Digital Economy and Rural Revitalization:
Evidence from China Based on County-level Panel Data

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Abstract

Digital economy is a new driving force for China's economic development and the strategy of rural revitalization is the overall focus of the "three rural issues" in the new era. As the rapid penetration of digital technology into rural areas has a potential to integrate digital economy with rural revitalization, in-depth empirical research is needed to find out how digital economy drives China's rural revitalization. However, relevant studies mostly focus on the impact of digital economy on one dimension of rural revitalization and lack a systematic exploration of the overall impact of digital economy on rural revitalization. To fill the gap with previous studies, this study constructs county-level comprehensive index system by the entropy weighting method and examines the driving effect and mechanisms of digital economy on rural revitalization based on several digital economy indicators and rural revitalization score by using county-level panel data in Zhejiang during 2010–2021. This study shows that digital economy measured by rural e-commerce, digital finance indexes, and the number of households using broadband Internet has a driving effect on rural revitalization. Moreover, this study finds that technological innovation and industrial structure transformation are important mechanisms of digital economy driving rural revitalization. Therefore, it is recommended that the local government accelerate digital industrialization and industrial digitalization process.

1. Introduction

Digital economy has become a new and important driving force for China's economic development. Moreover, digital economy in rural areas has become a powerful driving force for rural reform and development, modernization of agriculture and rural areas, and leapfrogging of rural areas (Zhang & Bai, 2022). The rural revitalization strategy is the overall focus of the work of the "three rural issues" in the new era. The Outline of the 14th Five-Year Plan proposes "Agricultural and Rural Development and Rural Revitalization" and "An Initiative to Build a Digital China". Rural revitalization is essentially a special stage in the long process of rural transformation and development (Guo & Liu, 2021). The rural revitalization strategy is one of the most important and fundamental development strategies of the Chinese government. This strategy completes the overarching task of addressing the recession in China's rural areas and achieving China's great rejuvenation. This strategy has been regarded by the central government as an important component of modern Chinese socialist society. As such, the strategy has become a major long-term sustainable development policy and is given top priority (Fan et al., 2023). By 2020, China has achieved eradication of absolute poverty and entered the stage of rural revitalization. The rapid extension and penetration of digital technology into agriculture and rural areas provides an opportunity to promote the integration of digital economy and rural revitalization, and in-depth empirical research is needed to find out how the digital economy drives China's rural revitalization, and whether such promotion is effective and what aspects of rural revitalization it promotes (He, Wang, & Wang, 2022).

However, relevant studies mostly focus on the impact mechanism of digital economy on one dimension of rural revitalization, such as agricultural development, social governance, farmers' income and farmers' entrepreneurship, and lack a systematic exploration of the overall impact mechanism of digital economy on rural revitalization. Meanwhile, most of the previous studies are qualitative and lack empirical studies regarding the driving effect of digital economy on rural revitalization in general (Zhao & Long, 2021). Therefore, it is important to examine the impact of digital economy on rural revitalization. This study examines the driving effect, the mechanism, and heterogeneity

of digital economy on rural revitalization based on several digital economy indicators such as e-commerce and digital finance, and rural revitalization score by using the county-level panel data in Zhejiang during the period of 2011–2021.

This study selects Zhejiang as an ideal case. The reasons for this are as follows. First, digital economy has become the main engine of Zhejiang's economy. In 2021, Zhejiang's digital economy added value reached 3.57 trillion RMB, ranking fourth in China, accounting for 48.6% of GDP, ranking first in China. Moreover, Alibaba, one of the largest Internet companies in China was founded in Hangzhou, Zhejiang in 1999. Zhejiang also has the third highest Digital Financial Inclusion Index of China. Second, Zhejiang is the only model province for rural revitalization in China. In 2021, the Ministry of Agriculture and Rural Affairs and the provincial government of Zhejiang jointly issued the "High-quality Creation of Rural Revitalization Demonstration Provinces for the Promotion of Common Prosperity Action Program for Construction of Demonstration Areas (2021-2025)", which became the only ministry-province action program for building a model province for rural revitalization. Therefore, the study of Zhejiang serves as a reference for rural revitalization in other provinces.

This study makes three major contributions to the literature. First, this study constructs a county-level comprehensive index system to evaluate rural revitalization in five dimensions, including industrial prosperity, affluent life, civilized rural style, effective governance, and ecological livability. While the existing literature focuses on provinces and prefecture-level cities, this study uses county-level data to fulfill the research gaps. Second, this study uses a variety of digital economy indicators from the perspectives of digital application degree and fundamentals of digital industry development. Third, this study examines mechanisms and heterogeneity of the effects of digital economy on rural revitalization.

The remainder of this paper is organized as follows. Section 2 reviews the existing literature and proposes the hypotheses. Section 3 provides research hypotheses. Section 4 presents the data and estimation method. Section 5 presents and discusses the empirical results. Section 6 further analyzes the mediation mechanism. The final section summarizes the main conclusions.

2. Literature Review

The inherent mechanism of rural revitalization empowered by digital economy is to drive changes in the modes of production, living and governance in the rural area with the help of modern information technology and digitized knowledge. However, most of the relevant research focuses on the impact mechanism of digital economy on certain dimensions of rural revitalization, such as agricultural development, rural residents' income and entrepreneurship, and lacks a systematic exploration of the overall impact mechanism of digital economy on rural revitalization. Furthermore, most of the previous studies are qualitative and lack empirical measurement of the driving effect of the digital economy on rural revitalization (Zhao & Long, 2021).

2.1 Research on digital economy

Research on digital economy can be described from three aspects: research on the exploration of the concept of digital economy, the statistical classification and measurement of the digital economy, and the empirical studies related to digital economy (He et al., 2022). Various studies find that the digital economy has a positive impact on society, the economy, and the environment. More specifically, digital economy can boost rural income (Sun & Liu, 2022), improve rural residents' quality of life (Wang et al., 2023), heighten total factor productivity (Tian & Liu, 2021; Wan & Luo, 2022), mitigate environmental pollution (Zhou & He, 2020; Che & Wang, 2022), reduce carbon emissions (Chen et al., 2022; Yi et al., 2022), optimize industrial structure (Liu & Chen, 2021), promote high-quality economic development (Ren, 2021), and narrow urban-rural income gap (Gao & Li, 2023).

