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Impact of Rural Digital Economy Development on Rural Revitalisation—Evidence from China

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Abstract: Comprehensively promoting rural revitalisation is an important task for China so asto build a strong agricultural country in the new era; industrial revitalisation is the top priority of rural revitalisation, and the rural digital economy is an important driving force to achieve rural revitalisation. Based on data on the development level of the rural digital economy and the development level of rural revitalisation in 30 provinces in China from 2013 to 2020, the impact of rural digital economy development on rural revitalisation was empirically analysed using a two-way fixed effects model. The results show that the level of rural digital economy development in all Chinese provinces has a positive impact on the level of rural revitalisation development. At the same time, the level of economic development, urbanisation rate, degree of openness to the outside world, demographic structure, and rural assets are all inputs that have a significant positive impact on the level of development of rural revitalisation. In order to promote the development of rural revitalisation, it is proposed to build a rural digital infrastructure and promote the construction of digital villages, combining the actual situation of each place, guiding the layout of rural industries in accordance with local conditions, and further giving play to the positive effects om the level of rural economic development. This paper also considers policy recommendations for fostering a rural digital workforce to fulfil the important role of human capital.

Keywords: rural digital economy; rural rejuvenation; driving mechanisms; two-way fixed effects

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1. Introduction

The implementation of the strategy of rural revitalisation is a major decision and deployment made by the 19th Congress of the Communist Party of China, a major historical task for China to build a moderately prosperous society in all aspects and a modern socialist country in all aspects, and a general guide for the work of the "three rural areas" in the new era. The Central Committee's Document No. 1 of 2024 was released, which is the 21st consecutive No. 1 document guiding the work of the "Three Rural Areas" since the beginning of the new century, pointing out that in order to push forward Chinese-style modernisation, it is necessary to persistently consolidate the foundation of agriculture and push forward the comprehensive revitalisation of the countryside. Modernisation of agriculture and rural areas is the overall goal of the implementation of the rural revitalisation strategy; adhering to the priority development of agriculture and rural areas is the general policy; and industrial prosperity, ecological livability, civilised rural customs, effective governance, and a rich life are the general requirements [1]. China's fast-growing digital economy is becoming an important engine to drive all-round high-quality economic and social development; therefore, digital economy-enabled rural development, rural construction, and rural governance is an important strategy for rural revitalisation [2]. The document also emphasises the continued implementation of digital rural development actions, the development of smart agriculture, narrowing the "digital divide" between urban and rural

areas, and strengthening the collaborative sharing of agricultural production and management, rural social management, and other agricultural-related information. Specifically, the digital economy is a new type of economic form that takes digitised knowledge and information as the key production factors, takes digital technology as the core driving force, takes the modern information network as the important carrier, and through the deep integration of digital technology and the real economy, continuously improves the digitalisation, networking, and intelligence of the economy and society and accelerates the restructuring of economic development and governance modes [3]. By incorporating data elements into agricultural production, digital products and services into farmers' lives, and digital thinking into rural government services, the digital economy helps diversify and intensify the agricultural industry, enhance farmers' skills and satisfy their spiritual life, and digitise and smarten rural governance, thus providing digital impetus for the realisation of the revitalisation of rural industries, talents, culture, ecology, and organisation. Therefore, it is of great policy significance and practical significance to study the impact of the development of the digital economy on rural revitalisation and put forward targeted development proposals.

2. Literature Review

Academic research on the digital economy mainly elaborates on the following three aspects: First, research on the concept of digital economy, which is a series of economic activities using digitised information resources as key production factors and modern data networks and technology platforms as important carriers, aiming to use the effective use of information and communication technologies as an important driving force to enhance efficiency and optimise economic structures [4]. The second is research on the evaluation index system of the digital economy, from the digital economic environment, digital infrastructure, digital transformation of agriculture, and digitalisation of life [5], from the degree of Internet penetration, the level of development of rural e-commerce, and the degree of development of rural inclusive finance [6], and from the construction of digital infrastructure, the development and management of data resources, the digitalisation of industry, industrial digitisation, and governance digitisation [7]. Third, empirical studies related to the digital economy, the digital economy and agricultural and rural economic development [8], employment [9], common wealth [10], the consumer market [11], urban–rural structural transformation [12], and other perspectives. By combing through the literature, it is found that scholars have not formed a unified standard for constructing indicators to measure the digital economy, and at the same time, affected by the availability of data, the level of the digital economy is measured over a shorter span of years, and the degree of research on the longitudinal development of the digital economy is low. The theoretical study of the digital economy and rural revitalisation is involved, but its empirical analysis is less extensive.

The research on rural revitalisation is mainly elaborated from the following three aspects: First, research on the connotations of rural revitalisation [13,14]. Second, rural revitalisation path research, scholars from multiple perspectives explaining specific initiatives, the new era of rural human resources [15], rural education [16], company's social entrepreneurship [17], digital financial inclusion [18], green food [19], rural migrant workers returning to their hometowns to start their own businesses [20], tourism and urbanisation [21], the agricultural land "three rights of ownership" system reform path [22], and so on. Third, the study of a rural revitalisation evaluation index system; scholars mostly construct an evaluation index system from the five aspects of industrial prosperity, ecological livability, a civilised countryside, effective governance, and an affluent life, and they use different methods to measure the level of rural revitalisation in each province [23–25], and there has been a consensus on the choice of first-level indicators.

The study of the digital economy and rural revitalisation is mainly elaborated from the following three aspects: First, changing the mode of agricultural production; the digital economy, by virtue of open and non-competitive data elements and technologies, affects

the relationship between agricultural labourers and the means of production, accelerates the transformation of new agricultural technology overflows, and creates advantageous conditions for the innovation of the rural rights relationship, which then affects a change in the mode of agricultural production [26,27]. The second is to increase the income of rural residents by reducing the cost of obtaining market information, improving the efficiency of agricultural production, improving the marketing model, and changing the way of thinking of rural residents, expanding non-agricultural production income by expanding access to employment information and strengthening the accumulation of rural human resources [28]. Thirdly, to accelerate the realisation of the sustainable development of the rural economy, the digital economy can, to a certain extent, eliminate urban–rural dual-structure institutional limitations, accelerate the flow of resources between urban and rural elements and the formation of the "sharing economy" [29,30].

After combing the literature at home and abroad, it is found that the existing studies mostly analyse the respective connotations, path, and construction and development level of evaluation indexes of the rural digital economy and rural revitalisation, but the empirical analysis is less extensive. Moreover, the empirical analysis only analyses the impact of the rural digital economy on a certain aspect of rural revitalisation, lacks empirical research on the overall impact of rural revitalisation, and does not systematically elaborate on the mechanism of the impact of the rural digital economy on rural revitalisation, nor does it systematically analyse the development trend and regional differences in the level of rural digital economy and rural revitalisation development in various regions of China. This paper will use data collected from 30 provinces in China over the period 2013–2020, with the aim of using a fixed effects model to study the impact of rural digital economic development on rural revitalisation and provide valuable insights into the realisation of rural revitalisation. At the same time, a detailed analysis of the impact mechanism of the rural digital economy and rural revitalisation is extended from a certain aspect to systematisation, systematically analysing development trends and regional differences in the level of development of the rural digital economy and rural revitalisation in each region of China. In addition, this paper also deals with the endogeneity issue with the help of a panel Granger causality test, which better improves the robustness of the article's conclusions.

