The Impact of Digital Economy on Rural Revitalization —— Based on the Perspective of Agricultural Green Total Factor Productivity

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Abstract. The digital economy, a new source of economic growth, has added new vitality to rural revitalization. Based on the rural revitalization index and the digital economy development index calculated from panel data of 30 provinces in China from 2005 to 2021, the driving force, mechanism, and heterogeneity of the digital economy with regard to rural revitalization are all empirically tested in this paper. A number of robustness tests support the research's conclusion that the digital economy significantly stimulates rural revitalization; productivity of the agricultural green total factor serves as an indirect conduit for the digital economy's support of rural development. Further research found that compared with the eastern region, the digital economic dividend enjoyed by rural development in the central and western regions is more significant; Considering the decomposition of rural revitalization, the digital economy has the strongest effect on life prosperity.

Keywords: digital economy, rural revitalization, agricultural green total factor productivity, indirect channels, high-quality economic development

1 Introduction

Following the agricultural and industrial economies, the digital economy emerges as a new form of economy. It centers on data resources, leveraging modern information networks as its main infrastructure. In the past few years, a range of technological developments have occurred at a rapid pace, including the advent of the Internet, big data, cloud computing, blockchain, and artificial intelligence. The digital economy has become deeply integrated with numerous economic and social sectors, all of which depend on the ongoing progress of digital technologies. This integration has facilitated more efficient production processes, improved service delivery, and enhanced connectivity across various industries. The digital economy serves as a powerful engine for promoting high-quality economic development, playing an increasingly important role in enhancing consumption, fostering innovation, increasing employment, boosting investment, and adjusting industrial structures. As a result, it is becoming a crucial factor in reallocating resources and improving economic structures globally, driving sustainable growth and development in the modern era.

In the part about high-quality development in the Party's Report to the 20th CPC National Congress, the need to speed up the construction of a digital China and comprehensively promote rural revitalization was mentioned. Building a digital China, realizing rural

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revitalization and promoting green development are all the inherent requirements and paths for high-quality development. Since GTFP is a crucial metric for assessing green development, clarifying the interplay between the digital economy, rural revitalization, and GTFP is essential for fostering high-quality economic growth. This understanding aids in advancing economic development in a sustainable and efficient manner. Currently, research on rural revitalization is primarily concerned with the pathways of rural regeneration[1] and the evaluation of rural revitalization effect[2]. Research in the digital economy primarily encompasses the measurement of the digital economy[3], its effects on economic growth[4][6], optimization of industrial structures[5], and international trade[6]. Previous research has examined the impact of the digital economy on GTFP[7]. Nevertheless, the research on the influence mechanism of the digital economy on rural revitalization is limited, with a paucity of empirical studies examining this phenomenon. Furthermore, there is even less research examining the role of GTFP in this process. This paper employs provincial panel data from China from 2005 to 2021 to conduct an extensive analysis of the impact of the digital economy on rural revitalization. The objective is to provide decision-makers with a reference framework and recommendations for rural revitalization, thereby facilitating high-quality economic growth.

The following might be used to summarize this paper's possible impact on the field of study: First of all, the index of the digital economy and rural revitalization is computed using the entropy methodology, which supplements and perfects the existing index system for rural revitalization and the digital economy; Second, the study investigates the influence of the digital economy on the components of the rural revitalization index, identifying specific pathways through which the digital economy fosters rural revitalization; Third, GTFP is brought into the mechanism analysis of the digital economy to promote rural regeneration, and it is proposed that GTFP is an indirect channel for digital economy to promote rural revitalization.

