comprehensive impact on rural economic development is beginning to manifest. Digital rural development strengthens rural information infrastructure, catalyzing the technology, talents, and capital in rural areas. The construction of digital villages will effectively enhance the level of digital infrastructure construction in rural areas; narrow the digital gap between urban and rural areas; promote the digital transformation of traditional agricultural production, operation and transactions; accelerate the upgrading of the rural industrial structure; expand the channels for farmers to increase their incomes; and contribute to the high-quality development of the rural economy in many ways [9–11]. The impact of digital village construction on China's agricultural economic development has already emerged. The China Digital Countryside Development Report (2022) states that by the end of 2022, 5G networks and broadband covered all counties. Accompanied by the construction of digital villages, new rural businesses continue to emerge and rural e-commerce continues to develop rapidly, with national rural online retail sales reaching CNY 2.17 trillion in 2022; the construction of smart agriculture is developing rapidly, with the rate of the informatization of agricultural production rising to 25.4%.

Since the emergence of digital village construction as a promising new growth aspect of the rural economy, research regarding digital rural areas has progressively gained attention [12]. Following the introduction of digital village construction, some scholars have begun to measure the level of digital village construction. Chang and Li synthesized representative indicators related to informatization, agricultural informatization, and rural informatization assessment, creating a comprehensive digital village evaluation indicator system that encompassed both capacity and effectiveness indicators [13]. This endeavor has offered a foundation for the subsequent design of indicators for digital village construction. Subsequently, different scholars have constructed a digital village construction index system from different perspectives to measure the level of digital village construction. For instance, Cui and Feng devised an evaluation indicator system based on four dimensions: digital investment, digital services, digital environment, and digital benefits [14]. Zhang et al., on the other hand, constructed an evaluation indicator system for digital village construction encompassing five dimensions: macro environment, infrastructure support, information environment, administrative environment, and application environment [15]. Ummah et al. performed a case study of Cijantur Village, Rumpin District, Bogor Regency, and attempted to see the extent of the effectiveness of the implementation of website-based e-Service by the local community [16].

With the advancement of research into the evaluation of digital village construction levels, some scholars have begun to employ data at the county level to measure the level

of digital village construction. However, to the best of the authors' knowledge, there are currently only two papers focusing on the measurement of digital village construction at the county level. One paper, conducted by Lin et al., utilized web-scraping techniques to gather information on digital village construction from 2012 to 2021 across 2997 counties and measured the level of digital village construction at the county level [17]. Another study, conducted by the Institute for New Rural Development at Peking University, comprehensively utilized macro statistical data, Alibaba's business platform data, aggregated data from relevant websites, and other information sources. This study measured the County-level Digital Village Construction Index for 1880 counties, encompassing digitalized elements and specific representations from aspects such as rural infrastructure, rural economy, rural living, and rural governance [18]. This index is one of the most comprehensive and authoritative indices in the current research on China's digital village construction levels [19].

Building upon the measurement of digital village construction levels, some scholars have initiated investigations into the impact of digital village construction on economic and social development. These studies have predominantly examined its influence from perspectives related to the adoption of digital technology and the development of the digital economy. The majority of these studies have concluded that the adoption of digital technology and the advancement of the digital economy positively affect aspects such as income growth, industrial structure upgrading, and the reduction of urban–rural income disparities. Regarding income growth, Jensen examined the impact of mobile phone usage on the income of Indian fishermen and found that mobile phone usage aids farmers in obtaining market information more effectively, thereby enhancing local market prices for agricultural products and increasing income [20]. Goyal conducted research on Indian soybean farmers and discovered that the introduction of internet-connected information kiosks significantly improved farmers' income [21]. Sun et al. utilized a propensity score matching method and China's Household Tracking Survey data in 2014 and 2016, to estimate the impact of internet usage on household income, and found that internet usage significantly increased rural households' net income [22]. Regarding industrial structure upgrading, Cai et al., employing provincial panel data from 2013 to 2019, empirically examined the impact of the digital economy on industrial structure upgrading. Their findings indicated that the development of the digital economy notably promotes the advancement and rationalization of the industrial structure [23]. Fang, based on the province-level panel data from 2001 to 2020, empirically investigated whether digital technology promotes industrial structure upgrading. Results indicated that digital technology promoted the upgrading of the industrial structure [24]. Regarding the urban–rural income gap, Ji, using panel data of 30 provinces in China from 2013 to 2019, employed a fixed-effects model to study the influence of the development of the digital economy on the urban–rural income gap. The outcomes revealed a significant improvement in the urban–rural income gap due to digital economic development [25]. Regarding rural development, Faxoon showed how agrarian relations shape patterns of digital connection and how farmers, migrants, and grassroots activists incorporate Facebook into daily efforts to secure livelihoods, support communities, and mobilize in struggles over land [26].

