

The Impact of Digital Inclusive Finance on Rural Revitalization: Evidence From China

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ABSTRACT

This article aims to study the role of digital finance in rural revitalization by utilizing the data for 30 provinces in China Mainland from 2012 to 2019, via the fixed effect model and differential GMM model. The empirical results show that the level of rural revitalization varies among different regions in China. In addition, the development of digital inclusive finance is essential in promoting rural revitalization, which is credible while we conduct several robustness tests such as changing the measurement of digital finance and including the dynamic progress by utilizing the GMM estimation. The impact of digital inclusive finance on rural revitalization is not constant among different regions, the positive impact of digital finance on rural revitalization is stronger in eastern region than that in central and western regions.

KEYWORDS

Digital Inclusive Finance, Heterogeneity, Rural revitalization

INTRODUCTION

As socialism with Chinese characteristics enters a new era, the main contradiction in China is now between the people's growing needs for a better life and unequal development. This main contradiction is particularly severe in rural areas of our country. In the 19th National Congress of the Communist Party of China, the Communist Party of China first elevated rural revitalization to a national strategic level. The importance of rural revitalization is to recognize that there is a connection between rural revitalization and poverty alleviation. The coordinated development and mutual promotion of the two are the only way to build a moderately prosperous society in an all-round way. Rural revitalization and comprehensive poverty alleviation both reflect the country's people-centered development philosophy and uphold the status of farmers as the main body. Since the concept of rural revitalization was proposed, many scholars have conducted research on the meaning, internal logic, construction of index evaluation systems, and implementation paths of rural revitalization (Cen et al., 2022; Zha and Liu, 2023) as well as the factors that can affect the rural revitalization (Luo et al., 2023; Liu et al., 2023b). Financial resources can bring prosperity to the industry, improvement of education, and

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technology upgrading, therefore, the financial development is essential in rural revitalization. However, referring to the role of financial development in rural revitalization, Xiong (2022b) shows that due to the financial exclusion effect of traditional finance, the development of China's rural areas in the financial field is still in its infancy. As a combination of finance and emerging digital technology, digital inclusive finance can effectively circumvent the financial exclusion effect of traditional finance and improve financial services in terms of availability, convenience, and comprehensiveness. Some scholars have engaged in investigating the impact of digital finance on rural revitalization, such as Zhao et al. (2022) who queried the role of digital inclusive finance on urban-rural income gap, as well as Li et al. (2022) who studied the role of digital finance in high-quality agricultural development. However, there are not many studies on the direct effect of digital inclusive finance on rural revitalization. Additionally, several scholars tried to query the role of digital technology or digital finance in rural development (Luo et al., 2023; Liu et al., 2023b; Xiong et al., 2022a; Zha and Liu, 2023; Han et al., 2024). For instance, Liu et al. (2023a) examined the role of digital entrepreneurial ecosystem in high-quality growth of rural areas. However, most scholars analyze the relationship between digital inclusive finance and rural revitalization by analyzing the economic data of a single or several provinces or analyzing how to do so from a national perspective.¹ In view of this, this article first theoretically analyzes the working mechanism of the relationship between digital inclusive finance and rural revitalization. It then uses the economic data of each province and city to construct a relatively scientific and reasonable indicator to measure the development level of rural revitalization in each region and analyzes the numbers from an empirical perspective, which can do some good to provide reference for the implementation of China's rural revitalization strategy and the development of digital inclusive finance.

The impact of digital finance on rural revitalization can be interpreted as follows. Digital financial inclusion, as a member of financial technology, can solve the problem of information asymmetry between borrowers and lenders to a certain extent, and can inject new energy into small farmers, township enterprises, or cooperatives that lack credit means and credit channels and whose development has stagnated to finally realize the prosperity of rural industries (Zhao et al., 2022). Aside from this, digital finance can change farmers' ideas and guide them to build green and environmentally friendly beautiful villages (Zhou et al., 2022). Digital inclusive finance can stimulate the growth of the green economy, indirectly promote the development of China's rural areas in a green direction, and ultimately realize rural revitalization (Sun and Zhu, 2022).

To empirically examine the impact of digital inclusive finance on rural revitalization, we collected the provincial data for 30 provinces, autonomous regions, and cities. Once we calculated the level of rural revitalization by utilizing the TOPSIS entropy weight method, we further conduct the regression by employing the panel FE estimation and GMM estimation. The results support that the digital inclusive finance exerts a positive impact on rural revitalization, which is credible while we conduct the robustness test by changing the measurement of digital finance. In addition, this positive impact varies among different regions in China. Compared to the existing literatures, the potential contributions of our study are as follows. Firstly, comparing existing empirical studies that only captured the rural revitalization from specific aspects such as industry prosperity, we select the five dimensions of rural revitalization such as industry prosperity, ecologically livable, rural civilization, effective governance, and prosperous life to build a comprehensive index to comprehensively capture the rural revitalization, which can gain a reliable conclusion on the impact of digital finance on rural revitalization (Chen et al., 2022). Additionally, unlike with earlier studies that only queried the linear impact of digital inclusive finance on rural revitalization in one province (Zha and Liu, 2023), we collect the data for 30 provinces in China to test the common sense of digital finance's impact on rural revitalization for China as a whole, which can offer more general ideas on the relationship between digital finance and rural revitalization. Finally, we also query the differences in digital finance's impact on rural revitalization among different regions, which can offer more detailed insight for local government to more effectively promote rural revitalization through the path of digital finance (Xiong et al., 2022b).