2 Text formatting

In his report to the 19th National Congress of the Communist Party of China, which convened on October 18, 2017, General Secretary Xi Jinping first proposed the strategy of rural revitalization. According to the strategic goal of the national "Thirteenth Five-Year Plan", 2020 is the decisive year for all the rural poor to get rid of poverty and build a well-off society in an all-round way. A new phase of rural revitalization has begun for rural development after 2020[8]. The concept of rural revitalization is predicated upon the eradication of absolute poverty within rural communities, but the relative poverty caused by it has become a significant obstacle to the effective implementation of rural revitalization initiatives[9]. In addition, China's rural development is also facing serious pollution, population hollowing out and low agricultural productivity. Rural revitalization is essentially a special stage of rural transformation and development, and it is a strategic choice to solve the outstanding problems faced by rural development after it has evolved to a certain stage[10]. Simultaneously, China's rapidly developing digital economy is becoming an important engine to drive all-round and high-quality economic and social development[11]. Empowering rural construction with digital economy is an important strategic direction for rural revitalization. Existing research generally believes that digital economy can empower rural revitalization. The digital economy

is primarily driven by three key factors: the transformation of agricultural production methods, the assurance of farmers' livelihoods, and the enhancement of rural government services, so as to improve the digital level of agriculture, meet the needs of farmers' material and spiritual development, enhance the efficiency of rural governance, and promote the comprehensive revitalization of rural areas by building a rich, livable and beautiful modern digital village[1]. Meng et al. demonstrated that the digital economy can affect rural revitalization by enhancing the capacity for scientific innovation, consumption upgrading and rural entrepreneurship[12]. Wang and Zhang believe that rural digital economy can revitalize rural areas from three aspects: rural industrial development and structural upgrading, increasing farmers' income and optimizing consumption structure, and coordinated development between urban and rural areas[13]. GTFP is based on the traditional productivity, which includes the factors such as resource consumption and pollution emission in the agricultural production process into the category of agricultural economic growth. It assesses the actual efficiency of production, taking account of the cost of resources and the impact on the environment, thereby providing a comprehensive measure of the competitive position of regional agriculture. Currently, the research on GTFP mainly includes the calculation of GTFP and the factors affecting it. A portion of the research examines the relationship between the digital economy and GTFP, analyzing how digital technologies can enhance GTFP by improving resource efficiency, reducing emissions, and fostering sustainable agricultural practices.

To sum up, there have been rich researches on digital economy and rural revitalization in academic circles, which provides useful reference for this paper. However, the existing literature on the impact mechanism of digital economy on rural revitalization is not extensive, and even less research has included GTFP. What effect does the development of digital economy have on rural revitalization? What role does agricultural green total factor productivity play in it? Need to combine empirical data for further verification.

3 Research hypothesis

3.1 The direct impact of the digital economy on rural revitalization

Digital economy contributes to the prosperity of rural industries. Digital economy can be integrated with modern agriculture, rural tourism and other industries to promote agricultural digitalization. This integration can simultaneously give rise to new industries and formats, thereby continuously optimizing the rural economic structure. Digital economy can also improve workers' skills, increase non-agricultural employment opportunities and make the rural employment structure more reasonable. In the digital economy, the Internet serves as a conduit for the dissemination of information. It can narrow information gaps between rural market players, facilitate information exchange, and extend industrial supply chains. One could argue that ecological livability can be achieved more easily with the help of the digital economy. Digital economy can promote green agricultural production, improve the supervision and management system of rural pollutant discharge, improve the recycling rate of rural biomass waste and agricultural waste, and help the construction of rural ecological civilization. The digital economy contributes to the realization of rural civilization. In addition to traditional education, rural residents can acquire knowledge and broaden their horizons through the Internet. Digital communication also allows for the advancement of modern deeds

and the spirit of the times to seep into the hearts of rural residents, fostering the development of rural civilization. The digital economy makes effective governance possible. Through the establishment of a rural government cloud platform supported by digital technology, information such as rural land ownership, commercial production and operation can be integrated into high-value data that is easy to analyze, use and transform, thus improving the efficiency of government services such as administrative examination and approval, making data run more and people run less errands, and providing strong government support for agricultural and rural modernization. The digital economy is conducive to achieving prosperity in life. While the digital economy does away with the physical barrier between urban and rural areas, giving rural businesses access to a wider market, it also optimizes the rural economic structure and creates more employment opportunities. This, in turn, enables farmers to achieve greater levels of prosperity. The analysis presented above allows us to conclude that the digital economy has a significant impact on rural revitalisation.**H1: The digital economy has the potential to enhance the process of rural revitalization.**