Only a few articles have examined the impact of digital village construction on economic growth and villagers. Bhatt explores the digital village scheme and Digital Village 2.0 campaign and its impact on villagers after its application in selected villages in India [27]. Lin et al. studied the impact of digital village construction on income growth in China's revolutionary old rural areas from 2012 to 2021. Their findings demonstrated that digital village construction propelled income growth [17]. Shi, relying on the 2018 Digital Rural Index released by Peking University and China's county-level data, empirically examined the impact of digital village construction on rural household income. The results indicated that digital village construction significantly promoted the growth of rural household incomes [19].

With the growth of the digital economy, some scholars have studied the adoption of digital technology and the impact of digitization on entrepreneurship. Nikitaeva et al. studied the impact of smart territories on the transition to sustainable regional development and the green economy in Botswana. Their study showed that the establishment of a smart territory is the core mechanism of a transition to a green economy. Smart territories help regional governments to reach the Sustainable Development Goals by using cutting-edge digital technologies [28]. Mashi et al. studied the adoption of digital technology of rural areas in Nigeria. The research showed that farmers who are more educated, older, have larger family sizes, income sources, and economic assets, have more climate change experience and local knowledge, and have farmlands in better physical condition are more aware of climate-smart agriculture adaptation strategies [29]. Barba-Sánchez et al. studied the relationship between the smart city label and the entrepreneurship rate in Spain. The results showed that the smart city label has positively influenced the effective creation of new businesses [30].

In conclusion, there have been fewer studies on digital village construction, the adoption of digital technology, and economic growth. More articles tend to explore the impact of digital economic development and the adoption of digital technology on industrial structure upgrading, income growth, and the urban–rural income gap. Only a limited number of studies have investigated the influence of digital village construction on income growth. These studies provide valuable references for our research. However, there is still a lack of research on the impact of digital village construction on economic growth, especially using the data from the county level. Therefore, using county-level data from 2018 to 2021, this paper examines the impact of digital village construction on economic growth and its driving mechanisms. The contributions of this study are as follows: firstly, it fills the gap in the research on the economic growth of counties due to digital village construction and provides empirical support for the impact of digital village construction on the high-quality development of county economies; secondly, this study enriches the studies on the driving mechanism of digital village construction for economic growth at the county level.

Therefore, this study examines the impact of digital village construction on economic growth at the county level, explores the mechanism by which digital village construction drives economic growth, and formulates policies to promote the development of digital village construction, which is of great significance for the future development of digital village construction and the economic growth in China.

2. Materials and Methods

2.1. Theoretical Framework

Since China formally introduced digital village construction in 2018, digital village construction is being replicated across the country. According to documents such as the "Digital Countryside Development Strategy" and the "Action Plan for the Development of Digital Villages (2022–2025)", the core components of digital village construction encompass refining rural information infrastructure, exploring novel rural economic models, and expanding the digitization of public services in rural areas. Existing research has already indicated that the enhancement of rural information infrastructure, the development of new rural economic forms, and the digitization of public services can have positive impacts on various aspects of rural life, including increased household income [31], fostering innovation and entrepreneurship [32], and driving rural revitalization [33]. Importantly, these influences collectively stimulate county-level economic growth.

For this reason, this paper proposes the first research hypothesis.

Hypothesis 1. *Digital village construction will promote economic growth in the country.*

Digital village building can contribute to economic growth by promoting entrepreneurship. On the one hand, the construction of digital villages has increased the rate of Internet and smartphones usage, and the popularization of the Internet and smartphones can im-

prove the convenience of farmers' access to information and knowledge, which not only helps rural residents to acquire new knowledge at a lower cost and enhance human capital, but also broadens farmers' social networks, promotes social capital accumulation, improves the convenience of entrepreneurial financing and the awareness of venture capital, and promotes entrepreneurial activities [19], thus enhancing the growth of the county economy. On the other hand, the application of digital technologies such as big data, cloud computing, and the Internet of Things in the field of agriculture and rural areas can effectively connect different environments, providing technical support for the development of new business forms in the rural economy [34], thus promoting the level of entrepreneurship and county economic growth.