2.2 Research on rural revitalization

Research on rural revitalization focuses on three aspects: research on the main body of rural revitalization, rural revitalization paths, and rural revitalization evaluation index system (He et al., 2022). Regarding research on rural revitalization evaluation index system, most scholars start from the five dimensions of industrial prosperity, ecological livability, rural civilization, effective governance and affluent life to construct the rural revitalization evaluation index system (Yan & Wu, 2019; Zhang et al, 2018; Jia et al,

2018), and basically a consensus has been reached on the selection of the first-level indexes (He et al., 2022).

Regarding the empirical studies on rural revitalization, using province-level panel data from 2011 to 2020, Fan et al. (2023) examine the impacts of financial development on rural revitalization and find that financial development has significantly promoted rural revitalization, while the development of urbanization and tourism have significantly inhibited the promotion of rural revitalization. Using province-level panel data from 2018 to 2020, Zhang, Yang, and Li (2022) examine the impact of fiscal expenditure structure on rural revitalization and find that while the total amount of fiscal resources related to agriculture has a significant impact on rural revitalization, the expenditure structure of fiscal resources related to agriculture also affects the effectiveness of rural revitalization.

2.3 Research on the impact of the digital economy on rural revitalization

Although previous studies provide valuable insights into digital economy and rural economy, few studies have examined the impact of digital economy on rural revitalization. Regarding direct study on the impact of digital economy on rural revitalization, using province-level panel data from 2015 to 2019, Zhao and Long (2021) find that digital economy has a significantly positive effect on rural revitalization, and its effect is heterogeneous among regions. The statistically significant positive effect is found in the central and western regions, while the positive effect in the eastern region is insignificant. Moreover, using province-level panel data from 2011 to 2018, He et al. (2022) find that digital economy promotes rural revitalization. Technological innovation and human capital are also found to be important mechanisms for rural revitalization driven by digital economy. Furthermore, using panel data from 11 prefecture-level cities in Zhejiang from 2011 to 2019, Cen, Lin, and Wu (2022) find that digital economy promotes rural revitalization.

To the best of my knowledge, no study has focused on the impact of digital economy including e-commerce on rural revitalization using county-level panel data. This study is unique in that it provides new evidence on digital economy and rural revitalization.

3. **Research hypothesis**

3.1 Direct effect of digital economy on rural revitalization

Digital economy such as digital inclusive finance, digital technology, the Internet and e-commerce promotes rural revitalization [1] (He et al., 2022). Digital economy has a multifaceted impact on rural revitalization: first, it brings new development modes to the rural areas such as agricultural digitization and cloud tourism; second, it brings efficient services and convenient life to the rural areas such as improving the efficiency of rural logistics and distribution; and third, it creates a fairer social environment in the rural areas, and further realizes information sharing (Feng et al., 2023). Zhao and Long (2021) explain the effect of digital economy on rural revitalization from the perspectives of industrial prosperity, ecological and livable, vernacular civilization, effective governance, and living well. First, digital economy promotes the construction of a modern agricultural system in rural areas, thereby promoting the prosperity of rural industries. Specifically, the digital economy promotes the integration of primary, secondary, and tertiary industries and the construction of a modern agricultural industrial system. Second, digital economy is helping to promote rural ecological livability through ecological remediation and optimized allocation of ecological resources. Digital technology enables to create an early warning system for rural habitat data, track trends in environmental development in real time, and respond to abnormal changes in a timely manner. Third, digital economy promotes rural civilization through the preservation and development of outstanding rural culture. Digital technology provides strong support for the storage, analysis and prediction of rural cultural data. The relevant departments have set up databases on rural culture, storing traditional culture (such as historical relics and handmade crafts) and humanities and cultural data of the villages in which they are located in the databases, so as to realize the inheritance and development of rural culture by means of the wide dissemination of the Internet. Fourth, digital economy contributes to effective rural governance by increasing the enthusiasm and effectiveness of villagers' participation in rural governance. Digital technology has broken the original social, economic, relational,

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[1] He et al. (2022) provide the comprehensive explanations of the effect of digital economy on rural revitalization from the perspectives of industrial prosperity, ecological and livable, vernacular civilization, effective governance, and living well.

geo-structural, and cultural structures of the countryside, forming an interactive group governance model characterized by interactivity and group structure. Fifth, digital economy is expanding the channels for farmers to increase their income and realizing an increase in farmers' income, thus contributing to the prosperity of rural life. Internet use and the development of digital inclusive finance can significantly increase the level of farmers' non-agricultural income. Relying on the Internet and big data, more effective sales channels can be opened up for farmers, upgrading the efficiency of upstream and downstream circulation, and driving the downward movement of high-quality agricultural products. Therefore, this study puts forward the following hypothesis:

H1: Digital economy promotes rural revitalization.

3.2 The indirect impact of digital economy on rural revitalization

Digital economy can also affect rural revitalization indirectly. Big data, the Internet and other digital technologies have broken the barrier between the rural areas and the outside world, prompting a large-scale flow of factors such as talent, knowledge and technology to the rural areas, and vigorously promoting the comprehensive revitalization of the rural areas. The impact mechanism of digital economy on rural revitalization includes the growth pole effect, human capital effect, and technological innovation effect (Zhang & Deng, 2023).

Growth pole effect can be explained as follows. The development of digital economy provides infrastructure protection for regional economic development, promotes the scale agglomeration of factor resources, and is conducive to the formation of new growth poles and the realization of regional economic structure restructuring (Zhang, 2019). The growth poles can generate economies of scale for the development of rural areas, drive the growth of rural residents' income through transfer income and other means (Chen & Wei, 2022), and then drive rural revitalization (Zhang & Deng, 2023).