3.2 The impact of digital economy on rural revitalization mechanism

The way that the digital economy influences rural revitalization is depicted in Figure 1. In China's rural areas, during a long period of time, there is a problem of insufficient motivation for green transformation and difficult sustainable development. It is imperative for rural areas to transform into a sustainable development model oriented to ecological priority and green development. GTFP can be raised by the digital economy through advancements in technology and increased technical efficiency. Through rural digital construction, agriculture-related enterprises can accurately grasp all aspects of agricultural production, improve the efficiency of agricultural machinery, enhance the efficiency of pesticide and fertilizer application, and lower greenhouse gas emissions and energy resource consumption. The improvement of digital infrastructure in rural areas has enabled the bidirectional transmission of agricultural data: the data of all agricultural production links is transmitted to enterprises and scientific research institutions more quickly, and the relevance of research and development in agricultural science and technology is increased. New agricultural sciences and technologies can also reach farmers more quickly and be applied in production. The advancement of human society will inevitably require the use of green technology that is both efficient and low-carbon, and the growth of the digital economy has encouraged the enhancement of GTFP. Green development is the driving force and inevitable requirement of rural regeneration. The combination of digital economy and GTFP can provide essential support for rural revitalization.**H2: One indirect way that the digital economy supports rural revitalization is through agricultural green total factor productivity.**

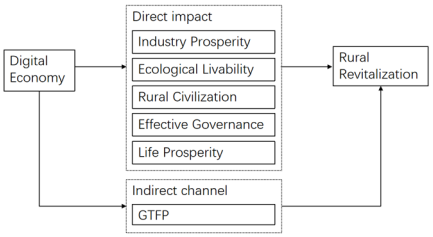

Fig.1. A theoretical framework that explains how the digital economy affects rural revitalization

4 Research design

4.1 Model setting

Firstly, OLS regression model is used to analyze the influence of Dige on Rural. The model is represented by the following equation:

$$Rural_{it} = \beta_0 + \beta_1 Dige_{it} + \beta_2 Control_{it} + \mu_i + \theta_t + \varepsilon_{it} \quad (1)$$

$Rural_{it}$represents the rural revitalization index, $Dige_{it}$ is a measure of the level of digital economy, Z_{it} is the control variable, μ_i is a province virtual variable, θ_t is a year virtual variable and ε_{it} is a random disturbance term.

To examine the mechanism of digital economy driving rural revitalization, this article examines the interaction between digital economy and GTFP and puts forward Equation (2):

$$Rural_{it} = \gamma_0 + \gamma_1 Dige_{it} * GTFP_{it} + \gamma_2 Control_{it} + \mu_i + \theta_t + \varepsilon_{it} \quad (2)$$

4.2 Data sources and variable selection

1) Explained variable: Rural Revitalization (Rural). The report from the 19th National Congress outlined five key requirements for rural revitalization: prosperous industry, livable ecology, civilized rural customs, effective governance and affluent life. In this paper, the entropy method is used to measure the Rural Revitalization Index. Table 1 lists all the primary and secondary indicators in the rural revitalization index system and their weights.

Industrial prosperity is the cornerstone. The development of modern agriculture is the most important content of industrial prosperity. The key point is to enhance the level of advanced varieties, mechanization, scientific and technological advancement, informational technology, standardization, institutionalization and organization through innovation in products, technology, systems, organization and management, thereby driving transformation and upgrading of the agriculture, forestry, animal husbandry, fishery and agricultural product processing industries.

Ecological livability is a crucial foundation for enhancing the quality of rural development. This concept encompasses the cleanliness of villages and the improvement of essential infrastructure such as water, electricity, and roads. It emphasizes the preservation of local character and rural features, the protection of rural ecosystems, the control of environmental pollution, and the achievement of harmonious coexistence between humans and nature. By focusing on these aspects, the goal is to create a more beautiful living environment for rural residents.