For this reason, a second research hypothesis is proposed in this paper:

Hypothesis 2. *Digital village construction promotes county economic growth by promoting entrepreneurship.*

Digital village construction will promote industrial structure upgrading from the supply side and demand side, thus promoting county economic growth. For the demand side, digital village construction eases information asymmetry. On the one hand, farmers can sell agricultural products directly through e-commerce platforms, changing the long-standing position of farmers as price takers, which will help farmers increase the price of their products and income. On the other hand, the emergence of new sales channels such as e-commerce platforms, live commerce, and the construction of the agricultural logistics system has expanded the sales channels of agricultural products, so that many specialty agricultural products are now known by the majority of consumers, and the added value of agricultural products has been improved, which has increased the income of farmers [35]. The increase in farmers' income not only stimulates consumption but also generates demand for higher-level consumption, thereby driving industrial structure upgrading [36,37]. On the supply side, digital village construction breaks down regional barriers to mobility. Firstly, digital village construction promotes the concentration of talent, capital, and technology in counties, providing support for county-level economic development, and consequently propelling industrial structure upgrading [38]. Secondly, the utilization of digital technology in agriculture enhances agricultural production efficiency, reducing the number of laborers engaged in agricultural production. This, in turn, encourages the shift of more labor resources from agricultural to non-agricultural sectors, driving the upgrading of the industrial structure in rural areas [39].

In this context, this paper proposes a third research hypothesis:

Hypothesis 3. *Digital village construction enhances county-level economic growth through industrial structure upgrading.*

Digital village construction can catalyze the elevation of regional innovation levels, thereby fostering county-level economic growth. Leveraging digital technology as its foundation, digital village construction effectively harnesses the advantages of the digital economy and digital technology to promote the enhancement of regional innovation levels. On one hand, it facilitates the dissemination of information, reducing the cost for enterprises and farmers to acquire information, thus stimulating innovative vitality. On the other hand, the application of digital technology can facilitate the contribution of research and development resources, breaking through the constraints of innovative resource allocation, promoting the spread and diffusion of technology, and ultimately fostering innovation [39].

Consequently, this paper proposes a fourth research hypothesis:

Hypothesis 4. *Digital village construction enhances county-level economic growth through the promotion of innovation.*

2.2. Data Sources

The data for this study are drawn from multiple sources. Firstly, county-level statistical data were collected and compiled based on the "China County Statistical Yearbook", county-level statistical bulletins, and government work reports. Secondly, the County-level Digital Village Construction Index was provided by Peking University's Institute of New Rural Development, and has only been published for three years, from 2018 to 2021, until now. Thirdly, county-level invention patent data were obtained from the National Intellectual Property Administration. Fourthly, the number of newly registered enterprises at the county level was obtained from the Qichacha APP. Fifthly, the list of National Digital Rural Pilot Counties was sourced from the Chinese government's official announcements. Sixthly, the spherical distance between the county and Hangzhou was calculated using the latitude and longitude of each county government's location. Using county-level codes as identifiers, data from different sources were matched to create the dataset for this study. After excluding counties with severely missing data, the final sample for this study consisted of 16 provinces (Shanxi, Jiangsu, Zhejiang, Anhui, Fujian, Henan, Hubei, Hunan, Guangxi, Hainan, Chongqing, Sichuan, Guizhou, Shaanxi, Gansu, and Ningxia) including 622 counties, covering most of China, spanning the years 2018 to 2021, resulting in an unbalanced panel dataset.

2.3. Variable Selection

2.3.1. Dependent Variable

In this study, the impact of digital village construction on county-level economic growth is investigated. Therefore, the county-level GDP growth rate (GDPR) is chosen as the dependent variable. Additionally, this study examines the effect of digital village construction on county-level economic growth by using per capita GDP (GDPC) and rural residents' disposable income (RDIN) as alternative variables for economic growth.