The remaining parts of this paper are organized as follows. Section 2 provides a theoretical analysis for the relationship between digital inclusive finance and rural revitalization. Section 3 contains the variable definition, data source, econometric models, and the measurement of rural revitalization. Section 4 displays the empirical findings. Section 5 presents the conclusion and relevant policy implications.

LITERATURE REVIEW AND THEORETICAL ANALYSIS

Literature Review

By browsing existing literature, some scholars have investigated the role of digital finance in rural development. For instance, Zhao et al. (2022) studied the specific impact of the three dimensions of digital financial inclusion on rural revitalization and finally concluded that: among the three dimensions of digital financial inclusion, the breadth of coverage and the degree of digitalization are more important for rural revitalization. Li et al. (2023) pointed out that the development of digital inclusive finance has significantly promoted the level of rural revitalization, and this promotion is mainly reflected in the four directions of rural revitalization: rural civilization, industrial prosperity, affluent life, and ecological livability. Zhang et al. (2023) believe that China's rural revitalization has five demands, namely industrial prosperity and ecological livability, and digital inclusive finance can meet the demands of rural revitalization in many aspects, such as reducing the financial exclusion of traditional finance, promoting rural households, innovation, enhanced risk management, and control capabilities, etc. Chen et al. (2022) mainly examined the impact of digital economy on rural revitalization and further conducted the mediating effect of industrial upgrading, which concluded that the digital economy would promote the rural industrial prosperity and thus eventually bringing about rural revitalization. Similarly, Zha and Liu (2023) utilized the Anhui province as the sample to study the impact of digital finance on rural revitalization and found that the digital finance and the coverage of it would improve rural revitalization, while the depth cannot affect it. Xiong et al. (2022a) tried to study the impact of digital inclusive finance on rural revitalization from the view of economic development and income disparity and declared that digital inclusive finance contributes to rural revitalization, which is supported by Liu et al. (2023c) and Luo et al. (2023).

Theoretical Analysis

In terms of mechanism analysis, most of the current domestic scholars' research focuses on a specific mechanism and path, which is one-sided to a certain extent; the overall mechanism analysis is relatively insufficient and incomplete. For the potential channels through which digital inclusive finance affect rural revitalization, we try to theoretical analysis on digital finance's impact on rural revitalization through such aspects as industrial prosperity, ecological livability, rural civilization, rural governance, poverty reduction, and income effect. Firstly, for industrial prosperity, China's agriculture can truly enter modern agriculture and provide more and higher-level contributions to their own economic development, such as product contributions, factor contributions, market contributions, and foreign exchange contributions (Cen et al., 2022). In addition, only when the industry is prosperous can China's rural areas truly gain sustainable endogenous growth momentum and finally realize the goal of "farmers' prosperity" (Li, 2022; Xu and Wang, 2023). However, China lacks a mainstream rural financing model. The innovation of traditional finance has not solved the financing problems of farmers and cooperatives at the level of risk and transaction costs (Ge et al., 2022). As a result, China's traditional financial system cannot support the sustainable development of China's agricultural real economy in the current economic environment. At the same time, there are still many problems that need to be solved urgently in China's agriculture, such as perfect competition market, low product added value, and so on. Digital inclusive finance can make up for the shortcomings of traditional finance and provide services for the country's agricultural economy in terms of availability, convenience,