Rural civilization is the soul. The construction of rural civilization includes not only promoting the development of rural culture, education, medical care and health care, but also improving rural basic public services; It also includes vigorously carrying forward the socialist core values, inheriting the fine rural customs such as obeying rules and regulations, respecting the old and caring for the young, helping neighbors, being honest and trustworthy, and striving to realize the combination of rural traditional culture and modern civilization.

Effective governance is the core. An effective rural governance system should be a system of social coordination, public participation and legal protection guided by party committees and governments. It is imperative to establish a harmonious relationship between the party and the masses, effectively align the interests of farmers and the collective, balancing short-term and long-term interests, and ensuring that rural society is vibrant, harmonious, and orderly.

Living well is the goal. In evaluating the efficacy of rural revitalization strategies, it is crucial to assess their impact on the living standards of farmers. The expansion of rural per capita disposable income, the decrease in the Engel's coefficient and the narrowing of the gap between urban and rural residents are indicative of the process of economic development. These factors contribute to the broad masses of peasants and the people of the whole country entering a well-off society in a comprehensive manner, enabling them to make sustained progress towards the goal of common prosperity.

Table 1. A system for the assessment of rural revitalization initiatives.

Primary index	Secondary index	Indicator attribute	weight
Industrial prosperity	GDP	+	0.08384
	The index of the production price of agricultural products	+	0.01388
	The aggregate value of agricultural, forestry, animal husbandry, and fishery outputs	+	0.06523
	The aggregate power capacity of all agricultural machinery	+	0.07458
	Grain yield per unit area	+	0.02388
	Per capita grain output	+	0.05741
Ecological livability	Application intensity of agricultural chemical fertilizer	-	0.01053
	Pesticide application intensity	-	0.00480
	Utilization of livestock manure	+	0.03671
	Rural greening rate	+	0.03577
	Proportion of administrative villages that treat domestic waste	+	0.03669
	Sanitary toilet penetration rate	+	0.03672
Rural civilization	Average length of education of rural residents	+	0.03685
	Proportion of the education, culture, and entertainment resources available to rural residents	+	0.03654
	Proportion of administrative villages that open Internet broadband services	+	0.03725
	Number of rural cultural stations	+	0.04226
Effective governance	Proportion of administrative villages that have prepared village planning	+	0.03609
	Proportion of administrative villages that have implemented village renovation projects	+	0.03698
	Number of units of villagers' committees	+	0.07761
	The average amount spent by rural residents on consumer goods per person	+	0.04996
	Per capita disposable income of rural residents	+	0.05335

Life Prosperity	Average number of color TV sets owned by rural residents per 100 households	+	0.01492
	Rural farmers' investment in fixed assets and building houses	+	0.06156
	Engel coefficient of rural residents	-	0.03659

2) The core explanatory variable: Digital Economy (Dige). Drawing on the definition of the digital economy and the available data, this paper references the academic contributions of Liu et al. (2020)[3] and Zhang et al. (2023)[14], as well as the digital economy development report. To measure the Digital Economy Index (Dige), this study selects several indicators: mobile phone penetration rate, length of long-distance optical cable lines, Internet penetration rate, number of mobile Internet users, express delivery volume, number of web pages, percentage of enterprises engaged in e-commerce transactions, and software business activity. Additionally, other relevant metrics such as digital payment usage and number of broadband access ports are also considered. The entropy method is utilized to calculate Dige, ensuring a comprehensive and accurate assessment of the digital economy's development level in this paper.

3) Agricultural Green Total Factor Productivity (GTFP). Based on the relevant research of Oh (2010)[15] and Hou et al. (2018)[16], this paper establishes the index system of GTFP as shown in Table 2,and the level of GTFP was calculated by super-efficient SBM model.