The selection of rural residents' disposable income (RDIN) as the alternative dependent variable stems from the fact that digital village construction primarily targets rural areas, thus exerting the most direct influence on rural residents' income [19]. Both rural residents' disposable income and per capita GDP are price-adjusted with 2017 as the base year. To address heteroscedasticity, the natural logarithms of per capita GDP and rural residents' disposable income are utilized.

2.3.2. Key Independent Variable

The key independent variable in this study is the digital village construction index (DVI), which comprehensively considers both producer and consumer, taking into account newly emerging digital phenomena in rural areas. The DVI is derived from a compilation of national macroeconomic statistics, industry data, and internet big data. It is currently one of the authoritative indices that reflects the level of China's digital village construction.

As China progresses in its digital village construction, significant efforts have been invested to boost this initiative. In 2020, the Chinese government introduced the National Digital Village Pilot Program and released the first batch of national digital village pilot counties, which included 117 counties. This study also employs the difference-in-differences (DID) method to examine the impact of digital village construction on county-level economic growth using the pilot policy as the robustness check.

2.3.3. Instrumental Variables

Given the potential endogeneity between the level of digital village construction and local economic development, the digital village construction level in this study could be an endogenous variable. To reduce estimation bias due to endogeneity problems, this study employs two instrumental variables: the average digital village construction index of other counties within the same province (IV1) and the distance between the county and Hangzhou (IV2). The mean value of the digital village construction index of other counties in the province is used as an instrumental variable because the development of

the digital economy has an obvious spatial aggregation effect, and the construction of digital villages in other counties within the province will not directly affect the economic development of the county [40,41]. The distance of counties from Hangzhou is used as an instrumental variable for the following reasons. First, the key dependent variable, the digital village construction index, is compiled based on underlying business data from the Alibaba Group, a major representative of large internet enterprises rooted in Hangzhou with radiating effects outward. Thus, the distance between the county and Hangzhou is significantly correlated with the level of digital village construction. Second, Hangzhou is just one of several significant cities in eastern China, and the distance between a county and Hangzhou does not determine the local economic growth. Hence, the instrumental variable reasonably satisfies the exogeneity assumption [42]. Since the distance from each county to Hangzhou is an exogenous and relatively fixed variable, and this study employs a fixed-effects panel regression model, the interaction between the distance and time is introduced as an instrumental variable to enhance their temporal heterogeneity.

2.3.4. Mechanism Variables

Based on the theoretical analysis in Section 2, the impact of digital village construction on county-level economic growth might be transmitted through three mechanisms: innovation (PATE), entrepreneurship (COMP), and industrial structure upgrading (STRU). Therefore, this study employs three mechanism variables to capture these mechanisms. For innovation, the quantity of invention patents released at the county level by the National Intellectual Property Administration is used as a proxy. For entrepreneurship, the number of enterprises registered in the county for the given year, retrievable from the "Qichacha" app, is utilized. To account for heteroskedasticity, the natural logarithm of both innovation and entrepreneurship variables is taken. Industrial structure upgrading is represented by the ratio of the added value of the secondary and tertiary industries to GDP. More detailed information, including variable names, full names, and descriptions, is summarized in Table 1.

Table 1. Data description.

Variable	Full Name	Description
GDPR	GDP Growth Rate	(GDP of year t-GDP of year t-1)/GDP of year t-1
GDPC	Per Capita GDP	GDP/End-of-year population (in yuan per person)
RDIN	Rural Disposable Income	Rural disposable income (in yuan)
DVI	Digital Village Construction Index	Standardized digital village construction index
FIND	Development of Primary Industry	Value added of the primary industry/GDP
SIND	Development of Secondary Industry	Value added of the secondary industry/GDP
GEXP	Government Expenditures	Government expenditures/GDP
LOAN	Financial Institution Loans	Total loans from financial institutions/GDP
EDU	Education Level	Number of students in middle schools/End-of-year total population
POP	Population Size	End-of-year resident population (in ten thousand people)
PATE	Innovation	Number of invention patents
COMP	Entrepreneurship	Number of newly registered enterprises
STRU	Industrial Structure	The proportion of value added from the secondary and tertiary industries to GDP

2.3.5. Control Variables

In order to control the heterogeneity at the county level, this paper selects the development of primary industry (FIND), the development of secondary industry (SIND), government expenditures (GEXP), loans from financial institutions (LOAN), the education level of the county (EDU), and the population size (POP) as control variables. Table 2 shows the statistical description of the sample data.