Human capital effect can be explained as follows. With the support of communication infrastructure, farmers can learn the necessary knowledge and basic skills for modern production at a lower cost, improve their knowledge and technology, and enhance their understanding of new agricultural technologies and advanced production information (Li & Li, 2022), which can effectively improve the level of human capital in

rural areas, change and optimize farmers' traditional production and life style, and create endogenous power for rural revitalization (Zhang & Deng, 2023). Moreover, in 2021, the Opinions on Accelerating the Revitalization of Rural Talents issued by the State Council and the General Office of the State Council of the People's Republic of China proposed that the key to rural revitalization lies in people, and that the development of rural human capital should be given top priority (He et al., 2022).

Technological innovation effect can be explained as follows. Digital economy is characterized by real-time transmission of information, which makes knowledge elements flow at high speed among innovation subjects, promotes the aggregation of innovation elements, facilitates agriculture-related business subjects to obtain innovation resources along the channel of information network (Zhao, 2021), and applies new innovative technologies to transform the traditional production and operation mode, extend the industrial chain, and enhance the value chain in the rural areas (Wen & Chen, 2020), promoting rural revitalization (Zhang & Deng, 2023). Additionally, in 2019, the Ministry of Science and Technology proposed that rural revitalization should be driven by innovation.

Furthermore, digital economy has become an important driving force for industrial upgrading, because industrial structure layout can be optimized by digital technologies (Zhang, 2018). Digital infrastructures include mobile Internet, big data, cloud computing, and artificial intelligence. These technologies can improve the traditional industrial structure, supporting the upgrading and transformation of the industrial structure. Digital economy will promote the upgrading, production efficiency, and high-quality development of traditional industries (Sheng, 2020).

Due to the limitations of data, this study examines the mechanism of digital economy on rural revitalization from the dimensions of technological innovation and industrial upgrading. Therefore, this study puts forward the following hypotheses:

H2: Digital economy promotes rural revitalization through technological innovation.

H3: Digital economy promotes rural revitalization through industrial upgrading.

4. Methodology

4.1 Data

To test the impact of digital economy on rural revitalization, this study constructed the county-level panel data in Zhejiang from 2010 to 2021 mainly based on Zhejiang Statistical Yearbooks and China Statistical Yearbook (county-level). Regarding digital economy data, Taobao Village list published by Alibaba, list of e-commerce demonstration villages and rural e-commerce demonstration service stations from Department of Commerce of Zhejiang, The Peking University Digital Financial Inclusion Index of China from the Institute of Digital Finance at Peking University and Ant Group.

4.2 Selection of variables

Dependent variable is rural revitalization score. With reference to existing studies (Cen et al., 2022; Fan et al., 2023; Liu & Yang, 2020; Wang, 2023), this study constructs a comprehensive score of five dimensions: prosperous industry, affluent life, civilized rural style, effective governance, and ecological livability, and uses the objective weighting method, specifically the entropy weight method for the calculation. Due to the limitation of data, this study uses 13 measurements from the above five dimensions for the calculation of rural revitalization score. These measurements include proportion of added value of primary industry to GDP, grain per capita, total power of agricultural machinery, fertilizer use per 10,000 people, urban-rural income gap, effective irrigation area, and per capita net income of rural residents. More specifically, Table 1 shows the specific evaluation score of rural revitalization.

Independent variable is digital economy. Although there is no consensus on the measurement of digitalization (Lee et al., 2022), e-commerce constitutes a considerable part of the digital economy (Kong, 2019). This study evaluates digital economy using several indicators such as rural e-commerce, digitization level, digital finance index, the number of households using mobile phones, and the number of households using broadband Internet. As Taobao Villages demonstrate the remarkable progress of e-commerce in rural China (Qin & Fang, 2022) and referring to the existing studies which use rural e-commerce demonstration county policy as a quasi-natural experiment (Peng et al., 2021; Qin & Fang, 2022; Qin et al., 2023), rural e-commerce is measured by the number of Taobao Villages and e-commerce demonstration villages and the proportion of

Taobao Villages and e-commerce demonstration villages in the county. AliResearch (Alibaba Group's research unit)'s identification criteria for a Taobao village include: (1) trading place: operation place is located in rural area with administrative village as unit; (2) trading volume: annual trading volume of e-commerce amounts to over RMB10 million; and (3) scale of online merchants: active online stores amount to over 100 or account for over 10 percent of local households. Moreover, following Li, Wang, Zhao (2021), this study uses the number of Taobao Towns as another indicator of e-commerce. According to Alibaba's official definition, the economic and social value of Taobao Towns is slightly different from that of Taobao Villages, with Taobao Towns having a more significant scale effect and emphasizing the degree of agglomeration of Taobao Villages (Li et al., 2021). Taobao Town is defined as a town or sub-district with three Taobao villages or above (AliResearch, 2016).

Regarding control variables, referring to existing studies (Fan et al., 2023; Zhao & Long, 2021) and data unavailability, this study uses the level of economic development measured by the logarithm of per capita GDP, trade openness measured by the proportion of total import and export to GDP, the level of financial development measured by the proportion of total loans of financial institutions to GDP, and the degree of government intervention measured by the proportion of government fiscal expenditure to GDP. Table 2 shows the descriptive statistics of each variable.