3. Theoretical Analysis and Research Hypotheses

Firstly, the rural digital economy promotes the prosperity of rural industries, which is mainly reflected in the integrated development of industries, the innovation of industrial subjects, and an improvement in product quality. Firstly, the digital economy can promote industrial development, accelerate the realisation of the integration of primary, secondary and tertiary industries, and promote the multifunctional development of agriculture. In the process of the rapid development of the digital economy, big data technology and artificial intelligence boost the specialised segmentation of each link of the agricultural industry chain, extend the agricultural industry chain and value chain through the primary processing and deep processing of agricultural products, and improve the problem of traditional agriculture being in the middle and low end of the value chain for a long time [31,32]. At the same time, new agricultural industries and modes of business, such as agricultural tourism and health and wellness, are being utilised to achieve a deeper integration of the tertiary and primary industries and to promote the revitalisation of rural industries. Secondly, the digital economy can cultivate new agricultural management subjects [33,34]. The digital economy can facilitate strong links between farmers and agricultural organisations and provide timely and accurate financial assistance to agricultural operators. Finally, the digital economy can help improve the quality of agricultural products [35,36]. The digital economy promotes the use of smart agricultural technologies, such as smart-sensing robots in agriculture and numerically controlled pesticide spraying, to achieve the goal of intelligence and efficiency in the whole chain of agriculture, from sowing to harvesting, which is of great significance in improving the level of agricultural automation and production efficiency. The big data collection and analysis platform of the digital economy can help

improve the quality and efficiency of agriculture by regulating the quality of agricultural products and forecasting risks, providing information on the varieties and quantities of agricultural products to be grown, and promoting the branding of agricultural products.

Secondly, the rural digital economy promotes rural eco-livability. Firstly, the digital economy promotes the greening of agriculture. The digital economy incorporates the whole process of agricultural production and processing into the agricultural intelligent agricultural IoT system, which puts forward higher requirements for the quality and safety traceability of agricultural products, especially the amount of fertilisers and pesticides used and the amount of residues, and boosts the green and low-carbon development of agricultural production [37,38]. Secondly, the digital economy can improve the efficiency and level of agricultural pollution control. In the process of digitising agriculture, the digital economy can leverage the Internet to rapidly disseminate advanced technologies for preventing and combating agricultural and rural pollution, collocate complete data on agricultural pollution, integrate resources for combating pollution, and improve the level of pollution control [39,40]. Thirdly, the digital economy is conducive to the improvement of the rural habitat and ecosystems. The digital economy can not only make use of digital networks to popularise the concept of green development in cities and towns to rural areas, but also make use of the rural environment monitoring system to effectively analyse in real time information on the living environment and ecological environment, such as the rural human environment, the ecology of farmland, rural rivers and lakes, and soil erosion, so as to continuously improve the efficiency of the improvement of the rural environment and the level of management specialisation [41,42].

Thirdly, the rural digital economy promotes rural civilisation from both the demand and supply sides. First, on the demand side, the inheritance and development of outstanding traditional culture in the countryside is being promoted through the development of the digital economy. The digital economy promotes the construction of rural digital networks, attracting a large number of farmers to invest in the construction of rural civilisation, such as the use of e-commerce live broadcasts to introduce the historical sites of the countryside, poems and ballads, traditional customs, folk legends, celebrity deeds, and township rules and regulations, which not only enriches the spiritual and cultural life of farmers but also inherits and develops the excellent traditional culture of the countryside through imperceptible influences [43,44]. Secondly, the effective supply of rural digital cultural products and services should be enhanced. Compared with urban residents, rural residents in China have fewer sources of access to information and the effective supply of cultural products is insufficient, leading to a more conservative mindset among rural residents and a lack of motivation for the revitalisation of talent, which constrains rural revitalisation. The provision of cross-regional information resources through the rural digital economy has met the spiritual and cultural needs of farmers and changed their original concepts of life, agricultural production, marriage, and consumption, promoting the development of digital value creativity and contributing to the long-term sustainable development of the construction of rural civilisation [45,46].

Fourthly, the rural digital economy promotes effective rural governance, mainly in the form of improved governance and governance efficiency. Firstly, convenient digital rural governance improves the efficiency of rural governance. In the process of gradually shifting the centre of gravity of grass-roots governance, villagers' awareness of rural governance and public awareness has developed more rapidly; villagers have to deal with more things in villages, and villagers have put forward new demands on the efficiency of the handling of affairs [47,48]. Digital village governance uses digital technology to build a platform for the timely appeal of villagers' opinions and needs, breaking down the long-standing barrier of "going into the government and applying face-to-face" and crossing the barriers of time and space. Secondly, digital rural governance optimises the way rural affairs are governed [49,50]. Digital village governance, in the close link between the villagers and village cadres' vertical relationship, at the same time also deepens the connection between villages in different regions; the excellent governance cases around

the appropriate combination with local rural governance can solve the problem of rural governance information blockage. The process of digital village governance will continue to improve the governance awareness and capacity of villagers, better exercise their rights to know, choose, participate and supervise, and further promote legitimate, transparent, efficient, and open procedures for village governance, so as to accelerate the implementation of good governance in the countryside.

Fifthly, the rural digital economy promotes a rich life. Farmers' income growth is an important objective of rural revitalisation. Firstly, the rural digital economy helps to sell agricultural products and increase farmers' household income. The "capital and skills" doctrine holds that the application of new technologies increases the income of skilled labour [51], but the adoption of new technologies does not necessarily reduce the income of unskilled labour [52]. The development of the rural digital economy has provided convenient conditions for the construction of rural commerce network trading platforms, and the use of rural commerce trading platforms to provide online and offline agricultural product-trading services for both the supply and demand sides has lowered the limitations of the farmers' supply side to enter the market and reduced the cost of searching for market information and trading between the supply and demand sides. At the same time, the use of a rural commerce network trading platform can widely and accurately obtain changes in the price of agricultural products, quality requirements, trading areas, and the number of transactions, to help the supply side of agricultural products to formulate accurate and reasonable marketing methods, so that farmers and consumers can effectively avoid the middlemen's layer-by-layer squeeze, and to strengthen the market position of the supply side of agricultural products in order to obtain more profits. Secondly, the rural digital economy increases the ways for farmers to increase their income and raise their wage income [53,54]. The development of the rural digital economy has also extended employment service businesses, closely linking the supply side of surplus rural labour with the demand side of market enterprises, promoting equal opportunities for employment and entrepreneurship, and helping surplus rural labour or short-term labourers in the agricultural idle period to flexibly take up employment or start their own businesses, so as to increase the income of farmers and promote a prosperous life.

As the systematic content of rural revitalisation, the rural digital economy promotes the development of these contents, while also promoting the development of rural revitalisation as a whole. Specifically, the theoretical mechanism of the rural digital economy empowering rural revitalisation is shown in Figure 1.

Based on this, the following hypothesis is put forward.

Hypothesis 1. The digital economy can significantly drive rural revitalisation.

The development of rural digital can promote the high-quality development of the agricultural business system, reduce information costs, build agricultural product brands, and develop multifunctional agriculture to promote rural industrial prosperity. It can build a whole industrial chain of agricultural production and green low-carbon development, and improve the efficiency and level of agricultural pollution control to improve the rural habitat and ecological environment to promote the construction of ecological livability. It can inherit and develop excellent traditional culture in the countryside, effectively supply digital cultural products and services in the countryside, and promote the construction of rural civilisation. It can improve the efficiency of rural governance, optimise the governance of rural affairs, and promote effective governance. It can increase the operating income of farmers, improve their wage income, and achieve a rich life.