Table 2. Descriptive Statistics of the Data.

Variable	Obs	Mean	Std. Dev.	Min	Max
GDPR	1745	0.061	0.131	−0.414	0.546
GDPC	1745	35,920.310	21,315.220	5069.304	181,081.800
RDIN	1320	12,823.940	4374.200	5606.034	31,085.800
DVI	1745	53.208	10.606	19.110	94.670
FIND	1745	0.195	0.089	0.016	0.610
SIND	1745	0.353	0.146	0.042	0.848
GEXP	1745	0.369	0.315	0.063	3.941
LOAN	1745	0.774	0.378	0.146	2.741
EDU	1745	0.053	0.016	0.016	0.113
POP	1745	39.892	27.910	4.190	183.260
PATE	1562	81.977	223.459	1.000	3435.000
COMP	1747	4755.641	5473.266	234.000	77,495.000
STRU	1747	0.805	0.089	0.361	0.984

Table 2 indicates that the annual average GDP growth rate is around 6%, with a per capita GDP of CNY 35,920. However, there are significant disparities in economic development among different counties. Some counties have achieved rapid economic growth, with an average annual GDP growth rate exceeding 50%, while others have experienced sharp economic decline, with an average annual GDP growth rate of −41%. Regarding per capita GDP, the minimum value is CNY 5069, and the maximum value is CNY 181,082. As for the key independent variable of this study, the digital village construction index (DVI) has an average value of 53, suggesting that the current level of digital village construction in China is still in its early stages. The maximum value of the DVI is 95, while the minimum value is only 19, indicating significant disparities in digital village construction among different counties.

2.4. Methods

Based on the previous analysis, this study utilizes unbalanced panel data from 2018 to 2021 for 622 counties to examine the impact of digital village construction on county-level economic growth. To mitigate potential endogeneity issues resulting from reverse causality, the key independent variable, the digital village construction index (DVI), is lagged by one period. The model is specified as follows:

$$GDPR_{it} = constant + \beta DVI_{it-1} + \gamma C_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (1)$$

where $GDPR_{it}$ represents the GDP growth rate of county i in year t. DVI_{it-1} represents the DVI for county i in year $t - 1$. C_{it} includes other control variables for county i in year t, such as the development of the primary industry (FIND), development of the secondary industry (SIND), government expenditure (GEXP), financial institution loans (LOAN), education level (EDU), and population size (POP). μ_i represents county fixed effects. δ_t represents year fixed effects. ε_{it} is the error term. The standard errors of the estimation coefficients are calculated using county-level clustered robust standard errors.

To ensure the robustness of the results, this study also employs the difference-in-differences (DID) method to assess the impact of digital village pilot programs on county-level economic growth. The DID model is as follows:

$$GDPR_{it} = constant + \beta_1 DV_i \times time + \beta_2 DV_i + \beta_3 time + \gamma_1 C_{it} + \pi_i + \rho_t + \varphi_{it} \quad (2)$$

where $GDPR_{it}$ represents the GDP growth rate of county i in year t, DV_i indicates whether county i is a digital village pilot county (1 for yes, 0 for no), and time is a time dummy variable (1 for the year of the pilot and thereafter, otherwise 0). Control variables are the same as in model (1).

$$Y_{it} = constant + \beta DVI_{it-1} + \gamma X_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (3)$$

where Y_{it} represents the mechanism variables ($PATE_{it}$, $COMP_{it}$, $STRU_{it}$), and X_{it} includes control variables affecting each mechanism variable, such as population size, education level, government expenditure, etc.

3. Results and Analysis

3.1. Main Results

Table 3 displays the impact of digital village construction on county-level economic growth. The dependent variables in columns (1) and (2) are the GDP growth rate and the logarithm of per capita GDP, respectively. All regressions include year fixed effect and county fixed effect. To mitigate potential biases from autocorrelation, robust standard errors are clustered at the county level. The results indicate that digital village construction has a significant positive effect on both GDP growth rate and per capita GDP. Specifically, for each 1-unit increase in the digital village construction index, the GDP growth rate increases by 0.23%. Considering the average GDP growth rate of 6.10% during the period of 2018–2021, digital village construction can account for approximately 4% of the observed GDP growth. Regarding per capita GDP, a 1% increase in the digital village construction index results in a 0.13% increase in per capita GDP.