Table 2. Evaluation index system of GTFP

Indicator type	Indicator name	Indicator description
Input index	capital input	Investment in fixed assets of the whole agricultural society
	Labor input	The number of employees engaged in agricultural activities
	Land resource input	Sowing area of crops
	Irrigation input	Effective irrigation area
	Pesticide input	Pesticide application
	Fertilizer input	Fertilizer application
	Investment in agricultural films	Usage of agricultural film
	Agricultural machinery input	The aggregate power of agricultural machinery
	Agricultural diesel input	Consumption of agricultural diesel oil
Expected output	Total agricultural output value	Total agricultural output value
Unexpected output	Carbon emissions from agriculture	Agricultural carbon emissions

The SBM model is represented in equation (3):

$$Min\rho = \frac{\frac{1}{m}\sum_{i=1}^{m}(\bar{x}/x_{ik})}{\frac{1}{r_1+r_2}\left(\sum_{s=1}^{r_1}\overline{y^d}/y_{sk}^d + \sum_{q=1}^{r_2}\overline{y^u}/y_{qk}^u\right)}$$

$$\begin{cases} \bar{x} \geq \sum_{j=1,\neq k}^{n} x_{ij}\lambda_j; \overline{y^d} \leq \sum_{j=1,\neq k}^{n} y_{sj}^d\lambda_j; \overline{y^d} \geq \sum_{j=1,\neq k}^{n} y_{qj}^d\lambda_j; \bar{x} \geq x_k; \overline{y^d} \leq y_k^d; \overline{y^u} \geq y_k^u; \\ \lambda_j \geq 0, i = 1,2,\cdots,m; j = 1,2,\cdots,n, j \neq 0; s = 1,2,\cdots,r_1; q = 1,2,\cdots,r_2; \end{cases} \quad (3)$$

4. Control variables. Besides the level of regional digital economy and GTFP, this paper controls other factors that may affect rural regeneration. Urbanization level (urban), which is depicted as the ratio of the population of the whole city to the administrative land area. Transportation (Road) is measured by road mileage. The level of human resources (edu) is measured by the proportion of undergraduate students in the total population. The number of domestic patent applications is used to measure technology level(lg_tec). The degree of local openness to foreign countries is expressed as the logarithmic sum of imports and exports. Government expenditure (lg_govern) is measured by local fiscal expenditure after logarithm.

The sample for this study is derived from a panel data set covering 30 provinces in China from 2005 to 2021. The primary data sources include the sectoral annual data sections of the China Rural Statistical Yearbook, the China Tertiary Industry Statistical Yearbook, and the China Digital Economy Development Report. The indicators for digital inclusive finance development are sourced from the Digital Finance Research Center at Peking University. This study addresses the samples through the following procedures. First, provinces with significant data gaps were excluded. Second, a linear interpolation method was used to fill in the missing data, and the cumulative probability distribution method was employed to handle relevant outliers. Finally, the descriptive statistics of all variables are presented in Table 3.

5 Empirical result analysis

5.1 Descriptive statistics of variables

Table 3 depicts the average value of Rural in China's provinces over the 2005-2021 period. The maximum value of 0.565 was attained in 2007. The minimum value, 0.0506, was observed in 2006. The standard deviation was 0.107, indicating a considerable variation in the Rural Index among different provinces. In the same period, from the standard deviation and average value of Dige and GTFP in different provinces in China, we can also find that there is also an obvious gap between the development of the two in different provinces. This regional difference is also reflected in the control variables.

Table 3. Descriptive statistics

variables	N	mean	sd	min	max
Dige	510	0.117	0.083	0.023	0.737
Rural	510	0.281	0.107	0.051	0.565
GTFP	510	1.054	0.479	0.329	6.521
urban	510	0.556	0.140	0.269	0.938
road	510	13.890	7.833	0.810	39.890
edu	510	0.019	0.006	0.006	0.043
lg_tec	510	4.160	0.734	1.898	5.941
lg_govern	510	3.452	0.386	2.180	4.261
lg_fdi	510	7.549	0.727	5.522	9.107