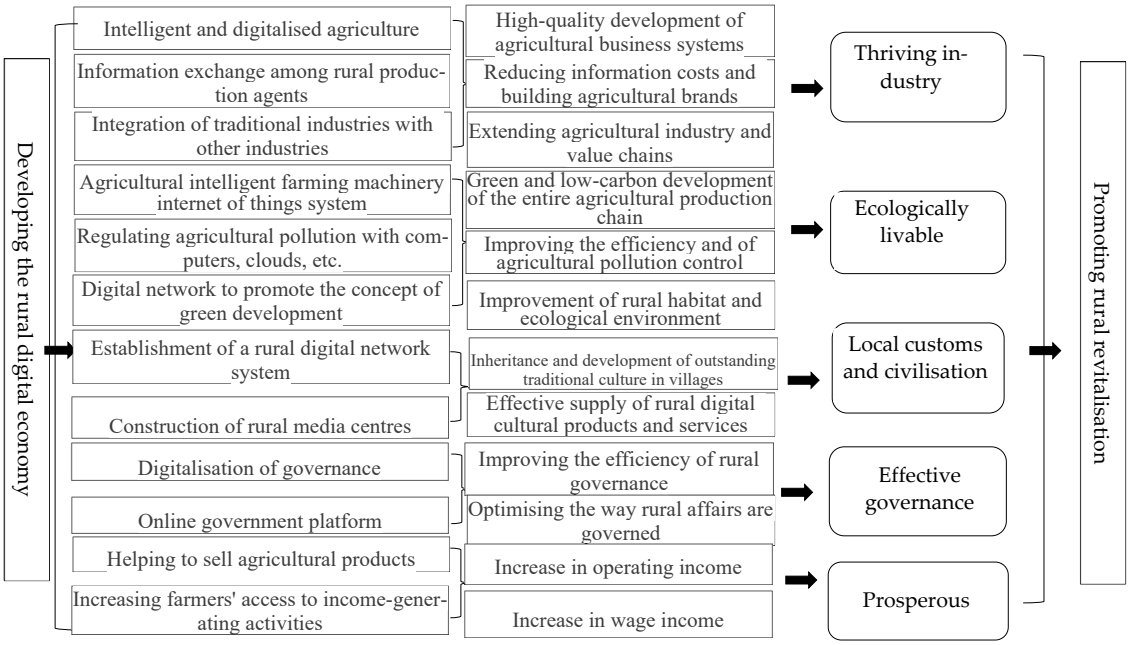

Figure 1. Theoretical mechanisms of rural digital economy enabling rural revitalisation.

4. Indicator System and Model Construction

4.1. Entropy Approach Model

Compared with other multi-indicator weighting evaluation methods, the entropy value method has the advantages of reducing the bias caused by the assignment of subjective factors, avoiding the problem of repetition of the information of indicator variables, and using simple algorithms with a high accuracy. Therefore, the entropy value method is more suitable for determining the weights of the indicator system of rural entrepreneurial activity in multiple provinces in multiple time periods in this paper, so as to measure the comprehensive evaluation value of rural digital economic development. Because of the differences in the units and attributes of the indicators in the constructed indicator system, it is first necessary to standardise the data to avoid the influence of the scale, and the model expression is as follows:

$$\text{Positive indicators}: \ Z_{ij} = (X_{ij} - \min(X_{ij}))/(\max(X_{ij}) - \min(X_{ij})) \tag{1}$$

$$\text{Negative indicators}: \ Z_{ij} = (\max(X_{ij}) - X_{ij})/(\max(X_{ij}) - \min(X_{ij})) \tag{2}$$

Among them, Z_{ij} denotes the results of the data normalisation of the raw indicator data. i indicates province, j indicates the first indicator. X_{ij} indicates i province, j indicator raw data. Secondly, after standardisation of the data, the authors measured the j information entropy of indicator raw data E_j (Formula (3)) and weights W_j (Formula (4)); included among these, n denotes the sample size and m indicates the number of indicators. Finally, the measurement of the composite value of digital economy development in rural villages in each province (Formula (5)).

$$E_j = -\frac{1}{\ln(n)} \sum_{i=1}^{n} \left(\frac{z_{ij}}{\sum_{i=1}^{n} Z_{ij}} \ln \frac{z_{ij}}{\sum_{i=1}^{n} Z_{ij}} \right. \tag{3}$$

$$W_j = (1 - E_j)/\sum_{j=1}^{m} (1 - E_j) \tag{4}$$

$$HQED_i = \sum_{j=1}^{m} W_j Z_{ij} \tag{5}$$

4.2. Two-Way Fixed Effects Model

Through the F-value statistic test method and the Hausman test method, the fixed effect model is selected as the most appropriate; meanwhile, in order to solve the problem of the individual effect and time effect, the final choice is to use a two-way fixed effect model to measure the impact of the level of rural digital economy development on the level of rural revitalisation development, and the model expression is as follows:

$$Y_{it} = a_0 + a_1 U_{it} + a_2 X_{it} + PRO_i + YEAR_t + \mu_{it} \quad (6)$$

In Equation (6), Y_{it} denotes i, the province, and t, the level of rural revitalisation development in the year; U_{it} denotes i, the province, and t, the level of rural digital economy development in the year; X_{it} denotes i, the province, and t, the vector of control variables for the year; PRO_i denoted the province fixed effects term, to control for unobservable and time-invariant individual heterogeneity at the district level; $YEAR_t$ denotes an observable time fixed effects term; U_{it} denotes the random error term; a_0, a_1, and a_2 all are parameters to be estimated.

4.3. Description of Data and Variables

4.3.1. Explanatory Variables

In this paper, referring to the measurement method of Luo Chunna et al. [55], we select the indicators of industrial prosperity, ecological livability, civilised rural culture, effective governance, and affluent life to construct the indicator system of the rural revitalisation development level, and we select the entropy method to measure the comprehensive evaluation value of the rural revitalisation development level, and the level of the comprehensive evaluation value indicates the high level of the rural revitalisation development level of the region, as shown in Table 1.

Table 1. List of variable indicators.

Subsystems	Primary Index	Secondary Index	Unit
Thriving industry	Industrial efficiency	Gross value of agricultural, forestry, livestock, and fishery production by region	Billions
		Total food production per capita	kg/person
	Level of mechanical production	Total power of agricultural machinery at end of year	Kilowatt (unit of electric power)
Ecologically livable	Renewable resources utilisation capacity	Total gas production from digester	Cubic metre
		solar water heater	Cubic metre
	Ecological governance capacity	Soil erosion control area	Thousand hectares
	Green production capacity	Water-saving irrigation area	Thousand hectares
Local customs and civilisation	Level of recreation	Percentage of farmers' expenditure on education, culture, and recreation	%
	Rural health pensions	Average village health centre staff per 1,000 rural population	Person
	Cultural infrastructure	Number of township cultural stations	Size
Effective governance	Human capital	Level of human capital	—
	Effectiveness of governance	Ratio of income of urban and rural residents	—
	Governing body	Number of Village Councils	Size