and comprehensiveness (Wang and Mai, 2022). Digital technology has reduced the transaction costs of rural finance on both the supply side and the demand side, not only breaking through the geographical restrictions of traditional financial outlets, but also significantly reducing rent-seeking costs (Zhang et al., 2023). Secondly, ecological livability is the top priority of rural revitalization. Many rural areas in the country are facing the dilemma of ecological environment destruction, water pollution, solid waste pollution, etc., which are restricting China from achieving the goal of a beautiful countryside. The reasons are as follows. Firstly, many rural areas in China are located in remote areas, the gap between infrastructure and cities is too large, and the level of disposal of garbage and other environmental pollution is very limited. Additionally, the awareness of environmental protection among rural villagers is relatively weak. Furthermore, the information is relatively blocked, and health promotion is not enough. These are some of the reasons why some rural areas have stepped into the “poverty trap” (Wu et al., 2023). The concept of green finance covered by digital inclusive finance helps to solve ecological and environmental problems in rural areas of China (Jiang et al., 2021; Wei et al., 2023). In addition, by optimizing the allocation of financial resources, we can guide funds to flow into projects with less pollution or environmental protection and improve the infrastructure and ecology of rural areas (Ma and Li, 2021). Thirdly, rural civilization is the soul of rural revitalization. Digital inclusive finance is conducive to the construction of rural civilization in China’s rural areas, mainly reflected by the notion that digital inclusive finance can deepen farmers’ understanding of the financial field and improve their financial literacy (Ye and Wang, 2021). In 2013, the People’s Bank of China conducted a sample survey on people’s financial literacy levels. The results show that the financial literacy is generally low, especially for rural residents. Digital inclusive finance can widely popularize financial knowledge in rural areas, continuously improve the financial literacy of villagers, and ultimately improve the level of human capital (Li et al., 2022). This is also the only way to cultivate new professional farmers. In addition, digital financial inclusion can increase the income of farmers by improving financial literacy and ultimately diversifying household asset portfolios, helping farmers get rid of poverty and increase their income (Li et al., 2021). The cultural consumption of rural residents can be promoted from three perspectives: increasing residents’ income, alleviating family mobility constraints, and reducing transaction costs (He et al., 2022). The improvement of cultural consumption will naturally help to improve the overall cultural level of the countryside and ultimately complete the goal of building a thriving rural civilization.

Effective governance is an important guarantee for rural revitalization. Digital inclusive finance can achieve the goal of effective governance from the two aspects of improving rural order and improving the quality of villagers. On one hand, China’s urban-rural dual structure leads to the rural endogenous order dominating the rural social relations. Qin et al. (2023) defined the grass-roots structure of Chinese rural society as a “different order pattern,” and the interpersonal relationship in rural areas is mainly determined by blood relationships and social communication rather than law and morality. As a modern economic system subject to legal and moral constraints, digital inclusive finance can reduce the closure of the endogenous order in rural China in an exogenously embedded way, improve rural residents’ awareness in the financial and legal fields, and enhance rural residents’ awareness of integrity, and improving their ability to understand and abide by the law will ultimately achieve the goal of improving the rural financial order (Xia et al., 2023). On the other hand, digital inclusive finance can improve the education investment level of residents and ultimately improve the quality and cognitive ability of rural residents (Wang et al., 2023). These two approaches can effectively improve the effective level of rural governance in our country.

Finally, a prosperous life is the fundamental goal of rural revitalization. The wide application of digital financial inclusion can provide a foundation for a prosperous life in terms of poverty reduction and prevention of returning to poverty (Li and Liu, 2023; Hu et al., 2023). After China eliminates absolute poverty in an all-round way, poverty governance in the new era will revolve around the poverty alleviation of the relatively poor population (Zha and Liu, 2023). Compared with absolute poverty, relative poverty has several new features, such as transference and multidimensionality. Digital

financial inclusion can achieve the goal of poverty reduction in the following two aspects: improving the accuracy of financial services (Wang, 2023) and improving the availability of financial services acquired (Du et al., 2022). Digital inclusive finance can accurately determine the number of lenders and the amount of loans through cloud computing, big data, and other modern financial technology technologies, can significantly reduce transaction costs, and ultimately achieve mutual benefits for lenders and borrowers (Yang et al., 2023). To improve the availability of financial services acquired, digital inclusive finance can break through the geographical restrictions of traditional finance, realize online lending, and ultimately realize the supply-side structural reform of financial services and promote the diversification of financial service products (Song et al., 2022). In terms of preventing poverty, digital financial inclusion can prevent poor families from returning to poverty in the following two aspects. First, digital financial inclusion can optimize the family income structure and help families achieve income diversification to a certain extent. The income structure of relatively poor families mostly presents a single feature. A single source of income means that household income is highly uncertain. If a relatively poor family encounters some kind of agricultural or health emergency that reduces or even eliminates the single income, the family will become a poor family again. Digital financial inclusion can help relatively poor families achieve income diversification by promoting family members' entrepreneurship or financial management. Second, digital financial inclusion can reduce information asymmetry and shorten the information gap for relatively poor families. As a kind of internet technology, digital inclusive finance can reduce information asymmetry to a certain extent, reduce information availability and information barriers, and make it easier for relatively poor families to obtain information and opportunities that were previously difficult to access and obtain, thereby reducing the probability of relapse into poverty.