Table 1 evaluation score of rural revitalization

Primary Measurement	Secondary Measurement	Sign Prediction
Industrial prosperity	Proportion of added value of primary industry in regional GDP (%)	Negative
	Agricultural labor productivity (the gross output value of agriculture, forestry, animal husbandry and fishery per capita (RMB))	Positive
	Grain per capita (kg)	Positive
	Total power of agricultural machinery (10000 kW)	Positive
	Electricity consumption per capita in rural areas	Positive
	Number of beds in health institutions per 10,000 people	Positive
Ecological and livable	Length of highway mileage per square kilometer (km)	Positive
	Number of doctors per 10,000 people (people)	Positive
	Fertilizer use per 10,000 people (tons)	Positive
Vernacular civilization	Education (regular secondary school student enrollment per 10,000 people)	Positive
Effective governance	Urban-rural income gap (times)	Negative
	Effective irrigation area (1000 ha)	Positive
Living well	Actual per capita net income of rural residents (RMB)	Positive

Table 2 Descriptive statistics

Variable	Obs	Mean	Std. dev.	Min	Max
rural revitalization score	624	0.620	0.102	0.341	0.868
Proportion of Taobao Villages	624	3.172	8.188	0.000	69.655
Number of Taobao Villages	624	1.069	1.411	0.000	5.288
Number of Taobao Towns	624	0.455	0.765	0.000	2.773
Proportion of e-commerce demonstration villages	624	0.411	1.314	0.000	10.417
Number of e-commerce demonstration villages	624	0.288	0.690	0.000	3.829
Digital financial digitization index	414	87.654	37.454	1.040	136.448

The Peking University Digital Financial Inclusion Index	414	112.123	16.369	62.860	136.562
Number of mobile phone users	621	4.013	0.789	2.163	5.846
Number of broadband users	617	2.531	0.897	-0.045	4.595
Telecom Business Income	612	10.708	0.905	8.648	12.587
real GDP per capita	624	10.824	0.469	9.288	12.209
share of secondary production in GDP	624	47.856	9.650	13.638	74.099
share of tertiary production in GDP	624	44.235	8.168	19.191	69.993
retail sales of consumer goods per capita	624	10.065	0.500	8.468	11.209
loans in financial institutions/GDP	624	126.859	34.021	36.222	289.518
proportion of fiscal expenditure to GDP	624	18.173	11.423	5.854	71.335
proportion of total import and export trade to GDP	622	12.989	21.145	0.289	225.589
Number of beds in health institutions	624	35.481	11.198	9.849	68.784
Number of industrial enterprises	624	5.660	1.158	2.197	7.628
patent application approved per capita	624	3.178	0.886	0.154	5.569
industrial structure upgrading	624	236.351	9.291	212.480	268.393

4.3 Measurement of rural revitalization level and digital economy level

In the selection of specific evaluation methods, this study selects the entropy weight method as the results calculated by the entropy weight method are more accurate and more objective, which can provide a better explanation for the analyzed results (Fan et al., 2023).

From county-level perspective, the evaluation indicators for the rural revitalization level and the digital economy development level are multidimensional and comprehensive evaluation indicator systems, and the smaller the number of indicators, the more suitable the entropy weighting method with higher accuracy (Fan et al., 2023). Referring to the existing studies (Fan et al., 2023; Zhao & Long, 2021), the specific procedure is as follows.

Step 1: Standardization of Indicators

As the units of measurement for each indicator are not uniform, the indicators must first be standardized. To avoid meaningless logarithmic calculations when calculating entropy

values, positive and negative indicators must be non-negative in the calculation and must have a uniform addition of 0.0001.

Positive indicators: $X'_{ij} = \left[\dfrac{\max(X_{1j,}, X_{2j,},\ldots,X_{nj,}) - X_{ij}}{\max(X_{1j,}, X_{2j,},\ldots,X_{nj,}) - \min(X_{1j,}, X_{2j,},\ldots,X_{nj,})}\right] + 0.0001$

Negative indicators: $X'_{ij} = \left[\dfrac{X_{ij} - \min(X_{1j,}, X_{2j,},\ldots,X_{nj,})}{\max(X_{1j,}, X_{2j,},\ldots,X_{nj,}) - \min(X_{1j,}, X_{2j,},\ldots,X_{nj,})}\right] + 0.0001$

Step 2: Calculation of the percentage of county i in index j.

$$P_{ij} = X'_{ij} / \sum_{i=1}^{n} X'_{ij}$$

Step 3: Calculation of the entropy value of each index.

$$E_j = -\frac{1}{\ln(n)\sum_{i=1}^{n} P_{ij}\ln(P_{ij})}, \; 0 \le E_j \le 1$$

Step 4: Calculation of the difference coefficient of the indicator j in all indicators.
$$G_j = 1 - E_j, \; 0 \le G_j \le 1$$

Step 5: Calculation of the weight of the indicator j in all indicators.

$$w_j = G_j / \sum_{j=1}^{m} G_j$$

Step 6: Calculation of the comprehensive scores of each county.

$$s_j = \sum_{i=1}^{n} w_j X'_{ij}$$

4.4 Model

This study adopts fixed effects (FE) model. Regarding e-commerce in digital economy, this study takes the emergence of Taobao Villages as an exogenous shock and take the proportion of Taobao Villages in the administrative villages of the county as the policy shock variable. The following empirical model is established to examine the effect of digital economy on rural revitalization:

$Rural\_revitalization_{it} = \alpha_0 + \alpha_1 Digital\_economy_{it} + \delta X_{it} + \lambda_i + C_{ct} + \varepsilon_{it}$ (1)

$Rural\_revitalization_{it}$ represents the level of rural revitalization and development in the county i and the year t; $Digital\_economy_{it}$ represents digital economy development level of the county i and the year t, which is the core independent variable;

X_{it} represents a series of control variables; λ_i represents a county-fixed effect; C_{ct} represents city-by-year effect; ε_{it} represents a random disturbance term.