Table 1. *Cont.*

Subsystems	Primary Index	Secondary Index	Unit
Prosperous	Income level	Per capita disposable income of rural residents	CNY
	Consumer structure	Engel's coefficient for rural inhabitants	%
	Livelihood protection	Expenditure on rural minimum subsistence guarantee	Thousand
Villages' digital economy	Digital infrastructure	Rural Internet penetration rate (number of rural Internet users/rural population)	%
		Rural smartphone penetration (average annual mobile phone ownership per 100 rural households)	Size
		Radio and television network coverage (actual number of rural cable radio and television subscribers/total number of rural households)	%
		Agrometeorological observation stations (number of agrometeorological observation stations)	Size
	Digitisation of agriculture	Scale of digitisation in agriculture (digital technology inputs/total inputs in agriculture, forestry, livestock, and fisheries)	%
		Digitalised transactions of agricultural products (e-tail sales of agricultural products)	Billions
	Digital industrialisation of agriculture	Strength of investment in agricultural production (fixed asset investment in plantations, livestock, fisheries, etc.)	Billions
		Information technology applications for agricultural production (number of people served by rural postal outlets)	Ten thousand people
		Agricultural rural digital base (number of Taobao villages)	Size
		Number and size of rural online payments (Rural Digital Financial Inclusion Index)	%
		Level of consumption of digital products and services (consumption expenditure on various types of lifestyle digital products and services such as smart devices and software/total household expenditure)	%

4.3.2. Core Explanatory Variables

In this paper, referring to the measurement methods of Han Zhaoan et al. [56], digital infrastructure, agricultural digitalisation, and agricultural digital industrialisation indicators are selected to construct the indicator system of the rural digital economy development level. On the basis of this indicator system, the entropy value method is used to measure the comprehensive evaluation value of rural digital economic development, and the level of the

comprehensive evaluation value indicates the level of rural digital economic development in the region.

4.3.3. Control Variable

This paper selects the level of economic development, urbanisation rate, degree of openness to the outside world, population structure, and rural asset investment as control variables. (1) The level of economic development is expressed by the real per capita gross regional product; (2) the urbanisation rate is expressed by the ratio of the urban population to the total population; (3) the degree of openness to the outside world is expressed by the amount of goods imported and exported to and from the gross domestic product; (4) the demographic structure is expressed by the value of the old age dependency ratio; and (5) the input of rural assets is expressed by the amount of the completed fixed-asset investment in rural households.

4.3.4. Data Sources

The basic data for measuring the level of rural digital economy development are mainly from the 2013–2020 China Tertiary Industry Statistical Yearbook, China Rural Statistical Yearbook, China Statistical Yearbook, the EPS data platform, data from the Ali Research Institute, the Centre for Spatial Planning of Nanjing University, and the digital financial inclusion indicators released by the Digital Finance Research Centre of Peking University. Data on rural revitalisation in each province comes from the 2013–2020 China Rural Statistics Yearbook, China Statistics Yearbook, China Population and Employment Statistics Yearbook, China Social Statistics Yearbook, China Civil Affairs Statistics Yearbook, and the statistical yearbooks of each province. Data on control variables were obtained from the China Statistical Yearbook, the China Population and Employment Statistics Yearbook, and the China Rural Statistics Yearbook.

4.3.5. Descriptive Statistics

According to Table 2, it can be seen that there is a large gap between the maximum and minimum values of the development level of rural revitalisation and the development level of the rural digital economy, indicating that there are regional differences in the development level of rural revitalisation and the digital economy in China.

Table 2. Variable definitions and descriptive statistics.

Variable Type	Variable Name	Definition and Description	Mean Value	Standard Deviation	Minimum Value	Maximum Value
Explanatory variable	Level of development of rural revitalisation	Measured level of rural revitalisation development	20.9848	11.2444	4.3580	55.6950
Core explanatory variables	Level of rural digital economy development	Measured level of rural digital economy development	31.1668	9.4849	9.6400	59.8000
Control variable	Level of economic development	Real GDP per capita	5.9963	2.7890	2.3200	16.4900
	Urbanisation rate	Urban population/ total population	60.3134	11.5814	37.8900	89.6000
	Degree of openness to the outside world	Amount of exports and imports of goods/GDP	25.2132	26.6975	0.7700	132.5100
	Population structure	Old age dependency ratio	18.8710	6.3989	7.6900	44.5600
	Rural asset inputs	Completion of fixed-asset investment in rural households	329.2928	232.6897	3.3000	966.7000

Note: This table is calculated by Stata16.0. The sample volume is 240 and contains observations for 30 provinces (Hong Kong, Macau, Taiwan, and Tibet are excluded from this study due to statistical constraints) for the period 2013–2020.

5. Results

5.1. Level of Rural Digital Economy Development

According to Equations (1)–(5), the level of development of the digital economy in the rural areas of 30 provinces in China (data for Tibet are missing, so it is rounded off) was measured from 2013 to 2020 (Table 3).

Table 3. Level of digital economy development in 30 provinces and villages in China, 2013–2020.

	Province	2013	2014	2015	2016	2017	2018	2019	2020	Average	Growth—Rate	Average Annual Increase in Percent
Eastern part	Beijing	0.2056	0.2122	0.2133	0.2266	0.2443	0.2633	0.2871	0.3466	0.2499	0.6859	8.5700
	Tianjing	0.0964	0.1040	0.1252	0.1568	0.1928	0.2165	0.2452	0.2000	0.1671	1.0757	13.4500
	Hebei	0.2121	0.2264	0.2558	0.2890	0.3160	0.3472	0.3387	0.3607	0.2932	0.7006	8.7600
	Shanghai	0.2556	0.2656	0.2459	0.2544	0.2657	0.2922	0.2515	0.3599	0.2738	0.4082	5.1000
	Jiangsu	0.4025	0.4318	0.4754	0.4885	0.4116	0.4263	0.4592	0.4834	0.4473	0.2011	2.5100
	Zhejing	0.2883	0.2905	0.3422	0.3650	0.4009	0.4707	0.4836	0.5562	0.3997	0.9291	11.6100
	Fujian	0.2466	0.2601	0.2857	0.3365	0.3561	0.3886	0.4642	0.4473	0.3481	0.8138	10.1700
	Shandong	0.3738	0.3967	0.4643	0.5073	0.5732	0.5976	0.5783	0.5980	0.5111	0.6000	7.5000
	Guangzhou	0.3457	0.3115	0.3468	0.3766	0.4508	0.4509	0.4877	0.5053	0.4094	0.4615	5.7700
	Hainan	0.1880	0.2012	0.2360	0.2628	0.2877	0.3303	0.3486	0.3683	0.2778	0.9588	11.9800
	Average value	0.2614	0.2700	0.2991	0.3263	0.3499	0.3784	0.3944	0.4226	0.3378	0.6162	7.7000
Central region	Shanxi	0.1805	0.2021	0.2329	0.2529	0.2752	0.2991	0.3115	0.3402	0.2618	0.8851	11.0600
	Anhui	0.2212	0.2485	0.2960	0.3125	0.3421	0.3735	0.4084	0.4275	0.3287	0.9328	11.6600
	Jiangxi	0.2162	0.2278	0.2579	0.3028	0.3256	0.3519	0.3650	0.3865	0.3042	0.7879	9.8500
	Henan	0.2465	0.2545	0.2906	0.3310	0.3659	0.4060	0.4194	0.4520	0.3457	0.8334	10.4200
	Hubei	0.2460	0.2512	0.2990	0.3151	0.3380	0.3817	0.4473	0.4584	0.3421	0.8633	10.7900
	Hunan	0.2043	0.2183	0.2654	0.2970	0.3253	0.3532	0.3971	0.4107	0.3089	1.0097	12.6200
	Average value	0.2191	0.2337	0.2736	0.3019	0.3287	0.3609	0.3915	0.4125	0.3152	0.8827	11.0300
Western region	Neimengu	0.1865	0.1960	0.2174	0.2412	0.2536	0.2843	0.2868	0.3273	0.2491	0.7544	9.4300
	Guangxi	0.2362	0.2520	0.2940	0.3100	0.3331	0.3680	0.4061	0.4390	0.3298	0.8586	10.7300
	Chongqing	0.1813	0.2001	0.2246	0.2443	0.3155	0.3375	0.3899	0.4289	0.2903	1.3654	17.0700
	Sichuan	0.2936	0.3045	0.3588	0.3879	0.4398	0.4771	0.4996	0.5323	0.4117	0.8129	10.1600
	Guizhou	0.1842	0.2121	0.2390	0.2743	0.3085	0.3321	0.3692	0.4053	0.2906	1.2002	15.0000
	Yunnan	0.2327	0.2260	0.2570	0.2792	0.2962	0.3421	0.3686	0.4351	0.3046	0.8700	10.8800
	Shanxi	0.1995	0.2277	0.2438	0.2726	0.3066	0.3519	0.4757	0.4424	0.3150	1.2178	15.2200
	Gansu	0.1809	0.2006	0.2318	0.2530	0.2866	0.3181	0.3448	0.3730	0.2736	1.0619	13.2700
	Qinghai	0.1406	0.1615	0.1853	0.2040	0.2362	0.2642	0.2915	0.3183	0.2252	1.2636	15.8000
	Ningxia	0.1522	0.1720	0.1994	0.2096	0.2410	0.2781	0.3177	0.3457	0.2395	1.2721	15.9000
	Xinjiang	0.2591	0.2624	0.2804	0.2994	0.3165	0.3525	0.3895	0.3992	0.3199	0.5409	6.7600
	Average value	0.2042	0.2195	0.2483	0.2705	0.3031	0.3369	0.3763	0.4042	0.2954	0.9791	12.2400
Northeastern part of China	Liangning	0.1931	0.2074	0.2423	0.2745	0.2866	0.3106	0.3177	0.3453	0.2722	0.7881	9.8500
	Jilin	0.2226	0.2355	0.2294	0.2461	0.2708	0.2979	0.2973	0.3385	0.2673	0.5205	6.5100
	Heilong jiang	0.2391	0.2316	0.2706	0.2925	0.3030	0.3385	0.3329	0.3784	0.2983	0.5825	7.2800
	Average value	0.2183	0.2248	0.2474	0.2710	0.2868	0.3157	0.3160	0.3541	0.2793	0.6220	7.7800
Nationwide	Average value	0.2277	0.2397	0.2702	0.2954	0.3222	0.3534	0.3793	0.4070	0.3119	0.7874	9.8400