DATA AND METHODOLOGY

Calculation of Rural Revitalization

Index Selection

In the 19th National Congress of the Communist Party of China, the Communist Party of China proposed a rural revitalization strategy that includes five dimensions: industrial prosperity, ecological livability, rural civilization, effective governance, and affluent life. Starting from these five dimensions, this article draws on Li's (2022) idea of parameter selection for index construction and follows the principles of comprehensiveness and scientificity to select a total of 13 secondary indicators to construct rural revitalization evaluation indicators representing each province and city. In order to simplify the calculation steps of the TOPSIS entropy weight method, the secondary indicators in this paper are all positive indicators, as shown in Table 1.

Calculating Method

In terms of data measurement, this paper uses the TOPSIS entropy weight method to reasonably measure the level of rural revitalization, which is similar to Chen et al. (2022). The TOPSIS entropy weight method can not only weight indicators more objectively and reduce the impact of subjective factors on the results it also has the advantages of both the TOPSIS method and the entropy weight method, such as the calculation process is simple and convenient, and the calculation results are reasonable. In order to measure the objective and effective level of rural revitalization, this article uses the TOPSIS entropy weight method to measure the level of rural revitalization in 30 provinces and cities in China. The specific steps are as follows.

The first step is to standardize the data to eliminate the impact of different dimensions on the results. When calculating and processing, use i to represent the province, j to represent the secondary index ($i=1,2,\dots,m; j=1,2,\dots,n$), and m to be the evaluation object number; n is the number of secondary

Table 1. The index selection of rural revitalization

Dimension	Variable	Definition	Unit
Industry prosperity	Rural production benefits	Per capita output value of agriculture, forestry, animal husbandry, and fishery	Ten thousand RMB
	Level of agricultural mechanization	Total power of agricultural machinery per capita	Ten thousand kw
	Rural informatization level	Ratio of transportation and communication expenditure to total expenditure	%
Ecologically livable	Ecological conditions	Forest coverage	%
	Medical conditions	Health technicians per 1,000 people	A
Rural civilization	Education level	Per capita years of education	Year
	Entertainment consumption level	Per capita education, culture, and entertainment consumption expenditure	RMB
	Accessibility of cultural facilities	Number of cultural stations per 10,000 people	A
Effective governance	Urban-rural income gap	Ratio of rural resident income to urban resident income	-
	Urban-rural consumption gap	Ratio of consumption expenditure of rural residents to urban residents	-
	Social security situation	Ratio of the number of people receiving minimum living allowances in rural areas to the total population	%
Prosperous life	Rationality of income structure	Ratio of wage income to disposable income	%
	Developmental and hedonic consumption	The proportion of daily necessities and service expenditures in total consumer expenditures	%

indicators. Since the data in this paper are all positive indicators, this paper positions the data standardization formula as formula (1).

$$Y_{ij} = \frac{X_{ij} - \min_{ij}}{\max_{ij} - \min_{ij}} \quad (1)$$

Among them, X_{ij} represents the original data before processing, Y_{ij} represents the data after normalization; \max_{ij} and \min_{ij} are the maximum and minimum values of the corresponding data, respectively.

The second step is to calculate the entropy value E_j of the indicator as seen in formula (2):

$$E_j = -k \sum_{i=1}^n p_{ij} \ln(p_{ij}) \quad (2)$$

in:

$$p_{ij} = \frac{Y_{ij}}{\sum_{i=1}^n Y_{ij}}, i=1, \dots, m; j=1, 2, \dots, n$$

$$k = \frac{1}{\ln(n)} > 0, E_j > 0$$

The third step is to calculate the redundancy d_j using formula (3):

$$d_j = 1 - E_j \quad (3)$$

The fourth step is to assign weights to the indicator Y_{ij} and find the weight W_j using formula (4):

$$W_j = \frac{d_j}{\sum_{i=1}^n d_j} \quad (4)$$

The fifth step is to establish the weighting matrix R as seen in formula (5):

$$R = (r_{ij})_{n \times m} \quad (5)$$

In formula (6),

$$r_{ij} = W_j \times Y_{ij} \quad (6)$$

In the sixth step, the ideal solution and anti-ideal solution are determined by the weighted matrix R calculated in the fifth step by using formulas (7) and (8):

$$Z_j^+ = (maxr_{i1}, maxr_{i2}, \dots, maxr_{in}) \quad (7)$$

$$Z_j^- = (minr_{i1}, minr_{i2}, \dots, minr_{in}) \quad (8)$$

The seventh step is to calculate the distance of each measure scheme to the ideal solution and anti-ideal solution by using formulas (9) and (10):

$$D_i^+ = \sqrt{\sum_{j=1}^n (Z_j^+ - r_{ij})^2} \quad (9)$$

$$D_i^- = \sqrt{\sum_{j=1}^n (Z_j^- - r_{ij})^2} \quad (10)$$

The eighth step is to calculate the paste progress C_i of the ideal solution with formula (11):

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \quad (11)$$

Calculating the Results

According to the data in Table 2 and the calculation method above, this paper calculates the annual rural revitalization level of each province in the country (except Hong Kong, Macao, Taiwan, and Xinjiang) during the period 2012–2019, as shown in Table 2.