This study also uses a combination model of the fixed effects and two-stage least squares (FE_2SLS) for robustness checks. This study selects digital economy variables of prefecture-level cities and a historical variable as instrumental variables. Regarding digital economy variables of prefecture-level cities, number of Taobao Villages and e-commerce demonstration villages in the cities to which the county belongs are used. The rationale for this is as follows. Digital economy variables of prefecture-level cities to which the county belongs can attract e-commerce development in the county. Thus, this variable meets a criterion of the instrumental variable—"relevance." Regarding another criterion of IVs—"exclusion restriction"—this IV does not seem to affect rural revitalization in the counties directly except through digital economy development in the counties. Regarding historical variables, the number of telephones in 1989 of prefecture-level cities to which a certain county belongs is used. The validity of this IV can be explained as follows. Digital economy has been empowered by the development of Internet technology. As suggested by the evolution of Internet access technology in China, Internet technology should have originated from the spread of landline phones. Before that, people communicated mainly through the post office system, the department responsible for laying landline phones. Therefore, areas with a historically high number of post offices and landline phones are likely to have a high-level digital economy, meeting the relevance requirement. Nonetheless, the historical impact of the number of post offices and landline phones on regional economies is fading. Nowadays, the number of post offices and landline phones has little effect on rural revitalization, meeting the exclusion restriction.

5. Empirical results

5.1 Impact of digital economy on rural revitalization

Table 3 presents the benchmark results estimated using FE model. Columns (1) - (5) show the effect of e-commerce on rural revitalization. Column (1) and (2) are the estimated result of the effect of Taobao Village on rural revitalization. Column (3) is the estimated

result of the effect of Taobao Town on rural revitalization. Column (4) and (5) is the estimated result of the effect of e-commerce demonstration villages on rural revitalization. Column (6) and (7) are the estimated result of digital financial digitization index and the Peking University Digital Financial Inclusion Index on rural revitalization, respectively. Column (8) - (10) are the estimated result of the effect of the scale of mobile phone users, broadband Internet users, and telecom business income on rural revitalization, respectively. Table 3 shows that most of the digital economy variables have a significant positive effect on rural revitalization. In particular, rural e-commerce measured by Taobao Village/Town and digital finance measured by digital financial digitization index and the Peking University Digital Financial Inclusion Index promote rural revitalization.

5.2 Endogeneity test

When identifying the effect of digital economy on rural revitalization, there may be interference due to endogeneity problems such as missing variables and mutual causality. To address the potential endogeneity, the instrumental variable method is used. Table 4 presents the estimation results of FE_2SLS. The Columns in Table 4 correspond to the benchmark regression one by one. In the first stage estimation, IVs have a significant positive impact on digital economy variables. Besides, the first stage passed the over identification test and the test of weak instrumental variables. Kleibergen-Paap rk Wald F statistic is almost always above 10, the critical value proposed by Stock and Yogo (2005), indicating that the instrumental variables are effective. There are no major differences from the estimation results of benchmark regression. This indicates that the estimation results of instrumental variables are robust and after overcoming the endogeneity problem, the effect of digital economy on rural revitalization remains stable. More specifically, rural e-commerce, digitization level, Digital Financial Inclusion Indexes, and the number of households using broadband Internet significantly and positively affect rural revitalization score.

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Table 3 Benchmark results estimated using fixed effects (FE) model

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
					Rural revitalization score					
Proportion of Taobao Villages	0.002***									
	(0.000)									
Number of Taobao Villages		0.014***								
		(0.004)								
Number of Taobao Towns			0.022***							
			(0.006)							
Proportion of e-commerce demonstration villages				0.005**						
				(0.002)						
Number of e-commerce demonstration villages					0.007					
					(0.005)					
Digital financial digitization index						0.001***				
						(0.000)				
The Peking University Digital Financial Inclusion Index							0.001***			
							(0.000)			

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Number of mobile phone users								0.088***		
								(0.019)		
Number of broadband users									0.044**	
									(0.017)	
Telecom Business Income										-0.023
										(0.016)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
city-by-year effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	622	622	622	622	622	412	412	619	615	610
R-squared	0.546	0.570	0.559	0.524	0.518	0.680	0.636	0.548	0.549	0.516
Number of county_id	52	52	52	52	52	52	52	52	52	52
Within R-squared	0.546	0.570	0.559	0.524	0.518	0.680	0.636	0.548	0.549	0.516
Between R-squared	0.342	0.384	0.370	0.296	0.304	0.429	0.398	0.005	0.099	0.423
Overall R-squared	0.380	0.419	0.405	0.338	0.343	0.480	0.444	0.037	0.163	0.444

Robust standard errors in parentheses

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

Table 4 Results of the fixed effects and two-stage least squares (FE_2SLS)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Second stage										
VARIABLES					Rural revitalization score					
Proportion of Taobao Villages	0.004***									
	(0.001)									
Number of Taobao Villages		0.026***								
		(0.006)								
Number of Taobao Towns			0.040***							
			(0.010)							
Proportion of e-commerce demonstration villages				0.014***						
				(0.004)						
Number of e-commerce demonstration villages					0.027***					
					(0.008)					
Digital financial digitization index						0.001***				
						(0.000)				
The Peking University Digital Financial Inclusion Index							0.002***			
							(0.000)			

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	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Number of mobile phone users								0.307***		
								(0.071)		
Number of broadband users									0.173***	
									(0.046)	
Telecom Business Income										0.031
										(0.026)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City-by-year effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	622	622	622	622	622	412	412	618	613	609
Number of county_id	52	52	52	52	52	52	52	52	52	52
Within R-squared	0.500	0.529	0.529	0.494	0.478	0.677	0.613	0.332	0.235	0.493
Between R-squared	0.383	0.441	0.418	0.291	0.318	0.426	0.385	0.103	0.020	0.106
Overall R-squared	0.408	0.460	0.440	0.330	0.349	0.477	0.432	0.043	0.000	0.160
First stage										
City-level digital economy variable	97.174***	13.503***	8.844***	88.319***	44.648***	0.459***	0.308***			
Number of telephones in 1989 of cities×current year's digital economy variables								0.050***	0.046***	0.112***