5.2 The benchmark regression results

Table 4. Benchmark Regression Results

variable	（1）	（2）	（3）	（4）	（5）	（6）	（7）
Dige	0.825***	0.781***	0.484***	0.535***	0.301***	0.160***	0.175***
	(18.882)	(15.996)	(8.965)	(9.606)	(5.323)	(2.932)	(3.220)
urban		0.057**	0.235***	0.122***	-0.103**	-0.209***	-0.251***
		(1.965)	(7.331)	(2.591)	(-2.102)	(-4.464)	(-5.162)
road			0.005***	0.005***	-0.001	-0.001**	-0.001**
			(9.878)	(8.314)	(-1.000)	(-1.992)	(-1.986)
edu				2.663***	1.888**	1.108	1.665**
				(3.269)	(2.510)	(1.583)	(2.311)
lg_govern					0.175***	0.070***	0.083***
					(9.746)	(3.499)	(4.067)
lg_tec						0.093***	0.066***
						(9.305)	(4.877)
lg_fdi							0.026***
							(2.929)
Constant	0.184***	0.158***	0.019	0.035*	-0.325***	-0.250***	-0.364***
	(29.392)	(10.576)	(0.954)	(1.731)	(-7.884)	(-6.421)	(-6.640)
Observations	510	510	510	510	510	510	510
R-squared	0.412	0.417	0.511	0.521	0.597	0.656	0.662
r2_a	0.411	0.415	0.508	0.517	0.593	0.652	0.657
F	356.532	181.201	176.332	137.454	149.423	160.097	140.524

t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

As shown in Table 4, Column (1) investigates the influence of digital economy on rural revitalization without considering control variables. The results reveal a statistically significant correlation between the digital economy and rural revitalization, indicated by a regression coefficient of 0.825 and a confidence level of 1%. This evidence supports the assertion that the digital economy can act as a driving power for rural revitalization and thus corroborates the hypothesis H1. In Columns (2) to (7), a set of control variables is introduced in stages to the regression equation. The results remain significant. According to the result in Column (7) of Table 4, the estimation coefficient of digital economy is 0.175, which is smaller than 0.825 in Column (1). This indicates that analyzing the effect of digital economy on rural revitalization might be overestimated when control variables are not considered. The coefficient of the urbanization rate variable is -0.251, which at the 1% level of significance indicates that a positive improvement in the urbanization rate is not necessarily beneficial for rural revitalization. In the process of urbanization, rural young and middle-aged population and funds flow out in large quantities, resulting in the decline of rural productivity; The road

level regression coefficient is -0.001, which is noteworthy at the level of 5%. The improvement of transportation infrastructure strengthens rural external relations, which is conducive to the circulation of products and the inflow of capital, and promotes the rapid development of local economy, on the other hand, it may also lead to the accelerated outflow of rural population and funds; The regression coefficient of human resource level is 1.665, which is significant at 5%, indicating that the improvement of human resource level can promote rural revitalization, and college students provide talent reserve and intellectual support for rural development; The regression coefficient of government expenditure is 0.083, which is noteworthy at the level of 1%. National policies and fiscal inclination provide financial support for rural development. The regression coefficient of science and technology level is 0.066, which is significant at the one percent level. The advancement of science and technology can enhance the efficiency of production and the processing of products. The regression coefficient of openness is 0.026, which is significant at the one percent level. This indicates that there is a notable relationship between openness and the promotion of rural revitalization. Trade openness can increase farmers' income, drive consumption in rural areas and promote rural construction.

5.3 Robustness test

Table 5. Robustness test

variable	(1)	(2)	(3)
Dige			0.403***
			(2.974)
Dige1	0.041*		
	(1.928)		
lag.Dige		0.215***	
		(3.342)	
urban	-0.220***	-0.262***	-0.245***
	(-4.621)	(-5.037)	(-3.811)
road	-0.001	-0.001*	-0.001
	(-1.606)	(-1.807)	(-0.703)
edu	0.821	1.893**	1.885**
	(1.198)	(2.516)	(2.060)
lg_govern	0.084***	0.088***	0.044*
	(4.048)	(4.006)	(1.762)
lg_tec	0.080***	0.060***	0.072***
	(6.072)	(4.286)	(4.231)
lg_fdi	0.023***	0.029***	0.017
	(2.621)	(3.230)	(1.224)
Constant	-0.396***	-0.391***	-0.230***
	(-7.361)	(-6.590)	(-3.076)
Observations	510	480	300
R-squared	0.658	0.652	0.626
r2_a	0.653	0.647	0.617
F	137.762	126.184	69.921

1)Replace the core explanatory variables

Adjust the evaluation index system of digital economy, re-measure the development level of digital economy, and then incorporated it into the panel data regression analysis. As illustrated in Column (1) of Table 5, the regression coefficient for the digital economy in relation to rural revitalization is 0.041, indicating a statistically significant result. This adjustment and re-measurement process ensure a more accurate assessment of the digital economy's impact on rural revitalization, highlighting the robustness and reliability of the findings.