Table 2. The performance of rural revitalization in China

	2012	2013	2014	2015	2016	2017	2018	2019	Rank
Beijing	0.478	0.487	0.515	0.466	0.515	0.513	0.550	0.559	1
Inner Mongolia	0.452	0.470	0.466	0.450	0.500	0.483	0.498	0.512	2
Shanghai	0.351	0.362	0.380	0.399	0.423	0.454	0.485	0.468	3
Zhejiang	0.369	0.386	0.416	0.419	0.414	0.405	0.435	0.467	4
Jiangsu	0.443	0.440	0.444	0.438	0.453	0.455	0.459	0.462	5
Guangdong	0.430	0.433	0.433	0.419	0.413	0.423	0.428	0.431	6
Fujian	0.387	0.392	0.411	0.407	0.402	0.386	0.386	0.430	7
Tianjin	0.410	0.423	0.429	0.429	0.402	0.419	0.421	0.425	8
Hubei	0.380	0.391	0.405	0.413	0.415	0.408	0.419	0.425	9
Anhui	0.430	0.428	0.434	0.428	0.421	0.400	0.414	0.420	10
Hainan	0.389	0.396	0.406	0.405	0.451	0.421	0.411	0.416	11
Chongqing	0.388	0.395	0.424	0.413	0.439	0.377	0.391	0.413	12
Shandong	0.411	0.379	0.391	0.406	0.404	0.393	0.411	0.413	13
Shaanxi	0.402	0.399	0.388	0.407	0.406	0.384	0.405	0.412	14
Henan	0.378	0.386	0.396	0.394	0.378	0.382	0.393	0.411	15
Sichuan	0.378	0.389	0.425	0.429	0.425	0.397	0.384	0.410	16
Jiangxi	0.355	0.368	0.381	0.382	0.360	0.354	0.381	0.389	17
Liaoning	0.409	0.404	0.403	0.407	0.380	0.350	0.377	0.387	18
Hunan	0.370	0.383	0.391	0.403	0.357	0.341	0.359	0.383	19
Guangxi	0.335	0.305	0.356	0.387	0.372	0.361	0.362	0.372	20
Shanxi	0.320	0.334	0.319	0.348	0.395	0.356	0.366	0.367	21
Hebei	0.330	0.330	0.312	0.350	0.320	0.315	0.345	0.360	22
Yunnan	0.307	0.314	0.316	0.402	0.358	0.348	0.349	0.354	23
Xinjiang	0.335	0.340	0.358	0.358	0.350	0.337	0.342	0.351	24
Guizhou	0.311	0.321	0.386	0.398	0.379	0.368	0.348	0.345	25
Heilongjiang	0.304	0.309	0.310	0.356	0.317	0.289	0.334	0.342	26
Jilin	0.307	0.319	0.325	0.363	0.313	0.298	0.316	0.336	27
Ningxia	0.317	0.318	0.319	0.326	0.327	0.314	0.327	0.334	28
Gansu	0.319	0.323	0.300	0.320	0.311	0.309	0.302	0.291	29
Qinghai	0.307	0.307	0.309	0.309	0.304	0.295	0.270	0.280	30

Source: Calculated by author based on MATLAB.

It can be seen from the measurement results that the level of rural revitalization in various provinces and cities is relatively slow, and there are obvious regional differences. According to the level of rural revitalization in 2019, China can be divided into three levels: the first level is the provinces whose rural revitalization level exceeds 0.45, and these provinces have basically reached the five-dimensional goals of rural revitalization in all aspects; the second level is provinces with a rural revitalization level exceeding 0.4, and these provinces have achieved some of the five dimensional goals and basically achieved rural revitalization, but there is still a long way to go before fully realizing rural revitalization; the third level is other provinces. It can be seen from Table 2 that there are only five provinces in the country whose rural revitalization level is greater than 0.45, reaching the first level. Among them, only Beijing and Inner Mongolia have a rural revitalization level exceeding 0.5, but the number of provinces that have entered the second level is relatively large. 11 provinces have basically achieved rural revitalization, the level of rural revitalization in 14 provinces is not optimistic, and there is a big gap between the first and second levels. In addition, the majority of the provinces in the first and second levels are the eastern coastal or southern provinces, while in the third level, the three northeastern provinces and the central and western regions are the main provinces. From this point of view, there are significant regional differences in the level of rural revitalization and development.

Variable and Data

This article selects 2012–2019 as the sample interval. The data mainly comes from the *China National Statistical Yearbook*, *China Environment Statistical Yearbook*, and *China Population and Employment Statistical Yearbook*. Because the data missing in Tibet, Hong Kong, Macao, and Taiwan are relatively large, this article does not include them in this study. Instead, it selects 30 other provinces, cities, and autonomous regions as the research objects. The digital financial inclusion index is derived from the digital financial inclusion index provided by the Digital Finance Research Center of Peking University in 2021. Table 3 shows the descriptive statistics of each variable in the model.