First-stage F-statistic	9.6	16.19	25.67	16.19	17.69	276.77	778.82	55.84	228.9	66.09
Cragg-Donald Wald F statistic	287.427	209.397	310.741	187.437	210.537	455.72	366.055	52.064	43.758	177.822
Kleibergen-Paap Wald rk F statistic	13.547	41.868	52.273	19.264	30.952	234.478	720.214	34.593	7.505	136.882
	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)
Anderson-Rubin Wald test	=25.67***	=25.67***	=25.67***	=12.87***	=12.87***	=52.95***	=24.95***	=17.32***	=11.93	=1.54

Robust standard errors in parentheses

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

5.3. Heterogeneity Analysis

The subject of this research is the counties or county-level cities of Zhejiang. In China's administrative divisions, counties and county-level cities have certain differences in fiscal self-management capacity, economic development autonomy, and economic development level. It is problematic to analyze them indiscriminately (Li & Qin, 2022). Therefore, it is necessary to examine counties and county-level cities separately. Table 5 and Table 6 show the estimated results of FE_2SLS for counties and county-level cities, respectively. The results are mostly consistent with those of benchmark regression model for both counties and county-level cities. This implies that the promotion effect of digital economy on rural revitalization is not significantly different from counties and county-level cities.

Moreover, given the considerable differences in the level of economic development and the geographic environment of northeastern Zhejiang and southwestern Zhejiang, this study examines the heterogeneity of the two regions. Table 7 and Table 8 show the estimated results of FE_2SLS for northeastern Zhejiang and southwestern Zhejiang, respectively. The results show that most of the digital economy indicators have significant positive effects on rural revitalization in both northeastern and southwestern Zhejiang. The results also show some differences between these two regions. In particular, the number of mobile phone users and that of broadband users have a significantly positive effect on rural revitalization for southwestern Zhejiang, but not for northeastern Zhejiang. Additionally, both proportion and number of rural e-commerce demonstration villages have a significantly positive effect on rural revitalization for northeastern Zhejiang, but not for southwestern Zhejiang. The overall results are mostly consistent with those of benchmark regression model. Additionally, the coefficients of rural e-commerce indicators are larger in northeastern Zhejiang than southwestern Zhejiang. This implies that the promotion effect on rural revitalization in underdeveloped southwestern Zhejiang is weaker than that in developed northeastern Zhejiang.

Table 5 Results of the fixed effects and two-stage least squares (FE_2SLS) for counties

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
					Rural revitalization score					
Proportion of Taobao Villages	0.007**									
	(0.003)									
Number of Taobao Villages		0.027**								
		(0.011)								
Number of Taobao Towns			0.038**							
			(0.016)							
Proportion of e-commerce demonstration villages				0.017***						
				(0.006)						
Number of e-commerce demonstration villages					0.028**					
					(0.011)					
Digital financial digitization index						0.001***				
						(0.000)				
The Peking University Digital Financial Inclusion Index							0.002***			
							(0.001)			

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Number of mobile phone users								0.361***		
								(0.085)		
Number of broadband users									0.275***	
									(0.076)	
Telecom Business Income										0.034
										(0.044)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City-by-year effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	394	394	394	394	394	262	262	390	389	382
Number of county_id	33	33	33	33	33	33	33	33	33	33
Within R-squared	0.540	0.512	0.521	0.536	0.535	0.660	0.611	0.315		0.539
Between R-squared	0.351	0.380	0.330	0.303	0.340	0.526	0.481	0.016	0.001	0.179
Overall R-squared	0.386	0.403	0.362	0.353	0.381	0.549	0.502	0.000	0.008	0.236
First stage										
City-level digital economy variable	39.216***	10.051***	7.043***	61.473***	37.526***	0.385***	0.314***			
Number of telephones in 1989 of cities×current year's digital economy variables								0.054***	0.050***	0.095***

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
First-stage F-statistic	8.47	9.21	13.82	8.79	10.38	184.45	585.65	30.79	288.05	102.38
Cragg-Donald Wald F statistic	106.955	83.288	172.427	78.048	99.348	161.506	247.536	32.461	28.429	94.503
Kleibergen-Paap Wald rk F statistic	19.052	21.491	29.883	13.511	19.682	66.196	333.164	18.756	12.172	103.444
	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)
Anderson-Rubin Wald test	=8.84***	=8.84***	=8.84***	=5.57***	=5.57***	=34.61***	=24.95***	=13.82***	=33.34	=0.64

Robust standard errors in parentheses

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

Table 6 Results of the fixed effects and two-stage least squares (FE_2SLS) for county-level cities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES					Rural revitalization score					
Proportion of Taobao Villages	0.003***									
	(0.001)									
Number of Taobao Villages		0.031***								
		(0.009)								
Number of Taobao Towns			0.051***							
			(0.016)							
Proportion of e-commerce demonstration villages				0.009**						

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
				(0.005)						
Number of e-commerce demonstration villages					0.021**					
					(0.010)					
Digital financial digitization index						0.000***				
						(0.000)				
The Peking University Digital Financial Inclusion Index							0.001***			
							(0.000)			
Number of mobile phone users								0.147		
								(0.096)		
Number of broadband users									0.046	
									(0.057)	
Telecom Business Income										0.004
										(0.035)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City-by-year effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	228	228	228	228	228	150	150	228	224	227
Number of county_id	19	19	19	19	19	19	19	19	19	19
Within R-squared	0.553	0.575	0.561	0.522	0.481	0.773	0.742	0.497	0.525	0.531

Between R-squared	0.301	0.405	0.370	0.238	0.248	0.041	0.022	0.000	0.085	0.191
Overall R-squared	0.372	0.456	0.428	0.313	0.309	0.183	0.134	0.025	0.171	0.279
First stage										
City-level digital economy variable	158.103***	14.039***	8.619***	137.059***	61.015***	0.494***	0.322***			
Number of telephones in 1989 of cities×current year's digital economy variables								0.045***	0.037	0.135***
First-stage F-statistic	32.01	47.40	126.35	36.34	93.31	818.50	606.41	63.04	112.44	91.21
Cragg-Donald Wald F statistic	187.213	71.995	81.638	140.174	146.108	222.95	78.189	16.268	9.581	77.545
Kleibergen-Paap Wald rk F statistic	17.41	42.601	34.026	14.343	21.789	159.414	130.162	15.962	2.281	105.058
	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)
Anderson-Rubin Wald test	=20.22***	=20.22***	=20.22***	=7.19***	=7.19***	=16.00***	=9.89***	=2.74*	=0.45	=0.01