Table 3. Main Results.

	(1)	(2)
DVI	0.0023 ***	0.0013 *
	(0.001)	(0.001)
FIND	−1.3331 ***	−1.7320 ***
	(0.237)	(0.194)
SIND	−0.0065	0.2196 ***
	(0.068)	(0.069)
GEXP	−0.1454 **	−0.2321 ***
	(0.070)	(0.075)
LOAN	−0.1818 ***	−0.2484 ***
	(0.045)	(0.045)
EDU	−0.2943	1.4815 ***
	(0.594)	(0.447)
POP	−0.1535 **	−0.8832 ***
	(0.061)	(0.043)
Constant	0.9583 ***	13.7656 ***
	(0.237)	(0.166)
County FE	Yes	Yes
Year FE	Yes	Yes
Observations	1747	1747
R-squared	0.575	0.983

Note: Robust standard errors are in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

3.2. Robustness Checks

Given the potential issue of reverse causality between digital village construction and economic growth, this study employs an instrumental variable (IV) approach to further verify the impact of digital village construction on economic growth. The instrumental variables used in this study are the average digital village construction index of other counties within the same province (IV1) and the distance between the county and Hangzhou (IV2). Columns (1) and (2) in Table 4 present the results estimated with IV1 and IV2, respectively. The F-statistics are all greater than 10, indicating the effectiveness of the selected instrumental variables. The positive relationship between DVI and county-level economic growth remains significant, consistent with the results in Table 3. This suggests the robustness of the findings.

Table 4. IV Estimation.

VARIABLES	(1)	(2)
DVI	0.0032 *	0.0056 *
	(0.002)	(0.003)
Cragg-Donald Wald F	392.02	87.43
Kleibergen–Paap Wald rk F	126.27	37.15
Control variable	Yes	Yes
County FE	Yes	Yes
Year FE	Yes	Yes
Observations	1746	1746

Note: Robust standard errors are in parentheses; * $p < 0.1$.

To further assess the robustness of the results, different regression methods and datasets are used to reexamine the impact of digital village construction on county-level economic growth. Column (1) of Table 5 presents the estimates using the natural logarithm of rural residents' disposable income as the dependent variable, showing a significant positive effect. Column (2) employs the difference-in-differences (DID) method to analyze the impact of the digital rural demonstration village pilot policy on county-level economic growth, revealing a significant positive effect. Column (3) presents results excluding the subsamples of Jiangsu and Zhejiang. The exclusion of Jiangsu and Zhejiang is due to the fact that these regions, being economically advanced and having well-developed infrastructure, particularly in terms of information infrastructure, might exhibit more pronounced network effects for digital rural development [31]. The regression results indicate that even after excluding Jiangsu and Zhejiang, the coefficients remain positive and significant, although their magnitudes become smaller. This suggests that the impact of digital village construction on county-level economic growth might be more pronounced in areas with more advanced infrastructure and stronger economic development.

Table 5. Additional robustness checks.

	(1)	(2)	(3)
DVI	0.0024 ***		0.0022 ***
	(0.000)		(0.001)
DV*time		0.0579 **	
		(0.025)	
Constant	9.8644 ***	1.1002 ***	0.9791 ***
	(0.117)	(0.228)	(0.249)
Control variable	Yes	Yes	Yes
County FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	1322	1747	1662
R-squared	0.98	0.574	0.573

Note: Robust standard errors are in parentheses; *** $p < 0.01$, ** $p < 0.05$.

3.3. Heterogeneity Tests

The Chinese economy is characterized as a large country economy with significant variations in factors of endowment and industrial development across different regions. To further analyze the regional heterogeneity of the impact of digital village construction on county-level economic growth, this study divides China into two major economic regions, the East and the Center-West, and two major geographic regions, the South and the North, according to the classification standards of the National Bureau of Statistics. Regression analyses are then conducted separately for these regions. Columns (1) and (2) in Table 6 represents the results for the northern and southern regions, respectively; columns (3) and (4) represent the eastern and central-western regions. The regression results indicate that the impact of digital village construction on county-level economic growth is mainly observed in the Southern and Eastern regions, while its effects in other regions are not

significant. This could be attributed to the relatively higher level of digital infrastructure development in China's eastern and southern regions, enabling digital village construction to achieve its intended effects more effectively. Additionally, this study examines the differences in the impact of digital village construction on county-level economic growth between counties with agricultural sectors and those with non-agricultural sectors. Column (5) represents agricultural counties, while column (6) represents non-agricultural counties. The results suggest that the effect of digital village construction on county-level economic growth is more pronounced in non-agricultural counties.