Estimating Model

According to the research purpose, this article first constructs a panel regression model with fixed effect to test the relationship between digital inclusive finance and rural revitalization, which is similar to Luo et al. (2023) and Liu et al. (2023c) who also tried to uncover the impact of digital finance on rural development by employing such method:

$$RR_{i,t} = \alpha + \beta DF_{i,t} + \gamma X + \varepsilon_{i,t}$$

Table 3. Summary of descriptive statistics

Variable	N	Mean	S.D	Min	Max
RURAL	240	0.385	0.052	0.270	0.559
DF	240	223.26	75.70	61.47	410.28
CITY	240	0.582	0.119	0.364	0.896
TV	240	0.988	0.011	0.930	1
GDP	240	56545.81	26585.07	19710	164220
OLDER	240	14.308	3.287	6.5	23.8
SUP	240	0.115	0.032	0.041	0.019

In this model, RR, as the explained variable, represents the level of rural revitalization and development in various provinces and cities; DF is the core explanatory variable, which is the logarithm of the digital financial inclusion index; X is the vector of control variable including *Urban*, *TV*, *GDP*, *Aging*, and *SUP* according to previous literatures focusing on the digital inclusive and rural revitalization such as Chen et al. (2022), Luo et al. (2023), and Liu et al. (2023c). *Urban* represents the urbanization level, *TV* denotes for the comprehensive program population coverage, *GDP* is the economic performance measured by logarithm of per capita GDP, *Aging* stands for the elderly population dependency ratio. ε represents the error term, and i and t represent the province and year.

In addition, according to economic common sense, the level of rural revitalization in the past is likely to affect the current level of rural revitalization, which will lead to deviations in the model's estimates. For this reason, this article further establishes a dynamic panel model of the relationship between digital inclusive finance and rural revitalization:

$$RR_{i,t} = \alpha + \lambda RR_{i,t-1} + \beta DF_{i,t} + \gamma X + \varepsilon_{i,t}$$

Since the data in this paper are short-panel data, there are limitations and endogeneity in data estimation, and generalized moment estimation is the best estimation method for short-panel data. Taking other factors into consideration, this paper uses the differential GMM method to study the dynamic panel model.

EMPIRICAL RESULTS

The Static Results

The data in this paper is panel data. Since the disturbance items of the same individual in different periods in the panel data generally have autocorrelation, the sample data does not satisfy the assumption of independent and identical distribution, which will overestimate the significance of parameter estimation and reduce the prediction accuracy. The reliability of the confidence interval reduces the prediction accuracy. In order to improve the diversity of estimation methods and ensure the accuracy of estimation results, this paper uses fixed effects (FE) and random effects (RE) to conduct static regression analysis on the development level of digital inclusive finance and rural revitalization and uses the Hausman test is used to determine which of the two models is the most effective. From the results of the Hausman test, the statistical value of the Hausman test is 36.81, and the corresponding P value is 0.0000. It can be judged that it is more effective to use the fixed effect model to estimate the parameters. As can be seen from Table 4, there is a significant positive correlation between digital inclusive finance and the level of rural revitalization development. After adding control variables, the parameters of the core explanatory variable DF in the fixed effects model did not increase significantly. The potential reason for this idea is that digital financial inclusion can improve the cultural consumption of rural residents. The role of digital inclusive finance in stimulating cultural consumption in rural areas is significantly greater than that in urban areas (Ouyang et al., 2022). Among all control variables, the level of urbanization (*Urban*) and the level of regional economic development (*GDP*) have a significant positive impact on the level of rural revitalization and development, indicating that promoting urbanization and economic development is helpful to build and develop the rural economy, which can promote rural revitalization.

Robustness Test

To prove the credibility of our earlier conclusion, we conduct the robustness test by employing the three aspects of digital finance of coverage breadth, depth of use, and degree of digitization; the result can be seen in Table 5. From the results in Table 5, we can find that the coefficients of *Coverage*,

Table 4. The static results

	Dependent variable: RURAL			
	FE		RE	
	(1)	(2)	(3)	(4)
DF	0.019*** (0.003)	0.029*** (0.008)	0.020*** (0.004)	-0.001 (0.017)
		-0.544*** (0.118)		-0.036 (0.074)
CITY		-0.017 (0.34)		-0.498 (0.325)
LNGDP		0.054*** (0.016)		0.054*** (0.017)
OLDER		0.001 (0.001)		0.001 (0.001)
SUP		-0.003 (0.13)		-0.104 (0.126)
_CONS	0.282*** (0.018)	-0.042 (0.311)		0.308 (0.332)
N	240	240	240	240
Hausman test	36.81			
P	0.0000			

Note: *, **, and *** stand for the significance level of 10%, 5%, and 1%. Standard error statistics in parenthesis.