The development of China's rural digital economy from 2013 to 2020 shows a trend of good development, growing from 0.2277 in 2013 to 0.4070 in 2020, an increase of 0.7874, with an average annual growth rate of 9.84 per cent, indicating that China's rural digital is generally stable and steadily developing. The growth rate of all regions also showed positive growth, of which the western and central regions grew faster, with an increase of 0.9791 and 0.8827, respectively, and an average annual increase of 12.24% and 11.03, respectively; eight of the nine provinces with the fastest growth rate were located in the western and central regions, namely Chongqing (1.3654), Ningxia (1.2721), Qinghai (1.2636), Shaanxi (1.2178), Guizhou (1.2002), Gansu (1.0619), and Hunan (1.0097). The northeastern region increased by 0.6220, and the average annual growth rate of 7.78 per cent was also higher than the growth rate of the eastern region. It can be seen that in the central, western, and northeastern regions, although the level of development of the rural digital economy is weaker, the growth rate is faster and the development potential is greater.

However, there are gaps between the levels of development of the digital economy in rural villages across regions and provinces. In terms of the average value of rural digital economy development water, the average value of rural digital economy development water is greater in the Eastern region than in the Central region, in the Central region than in the Western region, and in the Western region than in the Northeastern region.

The average value of rural digital economy development water is greater. The inter-regional development gap is large; the rural digital economy development level higher is than the national average level for a total of 12 provinces, mostly distributed in the northeastern region and the central region; the distribution is Shandong, Jiangsu, Sichuan, Guangdong, Zhejiang, Fujian, Henan, Hubei, Guangxi, Anhui, Xinjiang, and Shaanxi. Six of the seven provinces with the highest mean values are located in the eastern region, namely Shandong (0.5111), Jiangsu (0.4473), Guangdong (0.4094), Zhejiang (0.3997), and Fujian (0.3481), which is related to the higher level of economic development in the eastern region, and how to reduce the inter-regional rural digital economy development gap has also become a key issue for the coordinated development of the rural digital economy.

5.2. Level of Development of Rural Revitalisation in China

From 2013 to 2020, the development level of China's rural revitalisation showed an overall stable and steady trend, increasing from 0.1633 in 2013 to 0.2836 in 2020, an increase of 0.8146, or an average annual increase of 10.18%, indicating that China's rural revitalisation has gained a good level of development. From the point of view of the growth rate of the development level of rural revitalisation in each region, the development level of rural revitalisation and rural digital development level in each region show a similar development state, with the fastest growth rate in the western region and the central region, with an increase of 1.0231 and 0.7515, respectively, and an average annual increase of 12.79% and 9.39%, followed by an increase in the central region with an increase of 0.7183, and an average annual increase of 8.98 per cent; the lowest increase in the northeastern region was 0.4975, with an average annual increase of 6.22 per cent.

At the same time, there are gaps between the levels of development of rural revitalisation in various regions and provinces. In terms of the average value of rural revitalisation development water, the average value of rural revitalisation development water is greater in the central region than in the eastern region, greater in the eastern region than in the western region, and greater in the western region than in the northeastern region. And there is a large development gap between regions, with the level of rural revitalisation development in the eastern region and the central region being higher than the national average, and the level of rural revitalisation development in the western region and the northeastern region being lower than the national average. From the point of view of the level of development of each province, the level of development of rural revitalisation is higher than the national average level for a total of 15 provinces, distributed in the western region, the central region, the eastern region, and the northeastern region, respectively—Shandong, Henan, Sichuan, Hebei, Jiangsu, Anhui, Hubei, Hunan, Yunnan, Guangxi, Heilongjiang, Xinjiang, Inner Mongolia, and Zhejiang (Table 4).

Table 4. Development level of rural revitalisation in 30 provinces in China, 2013-2020.

	Province	2013	2014	2015	2016	2017	2018	2019	2020	Average	Growth—Rate	Average Annual Increase in Percent
Eastern part	Beijing	0.0650	0.0700	0.0770	0.0790	0.0830	0.1040	0.0940	0.0940	0.0833	0.4462	0.0558
	Tianjing	0.0630	0.0700	0.0880	0.1210	0.1430	0.1680	0.1760	0.1740	0.1254	1.7619	0.2202
	Hebei	0.3420	0.3480	0.3480	0.3350	0.3290	0.4100	0.4210	0.4710	0.3755	0.3772	0.0471
	Shanghai	0.0660	0.0780	0.1110	0.1180	0.1190	0.1240	0.1130	0.1130	0.1053	0.7121	0.0890
	Jiangsu	0.2390	0.2550	0.2580	0.2690	0.2750	0.3640	0.3770	0.3860	0.3029	0.6151	0.0769
	Zhejing	0.1750	0.1790	0.1850	0.1880	0.1900	0.2620	0.2510	0.2850	0.2144	0.6286	0.0786
	Fujian	0.1090	0.1150	0.1170	0.1180	0.1170	0.1710	0.1650	0.1720	0.1355	0.5780	0.0722
	Shandong	0.4190	0.4330	0.4430	0.4290	0.4250	0.5230	0.5190	0.5570	0.4685	0.3294	0.0412
	Guangzhou	0.1220	0.1320	0.1370	0.1370	0.1360	0.2460	0.2560	0.2920	0.1823	1.3934	0.1742
	Hainan	0.0820	0.0860	0.0870	0.0900	0.0930	0.1170	0.1090	0.1100	0.0968	0.3415	0.0427
	Average value	0.1682	0.1766	0.1851	0.1884	0.1910	0.2489	0.2481	0.2654	0.2090	0.7183	0.0898
Central region	Shanxi	0.1610	0.1670	0.1660	0.1590	0.1480	0.2260	0.2180	0.2230	0.1835	0.3851	0.0481
	Anhui	0.1820	0.1910	0.1990	0.2040	0.2050	0.3440	0.3680	0.4070	0.2625	1.2363	0.1545
	Jiangxi	0.1470	0.1540	0.1530	0.1570	0.1600	0.2820	0.2770	0.2970	0.2034	1.0204	0.1276
	Henan	0.3290	0.3430	0.3550	0.3520	0.3460	0.4730	0.4780	0.5140	0.3988	0.5623	0.0703