Robust standard errors in parentheses

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

Table 7 Results of the fixed effects and two-stage least squares (FE_2SLS) for northeastern Zhejiang

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
					Rural revitalization score					
Proportion of Taobao Villages	0.002**									
	(0.001)									
Number of Taobao Villages		0.041***								
		(0.016)								
Number of Taobao Towns			0.056**							
			(0.022)							
Proportion of e-commerce demonstration villages				0.011***						
				(0.004)						
Number of e-commerce demonstration villages					0.027***					
					(0.010)					
Digital financial digitization index						0.001***				
						(0.000)				
The Peking University Digital Financial Inclusion Index							0.002***			
							(0.000)			

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Number of mobile phone users								-0.079		
								(0.149)		
Number of broadband users									-0.019	
									(0.107)	
Telecom Business Income										-0.061*
										(0.035)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City-by-year effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	240	240	240	240	240	158	158	236	231	231
Number of county_id	20	20	20	20	20	20	20	20	20	20
Within R-squared	0.704	0.463	0.561	0.709	0.684	0.811	0.729	0.669	0.661	0.709
Between R-squared	0.009	0.250	0.003	0.046	0.024	0.006	0.074	0.182	0.004	0.319
Overall R-squared	0.131	0.280	0.104	0.019	0.029	0.165	0.015	0.298	0.061	0.452
First stage										
City-level digital economy variable	107.388**	5.798***	4.323***	109.374***	45.049***	0.479***	0.290***			
Number of telephones in 1989 of cities×current year's digital economy variables								0.151**	0.027	0.113***

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
First-stage F-statistic	7.95	11.79	33.90	32.08	59.48	19.93	1900.22	148.97	31.2	30.16
Cragg-Donald Wald F statistic	88.546	18.043	28.803	97.891	122.009	167.041	93.278	2.63	4.323	46.843
Kleibergen-Paap Wald rk F statistic	6.938	7.143	11.43	23.452	39.382	145.361	409.796	5.329	1.181	27.653
	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)
Anderson-Rubin Wald test	=12.77***	=12.77***	=12.77***	=11.28***	=11.28***	=19.93***	=17.02***	=0.34	=0.05	=4.07**

Robust standard errors in parentheses

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

Table 8 Results of the fixed effects and two-stage least squares (FE_2SLS) for southwestern Zhejiang

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES					Rural revitalization score					
Proportion of Taobao Villages	0.004**									
	(0.002)									
Number of Taobao Villages		0.015***								
		(0.005)								
Number of Taobao Towns			0.023***							
			(0.009)							
Proportion of e-commerce demonstration villages				0.007						

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
				(0.005)						
Number of e-commerce demonstration villages					0.011					
					(0.007)					
Digital financial digitization index						0.001***				
						(0.000)				
The Peking University Digital Financial Inclusion Index							0.001***			
							(0.000)			
Number of mobile phone users								0.248***		
								(0.064)		
Number of broadband users									0.215**	
									(0.084)	
Telecom Business Income										0.049
										(0.036)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City-by-year effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	382	382	382	382	382	254	254	382	382	378
Number of county_id	32	32	32	32	32	32	32	32	32	32
Within R-squared	0.576	0.627	0.621	0.585	0.592	0.655	0.638	0.549	0.206	0.590

Between R-squared	0.319	0.320	0.275	0.249	0.231	0.247	0.246	0.144	0.076	0.004
Overall R-squared	0.388	0.406	0.369	0.350	0.336	0.324	0.324	0.027	0.005	0.089
First stage										
City-level digital economy variable	78.529***	18.689***	12.278***	65.243***	43.694***	0.371***	0.316***			
Number of telephones in 1989 of cities×current year's digital economy variables								0.088**	0.045	0.110***
First-stage F-statistic	39.87	21.76	30.84	14.25	35.16	260.14	716.93	56.91	537.35	128.66
Cragg-Donald Wald F statistic	144.762	182.43	295.209	64.277	100.624	146.269	131.463	71.922	26.252	133.757
Kleibergen-Paap Wald rk F statistic	18.507	49.373	55.051	6.327	13.737	114.259	358.561	53.313	2.241	182.852
	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)
Anderson-Rubin Wald test	=10.74***	=10.74***	=10.74***	=3.06*	=3.06*	=23.30***	=9.21***	=13.65***	=6.23**	=1.74

Robust standard errors in parentheses

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

5.4 Robustness checks (Elimination of the impact of COVID-19 epidemic)

Due to the difficulty of excluding unpredictable perturbations in relevant variables affected by COVID-19 epidemic, referring to Han et al. (2023) and Feng et al. (2023), this study limits the analysis period during 2010-2019 to remove the impact of COVID-19 in 2020 and 2021.

The results are presented in Table 9 and are consistent with those of benchmark regression model. Therefore, the results are robust to eliminating the particular effect of COVID-19 in 2020 and 2021.