Depth, and *Degree* are all significant at the 5% level at least, suggesting that the digital finance would benefit rural revitalization, supporting the credibility of our earlier finding.

Dynamic Analysis

In order to avoid possible endogeneity problems in the model setting and considering that the level of rural revitalization may be affected by the level of rural revitalization in the previous period, this paper introduces the lag term of the explained variable and uses the difference GMM method in generalized moment estimation to conduct a dynamic regression analysis on the relationship between digital inclusive finance and rural revitalization. The second-order serial correlation test of this model (i.e., the value of AR(2)) can conclude that there is no second-order serial correlation in the regression equation, and Sargan's over-identification test proves that the null hypothesis of instrumental variable validity is true, providing that the setting of the model in this article is reasonable and the instrumental variables are also effective.

From the results in Table 6, it can be seen that the coefficients of *L. RURAL* are all passing the significance test at the 1% level with a positive symbol, meaning that there exists dynamic progress in rural revitalization. Additionally, the coefficient for *DF*, *Coverage*, *Depth*, and *Degree* are all significant at the 5% level at least, suggesting that digital inclusive finance has a significant positive impact on the level of rural revitalization and development, indicating that the promotion of digital inclusive finance in rural areas of China has a positive effect on rural revitalization.

Table 5. The robustness test-changing measurement of digital finance

		Dependent variable: RURAL		
		(1)	(2)	(3)
Coverage		0.308** (2.37)		
			0.402* (1.85)	
Degree				0.176*** (3.15)
CITY		0.018* (1.94)	0.037** (2.26)	0.034*** (2.95)
TV		0.108* (1.70)	0.187** (2.27)	0.015 (0.27)
LNGDP		0.138* (1.79)	-0.093 (-0.75)	-0.019 (-0.28)
OLDER		-0.014*** (-3.04)	0.015* (1.82)	-0.013* (-1.73)
SUP		-0.124** (-2.16)	-0.006 (-0.08)	-0.098* (-1.88)
CONS		0.069* (1.92)	0.118** (2.15)	0.053** (2.14)
N		240	240	240
R ²		0.668	0.717	0.747

Note.*, **, and *** stand for the significance level of 10%, 5%, and 1%. Standard error statistics in parathesis.

Differences Among Different Regions

In view of the differences in economic development levels and resources between regions in China, we divide the total sample into east, central, and west regions, whose results can be seen in Table 7.²

The coefficient of DF in column (1) is 0.374, which is not significant at the 10% level, while the coefficient of DF in columns (2) and (3) is 0.401 and 0.513, respectively; both are significant at the 5% level at least. These results suggest that digital finance exerts significantly positive impact on rural revitalization in the western and central regions, while it exerts no significant impact on rural revitalization in eastern regions. One possible reason lies at the mature development of financial market and inclusive finance in the eastern region, thus the development of digital inclusive finance brings some weaker externality on the rural financial development. On the contrary, the development of digital technology would bring more advancement of financial development and inclusive development in the western and central regions due to their lower development of traditional financial services in the rural areas, thus it can bring about the improvement of rural revitalization (Hu et al., 2022).

Table 6. The dynamic results

	Dependent variable: RURAL			
	(1)	(2)	(3)	(4)
L. RURAL	0.929*** (3.99)	0.982*** (3.79)	0.903*** (3.01)	0.919*** (6.37)
	0.052** (1.98)			
Coverage		0.068** (2.09)		
			0.6247*** (6.06)	
Depth				0.599*** (4.13)
CITY	0.055*** (5.82)	0.062*** (6.10)	0.041*** (4.96)	0.239*** (6.32)
	0.023 (1.36)	0.043** (1.97)	-0.005 (-0.28)	0.016 (1.48)
LNGDP	0.204*** (3.67)	0.355*** (6.10)	0.173*** (4.88)	0.129** (2.54)
	0.029* (1.76)	0.020 (0.71)	0.016*** (3.71)	0.018 (1.10)
SUP	-0.067*** (-4.92)	-0.088*** (-4.70)	-0.073*** (-5.71)	-0.094*** (-5.56)
	N	240	240	240
AR(1)	0.372	0.493	0.501	0.339
AR(2)	0.000	0.002	0.000	0.004
Sargan	0.794	0.813	0.925	0.847

Note.*, **, and ***stand for the significance level of 10%, 5%, and 1%. Standard error statistics in parenthesis.