2) Lagging core explanatory variables

The core explanatory variables are lagged by one period to examine their impact on the level of rural revitalization. This approach tests how past values of these variables influence the current level of Rural. The test results are presented in Column (2) of Table 5. It can be observed from Column (2) that the regression coefficient of the digital economy lagging behind the initial phase in rural revitalization is 0.215, which is significant at the one percent level. This illustrates that the digital economy still raises the level of rural regeneration after lagging behind the core explanatory variables.

3) Adjust the sample interval

A further regression analysis was conducted using panel data from 2006 to 2015. The findings, presented in Table 5 (3), reveal a noteworthy inverse relationship between the digital economy and rural revitalization, with a coefficient of 0.403 ($p < 0.001$). These results corroborate the hypothesis that the digital economy can significantly contribute to rural revitalization.

5.4 Analysis of the influence mechanism

Table 6. Analysis of influence mechanism

VARIABLES	(1)	(2)	(3)
Dige	0.175***		
	(3.220)		
GTFP		0.037***	
		(5.744)	
Dige*GTFP			0.129***
			(4.551)
urban	-0.251***	-0.283***	-0.273***
	(-5.162)	(-5.924)	(-5.629)
road	-0.001**	-0.001	-0.001
	(-1.986)	(-1.501)	(-1.558)
edu	1.665**	2.053***	2.144***
	(2.311)	(2.953)	(2.950)
lg_govern	0.083***	0.097***	0.082***
	(4.067)	(4.939)	(4.081)
lg_tec	0.066***	0.075***	0.068***
	(4.877)	(5.901)	(5.194)
lg_fdi	0.026***	0.020**	0.023***
	(2.929)	(2.401)	(2.643)
Constant	-0.364***	-0.427***	-0.345***
	(-6.640)	(-8.268)	(-6.352)

Observations	510	510	510
R-squared	0.662	0.676	0.669
r2_a	0.657	0.672	0.664
F	140.5	149.9	144.8

In consideration of the influence of GTFP on rural revitalization, the regression results are presented in Table 6. The regression coefficient of GTFP to rural revitalization is 0.037, and it is significant at 1% level; The regression coefficient of the interaction between digital economy and agricultural green total factor productivity to rural revitalization is 0.129, which is significant at 1% level. The interactive regression coefficient is smaller than the digital economy regression coefficient, but larger than the GTFP regression coefficient, all of which are significant at 1% level. The regression results indicate that the digital economy exerts a considerable influence on rural revitalization. Furthermore, the interaction term continues to exert a significant positive effect on rural revitalization following the incorporation of GTFP. The digital development of rural areas can be seen as influencing GTFP by boosting agricultural output while simultaneously reducing carbon emissions from agricultural production processes. This dual effect enhances the overall level of rural revitalization. Consequently, the adoption of digital technologies in rural areas not only promotes more efficient and sustainable agricultural practices but also contributes significantly to the broader goals of rural revitalization by integrating environmental and economic benefits.