Table 4. *Cont.*

	Province	2013	2014	2015	2016	2017	2018	2019	2020	Average	Growth—Rate	Average Annual Increase in Percent
Central region	Hubei	0.1990	0.2040	0.2100	0.2130	0.2140	0.3230	0.3220	0.3660	0.2564	0.8392	0.1049
	Hunan	0.2190	0.2310	0.2320	0.2210	0.2180	0.2920	0.2970	0.3210	0.2539	0.4658	0.0582
	Average value	0.2062	0.2150	0.2192	0.2177	0.2152	0.3233	0.3267	0.3547	0.2597	0.7515	0.0939
Western region	Neimengu	0.1620	0.1690	0.1740	0.1760	0.1860	0.2880	0.2880	0.3040	0.2184	0.8765	0.1096
	Guangxi	0.1770	0.1870	0.1910	0.1950	0.1920	0.2950	0.3050	0.3910	0.2416	1.2090	0.1511
	Chongqing	0.0870	0.0910	0.0960	0.1010	0.1000	0.1700	0.1590	0.1690	0.1216	0.9425	0.1178
	Sichuan	0.3150	0.3240	0.3490	0.3300	0.3270	0.4920	0.4930	0.5380	0.3960	0.7079	0.0885
	Guizhou	0.1080	0.1170	0.1220	0.1170	0.1180	0.2610	0.2510	0.2770	0.1714	1.5648	0.1956
	Yunnan	0.1650	0.1770	0.1810	0.1940	0.2020	0.3540	0.3520	0.3950	0.2525	1.3939	0.1742
	Shanxi	0.1480	0.1520	0.1500	0.1480	0.1450	0.2220	0.2230	0.2560	0.1805	0.7297	0.0912
	Gansu	0.1150	0.1220	0.1270	0.1240	0.1270	0.2340	0.2080	0.2250	0.1603	0.9565	0.1196
	Qinghai	0.0450	0.0510	0.0440	0.0460	0.0480	0.0880	0.0810	0.0880	0.0614	0.9556	0.1194
	Ningxia	0.0560	0.0590	0.0640	0.0690	0.0740	0.1210	0.1060	0.1120	0.0826	1.0000	0.1250
	Xinjiang	0.1580	0.1680	0.1730	0.1800	0.1840	0.3020	0.2980	0.3030	0.2208	0.9177	0.1147
	Average value	0.1396	0.1470	0.1519	0.1527	0.1548	0.2570	0.2513	0.2780	0.1915	1.0231	0.1279
Northeastern part of China	Liangning	0.1330	0.1350	0.1410	0.1410	0.1390	0.1970	0.1870	0.1950	0.1585	0.4662	0.0583
	Jilin	0.1300	0.1330	0.1370	0.1390	0.1420	0.1840	0.1820	0.1920	0.1549	0.4769	0.0596
	Heilongjiang	0.1820	0.1890	0.1950	0.2020	0.2180	0.2780	0.2650	0.2820	0.2264	0.5495	0.0687
	Average value	0.1483	0.1523	0.1577	0.1607	0.1663	0.2197	0.2113	0.2230	0.1799	0.4975	0.0622
Nationwide	Average value	0.1633	0.1710	0.1770	0.1784	0.1801	0.2638	0.2613	0.2836	0.2098	0.8146	0.1018

5.3. Analysis of the Results of the Baseline Model

In order to accurately estimate the overall effect of rural digital economic development on the level of rural revitalisation development, the core explanatory variables were first regressed. Meanwhile, the development level of rural revitalisation is affected by other factors, and appropriate control variables are selected for the F-test and Hausman test to choose the appropriate estimation model. Among them, the uncontrolled variables are the regression results of the level of rural digital economic development on the level of rural revitalisation development. Considering that the level of rural revitalisation development is affected by other factors, in order to more accurately reflect the effect of the level of rural digital economic development on the level of rural revitalisation development, the OLS estimation, FE estimation, and RE estimation in Table 5 are the results of the estimation of the mixed effect, individual fixed effect, and individual random effect models of the core explanatory variable rural digital economic development level on the level of rural revitalisation development after the introduction of the control variables (the level of economic development, the urbanisation rate, degree of openness to the outside world, population structure, and rural asset input), after the introduction of the core explanatory variables' rural digital economy development level on the development level of rural revitalisation of the mixed effects, individual fixed effects, and individual random effects model estimation results. By analysing the F-value test and Hausmann test, it can be seen that the two-way fixed effects model is the most appropriate. According to Equation (6), the overall effect of the level of rural digital economy development on the level of rural revitalisation development in 30 Chinese provinces (Tibet data are missing, so it is rounded off) from 2013 to 2020 has been measured by the two-way fixed effects model (Table 5).

Therefore, the FE estimates are more accurate and the conclusions drawn from each estimate are more consistent: the level of rural digital economy development in each province has a significant positive impact on the level of rural revitalisation development from 2013 to 2020. Estimates without control variables are shown to show that for every 1 percentage point increase in the level of rural digital economy development, the level of rural revitalisation development increases by 0.6394. The estimation results after adding the control variables show that for every 1 percentage point increase in the level of rural digital economy development, the level of rural revitalisation development increases by 0.1938. The role of the level of rural digital economy development in increasing the level of rural revitalisation development has decreased, but still has a significant positive impact.

The estimation results obtained by introducing control variables are more consistent in the direction of the impact of the level of rural digital economy development on the level of rural revitalisation development, i.e., in line with theoretical expectations. Among them, the level of economic development has a significant positive impact on the level of rural revitalisation development, and an increase in the level of economic development will increase the level of rural revitalisation development with an elasticity of 0.9805, i.e., for every 1 percentage point increase in the level of economic development, the level of rural revitalisation development will increase by 0.9805.

Table 5. Estimated results of the impact of the rural digital economy on rural entrepreneurial activity.

	(1) No Control Variables	(2) OLS Estimates	(3) FE Estimate	(4) RE Estimates
Level of rural digital economy development	0.6394 *** (0.0344)	0.4783 *** (0.0963)	0.1938 ** (0.0946)	0.4936 *** (0.0948)
Level of economic development	—	0.1452 (0.5487)	0.9805 *** (0.3460)	0.1265 (0.4231)
Urbanisation rate	—	0.0897 (0.1540)	0.5361 *** (0.1875)	−0.0291 (0.1263)
Degree of openness to the outside world	—	−0.1196 ** (0.0445)	0.0978 ** (0.0479)	-0.0330 (0.04279)
Population structure	—	0.2255 (0.1878)	0.2640 *** (1.1070)	0.3751 *** (0.1428)
Rural asset inputs	—	0.0219 *** (0.0053)	0.0026 (0.0050)	0.0101 *** (0.0031)
Constant term (math.)	1.0555 (1.0960)	−8.6598 (6.1873)	−31.5716 *** (9.3720)	−2.9869 (5.2590)
R^2 within group	0.4999	0.6984	0.0228	0.6516
F-value	345.0700	36.2200	71.0800	—
Sample size	240.0000	240.0000	240.0000	240.0000
F-test	—	—	22.5400	—
p-value	—	—	0.0000	—
Hausman	—	—	—	29.2120
p-value	—	—	—	0.0001

Note: ① *, **, *** indicate 10%, 5%, and 1% significance levels, respectively; ② Figures in parentheses are ordinary standard errors at provincial level.