Table 6. Heterogeneity tests.

	(1)	(2)	(3)	(4)	(5)	(6)
DVI	0.0017	0.0020 **	0.0040 ***	0.0015	0.0005	0.0026 **
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.6325 *	1.5624 ***	2.7959 ***	0.8051 ***	0.8766 **	1.3586 ***
	(0.325)	(0.354)	(0.608)	(0.272)	(0.380)	(0.344)
Control Variable	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	643	1104	352	1395	693	939
R-squared	0.658	0.579	0.531	0.593	0.536	0.619

Note: Robust standard errors are in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

3.4. Mechanism Checks

The aforementioned regression results have shown that digital village construction significantly promotes county-level economic growth. However, what are the underlying mechanisms through which digital village construction fosters this economic growth? To address this question, this study combines the theoretical analysis mentioned earlier and introduces three mechanism variables: innovation, entrepreneurship, and industrial structure upgrading. These variables are utilized to investigate the mechanisms through which digital village construction influences county-level economic growth. Table 7, columns (1) and (3), present the effects of digital rural development on innovation and industrial structure upgrading, respectively. The results for both mechanisms are not significant, suggesting that the impact of digital rural development on innovation and industrial structure upgrading has not yet materialized. This could be attributed to the fact that digital rural development is currently in its early stages, and its effects on overall innovation levels and industrial structure upgrading at the county level may not have fully manifested. However, as displayed in column (2) of Table 7, the impact of digital village construction on entrepreneurship is significantly positive. With the advancement of digital village construction and the improvement of infrastructure, more opportunities have been created for surplus labor in rural areas. This has led to the establishment of numerous small enterprises and individual businesses, thus promoting entrepreneurship [43].

Table 7. Mechanism Checks.

	(1)	(2)	(3)
DVI	0.0039	0.0053 ***	−0.0002
	(0.007)	(0.002)	(0.000)
Constant	4.2426	7.7652 ***	−0.8621 ***
	(4.019)	(1.187)	(0.119)
Control Variable	Yes	Yes	Yes
County FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	1543	1747	1747
R-squared	0.867	0.952	0.976

Note: Robust standard errors are in parentheses; *** $p < 0.01$.

4. Conclusions

This study has empirically examined the impact of digital village construction on county-level economic growth in China, utilizing non-balanced panel data from 16 provinces and 622 counties for the years from 2018 to 2021. The study also investigated the underlying mechanisms and conducted heterogeneity and robustness tests using various analytical methods, including instrumental variables and the difference-in-differences (DID) approach.

The findings reveal that digital village construction significantly enhances county-level economic growth, with a more pronounced effect observed in southern regions, eastern regions, and non-agricultural counties. The primary mechanism through which digital village construction drives economic growth at the county level is by promoting entrepreneurship. The validity of hypothesis 1 and hypothesis 2 were tested. This study not only empirically examines the importance of digital village construction for economic growth in China, filling the gap in existing empirical research, but also enriches the theoretical research on digital village construction for economic growth.

Based on the research conclusions, several policy recommendations are proposed. Firstly, the Chinese government should continue to promote digital village construction. This entails strengthening digital infrastructure, improving rural roads, cold-chain logistics, and internet networks, while continuously expanding the scope of digital applications to better facilitate county-level economic growth. Secondly, the existence of the "digital gaps" and regional disparities in digital village construction should be addressed. Governments should focus on integrated development from institutional and policy perspectives and accelerate the improvement of digital village construction in the central, western, and northern regions. Third, the government should strengthen the digital infrastructure in the central and western parts of China, and transform digital rural development into a new engine for boosting county-level economic growth.

However, there are some limitations to this study. First, due to data limitations, the research sample only covers 622 counties, which may not fully represent the entire relationship between digital village construction and the county-level economic growth in China. Second, the current digital village construction index only spans three years, a relatively short time span. As digital village construction continues to progress, its impact on county-level economic growth might extend further.

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