CONCLUSION

This paper first constructs a comprehensive evaluation index system for the development level of rural revitalization in China, and evaluates the development level of rural revitalization in 30 provinces across the country from 2012 to 2019 based on the entropy weight TOPSIS method. The results show that the overall level of rural revitalization in each province is currently improving slowly, and development is unbalanced among regions. Secondly, based on the provincial panel data, this paper first uses the fixed effect model to analyze the static relationship between the two, and then uses the difference GMM method to deeply study the impact of digital inclusive finance on the development level of rural revitalization. The research shows that digital financial inclusion has a significant positive effect on the development level of rural revitalization in China in both static and dynamic regressions.

Table 7. Heterogeneity test

		Dependent variable: RURAL		
		(1) Eastern	(2) Central	(3) Western
DF		0.374	0.401**	0.513***
		(1.43)	(2.31)	(6.22)
CITY		0.4820***	0.3026***	0.1926***
		(15.23)	(9.19)	(5.62)
TV		1.0512***	1.0376***	1.1072***
		(28.96)	(27.25)	(32.50)
LNGDP		0.3892	0.5022	0.8078
		(0.56)	(0.85)	(1.22)
OLDER		1.5822	1.9737**	2.6640*
		(0.99)	(2.10)	(1.66)
SUP		0.6361	0.7572	0.0183***
		(0.78)	(1.26)	(10.81)
CONS		0.986***	0.225***	0.637***
		(15.60)	(8.06)	(9.19)
N		88	80	72
R ²		0.310	0.328	0.568

Note.*, **, and ***stand for the significance level of 10%, 5%, and 1%. Standard error statistics in parenthesis.

As an applying research, we provide several policy implications focusing on rural revitalization. Firstly, the government should expand the coverage of digital financial inclusion and strengthen the implementation of digital financial inclusion, thereby improving the level of rural revitalization and development in rural areas. Specifically, the government should increase its support for digital inclusive finance from the policy level, such as introducing relevant preferential policies or investment promotion policies to guide capital from cities to rural regions. Furthermore, the government should support the construction and improvement of related infrastructure. The government can use policies and funds to support relevant enterprises and institutions to improve the infrastructure construction of rural digital financial platforms. The government also needs to use financial funds to build rural basic networks and communication facilities, such as power grids, TVs, networks, etc., and ultimately realize digital expansion of financial coverage. Moreover, the government and relevant departments should increase the promotion of digital financial inclusion which can effectively and efficiently improve farmers' understanding of it.

Secondly, the government should play the role of overall planning and strive to give full play to the positive role of digital inclusive finance in promoting rural revitalization. In terms of industrial prosperity, the government can provide farmers with special lectures and other services to help them realize the layout of rural e-commerce. In addition, the government should also encourage internet e-commerce and express delivery companies to set up more service centers and logistics centers at the county and township levels to realize the organic combination of agriculture and e-commerce and the “internet +” upgrade of agricultural supply and demand sides. In terms of ecological livability, the government should not only pay attention to the availability of digital financial inclusion to individual farmers, but also pay attention to the green financial attributes of digital financial inclusion in promoting the development of it.

Thirdly, all regional governments should formulate local digital inclusive financial development strategies according to local conditions. Therefore, it is necessary for governments to give full play to the economic driving role of digital financial inclusion and formulate financial and rural revitalization strategies that are in line with local development directions. On the other hand, it is also necessary to increase the supervision of digital inclusive finance and reduce the negative effects and risks of digital inclusive finance. Additionally, in terms of rural civilization, the government should assist in the cultural education and consumption guidance of digital inclusive finance. The government should also help the civilized role of digital inclusive finance in these two aspects. The government can promote the return of rural talents to the countryside and improve the financial education system to realize the connection between the endogenous order of the countryside and the exogenous financial system. In terms of reducing poverty and increasing income, the government should be a good participant and a “night watchman” at the same time.

Due to our limited time and energy, one may further explore the interaction between environmental performance and green finance on green innovation, which can better clarify the nexus among these three aspects. Furthermore, due to data availability, this study only investigates the relationships among environmental performance, green finance, and green innovation between developing countries. An investigation for developed countries should be further conducted once data becomes available.

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COMPETING INTERESTS

The authors of this publication declare there are no competing interests.

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ENDNOTES

¹ It is worth noting that the five autonomous regions and four municipalities can be seen as the province according to the administration level of China, thus we utilize the province to represent the common province, autonomous regions, and municipalities.

² The east region includes 11 provinces: Beijing, Hebei, Tianjin, Zhejiang, Shandong, Liaoning, Shanghai, Fujian, Guangdong, Jiangsu, and Hainan. The central region includes 10 provinces: Heilongjiang, Shanxi, Jiangxi, Hunan, Jilin, Guangxi, Inner Mongolia, Henan, Hubei, and Anhui. The west region covers 9 provinces: Sichuan, Xinjiang, Shaanxi, Gansu, Chongqing, Yunnan, Qinghai, Ningxia, and Guizhou.

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