Table 9 Results of the fixed effects and two-stage least squares (FE_2SLS) before COVID-19 epidemic

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
					Rural revitalization score					
Proportion of Taobao Villages	0.005***									
	(0.001)									
Number of Taobao Villages		0.032***								
		(0.007)								
Number of Taobao Towns			0.046***							
			(0.010)							
Proportion of e-commerce demonstration villages				0.017**						
				(0.007)						
Number of e-commerce demonstration villages					0.026**					
					(0.012)					
Digital financial digitization index						0.001***				
						(0.000)				
The Peking University Digital Financial Inclusion Index							0.002***			
							(0.000)			

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Number of mobile phone users								0.258***		
								(0.085)		
Number of broadband users									0.177***	
									(0.057)	
Telecom Business Income										0.041
										(0.025)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City-by-year effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	518	518	518	518	518	308	308	518	514	513
Number of county_id	52	52	52	52	52	52	52	52	52	52
Within R-squared	0.565	0.491	0.553	0.546	0.552	0.806	0.642	0.410	0.193	0.535
Between R-squared	0.290	0.472	0.378	0.200	0.212	0.446	0.326	0.064	0.013	0.022
Overall R-squared	0.335	0.477	0.407	0.247	0.258	0.500	0.378	0.023	0.000	0.058

First stage

City-level digital economy variable	96.597***	13.759***	9.674***	68.579***	44.165***	0.380***	0.367***			
Number of telephones in 1989 of cities×current year's digital economy variables								0.045***	0.04**	0.117***

First-stage F-statistic	6.40	16.11	23.20	10.43	13.24	250.97	621.96	52.13	167.49	85.52
Cragg-Donald Wald F statistic	235.573	111.35	214.288	99.282	194.921	216.838	252.332	35.117	25.472	153.053
Kleibergen-Paap Wald rk F statistic	15.111	43.192	50.82	10.76	23.721	102.319	520.043	19.041	4.787	319.633
	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)	Chi-sq(1)
Anderson-Rubin Wald test	=30.37***	=30.37***	=30.37***	=4.96**	=4.96**	=48.62***	=72.93***	=9.16***	=10.40***	=2.73*

Robust standard errors in parentheses

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

6. Mechanism analysis

Moreover, this study uses mediation effect model to reveal the process and the intermediate mechanism of the influence of the independent variable has on the dependent variable referring to the study of the mediating effect model (Baron & Kenny, 1986; He et al., 2022; Wen & Ye, 2014). The following empirical model is established to examine the role mechanism of rural revitalization by digital economy:

$$Rural\_revitalization_{it} = \alpha_0 + \alpha_1 Digital\_economy_{it} + \delta X_{it} + \lambda_i + C_{ct} + \varepsilon_{it} \quad (2)$$

$$Mediation_{it} = \beta_0 + \beta_1 Digital\_economy_{it} + \delta X_{it} + \lambda_i + C_{ct} + \varepsilon_{it} \quad (3)$$

$$Rural\_revitalization_{it} = \gamma_0 + \gamma_1 Digital\_economy_{it} + \gamma_2 Mediation_{it} + \delta X_{it} + \lambda_i + C_{ct} + \varepsilon_{it} \quad (4)$$

In equation (2), α_1 represents the total effect of digital economy development level on rural revitalization. In equation (3), β_1 indicates the effects of digital economy on the intermediate variable. In equation (4), γ_1 represents the direct effects of digital economy on rural revitalization, and $\beta_1\gamma_2$ indicates the indirect effects of digital economy on rural revitalization. Mediating variables are industrial structure upgrading measured by industrial structure upgrading index by referring to the studies of Du et al. (2021) and Xu et al. (2022) and technological innovation measured by patent applications approved for inventions per capita.

Table 10 presents the result of mediation effect model to reveal the process and the intermediate mechanism of the influence of digital economy on rural revitalization. Columns (1) and (2) show that digital economy measured by e-commerce has a significantly positive effect on industrial structure upgrading and digital economy has both direct and indirect effects on rural revitalization. Column (3) and (4) show that while digital economy measured by e-commerce has a significantly positive effect on technological innovation, technological innovation does not have significantly positive effect on rural revitalization. Therefore, it is implied that industrial structure upgrading is important mechanisms of the digital economy driving rural revitalization.

Table 10 Mechanism analysis

VARIABLES	(1)	(2)	(3)	(4)
	Industrial stracture upgrading (isu)		technological innovation	
			patent applications approved	
	isu	rural revitalization score	for inventions per capita	rural revitalization score
taobao100	0.181**	0.004***	0.050***	0.004***
	(0.080)	(0.001)	(0.016)	(0.001)
isu		0.002*		
		(0.001)		
lnpc_patent_innovation				0.005
				(0.003)
Controls	Yes	Yes	Yes	Yes
County-fixed effect	Yes	Yes	Yes	Yes
city-by-year effect	Yes	Yes	Yes	Yes
Observations	622	622	614	614
Number of county_id	52	52	52	52
Within R-squared	0.738	0.414	0.668	0.431
Between R-squared	0.050	0.394	0.114	0.310
Overall R-squared	0.279	0.399	0.405	0.336
First stage				
City-level digital economy				
variable	98.18***	99.02***	99.32***	100.44***
First-stage F-statistic	10.38	9.42	10.52	9.72
Cragg-Donald Wald F statistic	326.29	319.49	313.14	284.59
Kleibergen-Paap Wald rk F				
statistic	14.04	13.75	13.89	14.10
Anderson-Rubin Wald test	Chi-sq(1) = 7.51***	Chi-sq(1) =42.44***	Chi-sq(1) =39.97***	Chi-sq(1) =32.28***

Robust standard errors in parentheses

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

7. Conclusions

This paper uses county-level panel data from 2010 to 2021 to measure the comprehensive score of rural revitalization in Zhejiang by the entropy weighting method and empirically analyzes the effect of digital economy on rural revitalization. This paper finds that most of the digital economy variables such as e-commerce and digital financial inclusion have a significant positive effect on rural revitalization. This effect does not have significant regional heterogeneity and robust after addressing the endogeneity problems. This paper also examines the potential mechanisms by mediation effect model. The results show that digital economy promoted industrial structure upgrading and technological innovation. Moreover, the results show that industrial structure upgrading mediates the effects of digital economy on rural revitalization, and the mediating effect is partial. Therefore, it is recommended that the local government accelerate digital industrialization and industrial digitalization process to realize rural revitalization.

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