The urbanisation rate has a significant positive effect on the level of rural revitalisation development, and an increase in the urbanisation rate increases the level of rural revitalisation development with an elasticity of 0.5361, i.e., for every 1 percentage point increase in the urbanisation rate, the level of rural revitalisation development increases by 0.5361.

The degree of openness to the outside world has a significant positive effect on the development level of rural revitalisation; an increase in the degree of openness to the outside world will increase the development level of rural revitalisation, and the elasticity is 0.0978, i.e., for every 1 percentage point increase in the degree of openness to the outside world, the level of rural revitalisation and development will increase by 0.0978.

Population structure has a significant positive effect on the level of rural revitalisation development, and an increase in population structure increases the level of rural revitalisation development with an elasticity of 0.2640, i.e., for every 1 percentage point increase in population structure, the level of rural revitalisation development increases by 0.2640.

Rural asset inputs have a positive effect on the level of rural revitalisation development, and an increase in rural asset inputs increases the level of rural revitalisation development

with an elasticity of 0.0026, i.e., for every 1 percentage point increase in rural asset inputs, the level of rural revitalisation development increases by 0.0026.

5.4. Endogeneity Test

When measuring the impact of the level of rural digital economy development on the level of rural revitalisation development, it may be affected by endogeneity, which includes two main factors: two-way causality and omitted variable bias. Bidirectional causation means that the level of rural digital economy development and the level of rural revitalisation development are causal to each other; the development of the rural digital economy promotes the level of rural revitalisation development, and at the same time, improvement in the level of rural revitalisation development drives the development of the rural digital economy, which in this context leads to the level of development of the rural digital economy related to the error term and the occurrence of the endogenous problem. Therefore, to address the potential two-way causation problem, this paper measures the level of rural digital economy development in the lagged period of the rural revitalisation development level by using a panel Granger causality test method [57], where the independent variable is treated as the dependent variable (Table 6). It can be found through the measurement results that there is no bidirectional causality between the level of rural digital economy development and the level of rural revitalisation development, and there is no endogeneity of the selected variables, thus verifying that the regression results in Table 5 are reliable.

Table 6. Estimated results of the impact of the rural digital economy on rural entrepreneurial activity.

Lag One Phase		Lag Two Phase	
SZSP1	0.2950	SZSP1	0.3320
		SZSP2	0.4610

Note: SZSP1 and SZSP2 are the lagging phases 1 and 2 of the level of development of the rural digital economy, respectively.

Omitted variable bias refers to the omission of certain explanatory variables from the model's setup process that affect the measurements. In this study to analyse the impact of rural digital economic development on the development level of rural revitalisation, five control variables, such as the level of economic development, the urbanisation rate, the degree of openness to the outside world, the demographic structure, and the input of rural assets, were chosen to avoid the problem of omitted variables as much as possible, but there may still be the defect of omitted variable bias that leads to biased estimation results. Therefore, to address the potential omitted variable bias problem, this paper measured the impact of rural digital economy development on the development level of rural revitalisation through a dynamic panel model (the systematic GMM method) [58] by adding the lagged value of the dependent variable, i.e., the previous year's value of the rural revitalisation development level, to the regression as the independent variable (Table 6). The results of the measurement show that the results of the regression model remain robust, and the impact of the level of rural digital economy development on the level of rural revitalisation development is significant at the 1% level (Table 7).

Table 7. Estimation results of system GMM model.

Variable Name	System GMM
The level of development of rural revitalisation is lagging behind phase I	0.6323 *** (0.0812)
Level of rural digital economy development	0.3349 *** (0.0999)
Level of economic developmevariable nament	−0.7210 ** (0.3405)
Urbanisation rate	0.1614 (0.1791)
Degree of openness to the outside world	0.0028 (0.0460)
Population structure	0.1213 (0.1166)
Rural asset inputs	0.0118 * (0.0067)
AR (1)	0.0000
AR (2)	0.1150
Hansen test of overid	0.4280

Note: ① *, **, and *** denote 10%, 5%, and 1% significance levels, respectively; ② Figures in parentheses are ordinary standard errors at provincial level.

5.5. Robustness Check

Robustness tests are carried out to prevent the influence of extreme values on the estimation results, which can be achieved by shrinking the continuous variables by 1 per cent, followed by the addition of other control variables that can affect the causality studied due to the possibility that important factors may have been overlooked in the analysis. On this basis, variables such as industrial structure, rural infrastructure, and financial support for agriculture were added to test the impact of the level of rural digital economy development on rural entrepreneurial activity (Table 8). As can be seen in Table 8, the level of rural digital economy development still has a significant positive impact on rural entrepreneurial activity, validating the robustness of the results.

Table 8. Robustness test results.

Variable Name	Model (1) 1 Per Cent Shrinkage Treatment	Model (2) Addition of Control Variables
Level of rural digital economy development	0.1779 * (0.0954)	0.2027 ** (0.0962)
Level of economic development	0.9915 *** (0.3505)	0.9592 ** (0.3715)
Urbanisation rate	0.5510 *** (0.1922)	0.5282 *** (0.0198)
Degree of openness to the outside world	0.0981 * (0.0499)	0.1030 ** (0.0507)
Population structure	0.2752 *** (0.0928)	0.2675 *** (0.0955)
Rural asset inputs	0.0025 (0.0049)	0.0024 (0.0050)
Industrial structure	—	0.0121 (0.0665)
Rural infrastructure	—	−0.0204 (0.0411)
Financial support for agriculture	—	0.7470 (2.3263)
constant term (math.)	−32.2456 *** (9.5685)	−30.8359 *** (11.0952)
sample size	240.0000	240.0000
p-value	0.0000	0.0000
R^2	0.0272	0.0351

Note: ① *, **, and *** denote 10%, 5%, and 1% significance levels, respectively; ② Figures in parentheses are ordinary standard errors at provincial level.

6. Discussion

This study analyses the impact of rural digital economy development on rural revitalisation based on data from 30 provinces in China from 2013–2020. Firstly, the development level, development speed, and regional differences of the rural digital economy and rural revitalisation in China's provinces from 2013 to 2020 are examined. Second, two-way fixed effects were used to validate the impact effects. Finally, the results are examined and similar conclusions are drawn using a panel Granger causality test, dealing with the endogeneity problem method by applying a 1 per cent deflator to the continuous variables and adding other control variables.