5.5 Heterogeneity analysis

Table 7. Heterogeneity Analysis

eastern region						
VARIABLES	Rural	Industry Prosperity	Ecological Livability	Life Prosperity	Rural Civilization	Effective Governance
Dige	0.551***	0.106***	0.085***	0.206***	0.098***	0.056***
	(10.260)	(4.417)	(6.362)	(15.099)	(7.079)	(4.117)
Constant	0.246***	0.050***	0.060***	0.044***	0.050***	0.042***
	(24.064)	(11.001)	(23.750)	(16.804)	(18.950)	(16.066)
Observations	187	187	187	187	187	187
R-squared	0.363	0.095	0.180	0.552	0.213	0.084
r2_a	0.359	0.0905	0.175	0.550	0.209	0.0790
F	105.27	19.51	40.48	227.98	50.11	16.95
central and western region						
VARIABLES	Rural	Industry Prosperity	Ecological Livability	Life Prosperity	Rural Civilization	Effective Governance
Dige	1.369***	0.361***	0.198***	0.436***	0.211***	0.163***
	(16.960)	(11.969)	(8.003)	(28.848)	(8.684)	(8.559)
Constant	0.121***	0.042***	0.030***	0.011***	0.018***	0.019***
	(13.908)	(13.063)	(11.422)	(6.474)	(7.054)	(9.291)
Observations	323	323	323	323	323	323
R-squared	0.473	0.309	0.166	0.722	0.190	0.186

r2_a	0.471	0.306	0.164	0.721	0.188	0.183
F	287.71	143.21	64.05	832.20	75.41	73.26

According to the research of Tian, this paper divided 30 provinces into two groups[17]. The influence of digital economy on rural revitalization is studied respectively. The influence of digital economy on rural revitalization was studied respectively. The results in Table 7 show that, in the central and western regions, the regression coefficient of digital economy to rural revitalization is 1.369, whereas the regression result is 0.551 in the eastern region. Considering the decomposition of rural revitalization, the strength of digital economy from strong to weak is rich life, prosperous industry, civilized rural customs, ecologically livable and effective governance. The regression coefficient for the relationship between digital economy growth and rural revitalization in the central and western regions is significantly higher than in the eastern regions. The potential explanations for this phenomenon are twofold. Firstly, in the eastern regions, the digital economy developed at an earlier stage, which means that much of the infrastructure and technological advancements have already been implemented, leaving less room for significant improvements or new innovations. Secondly, the eastern regions have benefited from earlier and more substantial investments in internet connectivity, mobile networks, and digital services, which have already maximized many of the potential benefits of the digital economy. The central and western regions are still in the early stages of digital economy development, meaning they have not yet fully reaped the benefits of digital transformation. Having larger agricultural sectors and rural populations, the central and western regions can benefit from digital tools and services like precision farming, online marketplaces, and digital financial services.

6 Conclusions

From the viewpoint of GTFP, on the basis of provincial panel data of China from 2005 to 2021, this paper empirically tests the influence of digital economy on rural revitalization and its internal mechanism on the basis of constructing rural revitalization level, digital economy development index and GTFP index system. This paper provides a series of empirical evidence for the digital economy to empower rural revitalization and development, and the final research conclusion has important enlightenment significance for formulating relevant policies. First of all, the digital economy can empower rural revitalization from multiple angles, such as ecology, industry, rural customs, etc. Rich life is the most direct and significant path along which the digital economy affects rural areas. All regions should vigorously promote the construction of digital villages, especially through the improvement of information infrastructure, consolidate the foundation of digital villages and smooth the existing agricultural information systems. Secondly, the digital economy can improve the level of rural revitalization by influencing GTFP, which further emphasizes the importance of green development. The application of digital technology can grasp all aspects of agricultural production and reduce pollution emissions; Digital information can also accurately match agricultural supply and demand and arrange production reasonably. It is recommended that the government facilitate the integration of agricultural development and digital technology, as well as the industrial transformation and upgrading process. Finally, the digital economy's impact on rural revitalization varies across different regions. In the central and western regions, where the digital economy is still in its early stages, its role in advancing the rural

revitalization strategy is more pronounced. It is imperative that the government assumes the role of formulating targeted and differentiated development strategies, with a particular concentration on narrowing the digital divide in central and western regions, in accordance with existing developmental frameworks, while simultaneously promoting regional coordinated development.

It should be noted that there are still some limitations in this paper, and subsequent research could focus on a smaller administrative region and a broader scope. For example, city or county data could be used for research purposes; additionally, we can consider the supporting policies related to the digital economy and rural revitalization, and comprehensively analyze the role of these policies. Furthermore, future studies might also explore the long-term effects of digital economy initiatives on rural areas, providing a more in-depth understanding of their impact over time.

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