Although relevant studies have confirmed that digital applications have contributed to rural revitalisation in one dimension, such as the digital economy empowering rural industries (Zhao et al., (2024) [59]), enhancing agricultural productivity (Fang et al., (2024) [60]) and the common prosperity of farmers (Mossberger (2022) [61]), empowering rural governance (Miao et al., (2024) [62]), and other dimensions of rural revitalisation, the research on the logic and mechanism of the digital economy has been fragmented and needs to be

deepened in a holistic and comprehensive way. The possible marginal contributions of this paper are mainly reflected in three aspects. First of all, compared with the existing literature that explores the application of the digital economy in rural revitalisation in the fields of agricultural production, industrial integration, rural governance, and other areas and its economic effects in a more fragmented manner, this paper assesses the economic effects of the overall architecture of rural revitalisation based on rural digital development, which is an improvement in the systematicity and comprehensiveness of the study. Secondly, it argues the mechanism of the rural digital economy's impact on rural revitalisation, using digital elements, digital products and services, and digital thinking to achieve industrial digitalisation, intelligent intensification, and greening; farmers are educated, good at business, have new skills, and live a good life; rural governance is modernised, allowing people to live intelligently and technologically and to promote industrial revitalisation, ecological revitalisation, talent revitalisation, cultural revitalisation, and organisational revitalisation, and ultimately to achieve revitalisation of the countryside. Finally, it analyses the variability in the level of development of the rural digital economy and rural revitalisation in various regions of China, making a useful addition to the implementation of targeted development recommendations. This is in line with the studies of Meng et al., (2023) [63] and He et al., (2022) [64]. Our findings also focus on analysing regional differences in the level of digital economy development and the level of rural revitalisation development in various regions of China, which to a certain extent supports the viewpoints mentioned in the study by Liu et al., (2023) [65]. Studies have also shown that the level of economic development, urbanisation rate, openness to the outside world, demographics, and rural asset inputs can all contribute to the development of rural revitalisation, which is similar to the findings of Yang et al., (2023) [66], Fung et al., (2024) [67], Liu et al., (2022) [68], Millard (2022) [69], and others.

7. Conclusions and Suggestion

7.1. Conclusions

Using panel data from 30 provinces in China from 2013 to 2020, this paper empirically analyses the rural digital economy through the perspective of its impact on the development level of rural revitalisation and establishes a number of models, including a two-way fixed effects model and a dynamic panel model. These models were used to empirically test the effectiveness and mechanisms of the rural digital economy on the level of development of rural revitalisation, and the main findings can be summarised as follows. Firstly, the research hypothesis was verified that the level of rural digital economy development in Chinese provinces has a significant positive impact on the level of rural revitalisation development. Estimates without control variables are shown to show that for every 1 percentage point increase in the level of rural digital economy development, the level of rural revitalisation development increases by 0.6394. According to the panel Granger causality test method, there is no bidirectional causality between the level of rural digital economy development and the level of rural revitalisation development, and there is no endogeneity of the selected variables. Meanwhile, through the dynamic panel model, the results of the regression model remain robust, and the impact of the level of rural digital economy development on the level of rural revitalisation development is significant at the 1% level. The robustness of the results is verified by the stability test, which shows that the level of rural digital economy development still has a significant positive impact on rural entrepreneurial activity. The results of Zhang's (2024) [70] study are consistent with our findings that the digital economy has become an important driving force for rural revitalisation. Secondly, China's rural digital economy development shows a good development trend, with an increase of 0.7874 and an average annual increase of 9.84 per cent. However, there is a gap between the level of rural digital economy development in various regions and provinces; in terms of the average value of rural digital economy development water, the eastern region (0.3378) > central region (0.3152) > western region (0.2954) > northeastern region (0.2793); there is a large gap in the development

of inter-regional development, which is in line with the study of Wang et al., (2024) [71]. Thirdly, the level of development of rural revitalisation in China has shown an overall stable, steady, and improving trend, with an increase of 0.8146 and an average annual increase of 10.18 per cent, while at the same time, there are gaps between the level of rural revitalisation development in various regions and provinces. In terms of the average value of rural revitalisation development water, the central region (0.2597) > the eastern region (0.2090) > the western region (0.1915) > the northeastern region (0.1799), and there is a large inter-regional development gap, which is in line with the study by Liu et al., (2023) [72]. Fourthly, an increase in the level of economic development will increase the level of rural revitalisation, and the elasticity is 0.9805. An increase in the urbanisation rate will increase the level of rural revitalisation, and the elasticity is 0.5361. An increase in the degree of openness to the outside world will increase the level of rural revitalisation, and the elasticity is 0.0978. An increase in the demographic structure will increase the level of rural revitalisation, and the elasticity is 0.2640. An increase in the investment in rural assets will increase the level of rural revitalisation, and the elasticity is 0.2640. An increase in asset investment will increase the level of rural revitalisation development, and the elasticity is 0.2640, which is consistent with the study of Wang (2024) [73].

7.2. Suggestions

The development of rural digital industrialisation plays an important role in promoting rural industrial prosperity, ecological livability, civilised rural culture, effective governance, and affluent living, thus having a positive impact on the development of rural revitalisation. To this end, this paper makes the following recommendations based on the findings of the study. Firstly, it is necessary to formulate a development strategy for targeted rural revitalisation in the light of the actual characteristics of each region in China, and to build a rational and orderly spatial pattern for rural revitalisation. Emphasis will be placed on upgrading the level of development of rural revitalisation in the western and northeastern regions, resolving key contradictions in inter-regional disparities, and promoting the coordinated advancement of rural revitalisation throughout the country as a whole. Secondly, in the process of developing the rural digital economy, it is necessary not only to do a good job of top-level design and plan the development of the rural digital economy by integrating it into the overall situation of the coordinated development of the country's regions, but also to take into account the level of economic development of each region, the structure of the development of the rural industry, and the ability to guarantee technology and human resources. Thirdly, to build a rural digital infrastructure and promote the construction of digital villages. In particular, the construction of big data infrastructure in the countryside, the formation of a big data centre for the development of rural industries at the national level, and the collection, collation, and analysis of all kinds of rural industries and their products in the whole area of data and information. Fourth, taking into account the actual development of each region in China, we will guide the layout of rural industries in accordance with local conditions, so as to further give full play to the positive role played by rural figures in the level of rural economic development. The central and western regions, as well as the northeastern region, should accelerate the development of the digital economy to reduce the negative impact of the low level of digital economic development on rural revitalisation. Rural economic development has an important role to play in promoting rural revitalisation, and increasing rural inputs, while maintaining economic development, has given impetus to rural revitalisation. Fifthly, cultivate a rural digital talent team and give play to the important role of human capital. In the process of the integration of digital economy-related industries and traditional industries, villages should conduct a scientific evaluation of the development of digital industries, increase the introduction of high-end talents and advanced technologies, and cultivate a group of composite talents who understand both traditional business and digital technology, so as to promote the vigorous development of the rural digital economy. Sixthly, it is necessary to deepen the reform of the household registration system and raise the urbanisation rate

of the household population. At the same time, it is necessary to improve the institutional mechanism for the integrated development of urban and rural areas and to narrow the development gap between urban and rural areas. It is necessary to accelerate the extension of basic public services to the countryside, accelerate the unified planning and construction of urban and rural infrastructure, and promote a greater flow of industrial capital and other types of factors to the countryside. Seventh, China's agriculture and rural areas should take advantage of the domestic mega-market, attract global agricultural resource elements with a large domestic cycle, make full use of the two domestic and international markets and two kinds of resources, and further improve the level of opening up of agriculture and rural areas to the outside world.

7.3. Limitations and Further Research

In terms of research themes, studies have confirmed from a macro perspective that the digital economy can be a driving force for rural revitalisation, but issues such as how the dimensions of the digital economy play a role in the different stages of the evolution of the digital countryside are yet to be explored, and there is a lack of research on the spatial effects of the digital economy and rural revitalisation. Future research may go down various avenues of exploration. This trajectory is supported by the scholarly contribution of Su et al., (2024) [74] and has been recently elaborated in that study.

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