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The impact of digital inclusive finance on rural revitalization based on econometric models

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Abstract: Finance is an essential component of modern economy, and rural revitalization cannot be separated from financial support. Digital inclusive finance can better support rural revitalization as an innovative sector developed through the growth of the Internet and inclusive finance. The level of rural revitalization in 260 Chinese prefecture-level cities is measured in this study using prefecture-level city panel data from 2011 to 2020. The development of digital inclusive finance is then tested for its effects on rural revitalization using the fixed-effects model and the mediated-effects model. It is found that digital inclusive finance effectively promotes rural revitalization, and this promotion effect still holds after considering the endogeneity problem. There is significant heterogeneity in digital inclusive finance for rural revitalization. Digital inclusive finance promotes rural revitalization by enhancing the level of regional financial development and innovation. To promote rural revitalization, the development of digital inclusive finance needs to be comprehensively promoted, and every effort needs to be made to smooth the path of digital inclusive finance to empower rural revitalization.

1. Introduction

In the process of integration and application of digitalization with various fields, the development of digital finance is particularly notable. Due to the limitations of the urban-rural dual structure, traditional finance has never been able to help modernize and urbanize the rural areas in the same way that it drives the rapid development of the urban economy. So, can digital inclusive finance, which integrates digital technology and inclusive features, promote rural areas revitalization? In the context of the current era, further in-depth research is necessary.

Although there is many research on relevant subjects in the body of literature already in existence, few of them specifically examine the connection between digital inclusive finance and rural rejuvenation. It has been discovered that supporting rural construction and governance, rural economic growth, and agricultural quality and efficiency all benefit from increased digital inclusive finance. The main points are as follows:

(1) Digital inclusive finance can promote economic development in rural areas. The study of Ozili, Buchak et al. (2018) shows that rural areas are difficult to access adequate financial services compared to urban areas[1-2]. Zhang Hailin and Wang Yanyan (2021), Chen Yajun (2022), and Kang Shusheng and Yang Nana (2022) empirically studied the impact of digital inclusive finance on rural revitalization and rural industry revitalization [3-5].

(2) Digital inclusive finance can promote the quality and efficiency of agriculture. Mei Yan and Jiang Yuqing (2020) argue that the growth of rural enrichment industry represented by rural e-commerce has a significant positive spillover effect, but this is more reflected in the mature stage of rural e-commerce development [6]. Luo Qianfeng (2022) et al. argued that with the gradual penetration of new digital technologies into the production system, operation system, and industrial system, technological empowerment promotes the high-quality development of agriculture mainly through the scale effect, aggregation effect, division of labor effect, and scope effect [7].

(3) Digital inclusive finance can promote rural construction and governance from a multi-industry perspective. Digital inclusive finance has generated new forms and modes of cultural tourism in the rural areas. Wu Xiaolong (2022) constructs a theoretical analysis framework from five aspects of digital economy, digital ecology, digital culture, digital livelihood, and digital governance to explore the governance issues and development direction of digital villages [8]. Yang Jianghua and Wang Yujie (2022) study the relationship between digital countryside construction and the newborn demographic dividend in the countryside, and believe that the foundation of digital countryside construction is people-oriented, and the key lies in dealing with the relationship between the city and the countryside, the government and the market [9]. Wang Yan and Sun Zhenglin (2022) study the allocation of rural financial resources, pointing out that the current rural finance is still generally characterized by a single system structure, limited coverage of basic resources, insufficient credit supply and other problems, which will further impede the development of rural finance to support rural revitalization [10].

Compared with existing studies, the innovation of this paper is mainly reflected in the following two aspects. First, with the flexible use of contemporary information technology of data, intelligence, and network, digital inclusive finance may offer accessible financial services for eligible financing topics at all levels in rural areas in a more scientific and exact manner. A solid basis for the continuous advancement of the rural revitalization plan can be established by investigating whether and how digital inclusive finance might boost rural revival. Secondly, in order to study the varied effects and transmission pathways of digital inclusive finance on rural regeneration, the panel data of 260 prefecture-level cities in China from 2011 to 2020 are used as an example. This closely integrates the characteristics of digital inclusive finance. The research's solid and reliable findings provide a comprehensive response to the topic of whether and how digital inclusive finance may foster rural revival.

2. Theoretical foundations and research hypothesis

The promotional effect of financial development on economic growth has been systematically demonstrated by the famous scholar McKinnon in the 1970s [11], but due to the differences in regional resource endowment, financial development to a certain extent will lead to unbalanced development of the economy. Especially under the reality of the urban-rural dual structure in China, the unbalanced development has widened the income gap between urban and rural areas and slowed down the transformation of rural industrial structure [12]. The development of digital inclusive finance offers the possibility of changing this situation. Inclusive features provide effective financial resources and services to disadvantaged rural groups, helping to eliminate financial exclusion and put financial support for agriculture into practice. Digital technology, on the other hand, increases regional financial accessibility and fairness, solves the limitations of traditional financial services in terms of mode, distance and cost, and effectively circumvents the dilemma of insufficient financial infrastructure in rural areas. Based on this, we propose hypothesis H1: digital inclusive finance development promotes rural revitalization.

The improvement of regional financial levels can promote rural revitalization. Driven by modern

digital technology, digital inclusive finance can effectively expand the coverage of the traditional financial system. In particular, it can provide timely and effective responses to the investment and financing demands of various types of agricultural business entities at all levels in rural areas and improve the efficiency of the use of rural financial resources. The concept of financial inclusion emphasizes the fairness and poverty benefit of financial services and resource supply, and lowers the threshold of access to the financial market, so that the majority of low- and middle-income groups can participate in it. Based on this, hypothesis H2 is proposed: digital inclusive finance development promotes rural revitalization by improving regional financial level.

Increased levels of innovation can contribute to rural revitalization. To begin with, an increase in the level of innovation leads to changes in sectoral productivity, causing factors of production to flow from low-productivity sectors to high-productivity sectors and creating industrial agglomeration and scale effects. The orderly flow of factor resources between primary, secondary and tertiary industries will cause industrial structure adjustment and optimization. Secondly, the improvement of innovation level can bring new technology, prompting the reorganization of production factors and increasing the compensation of the industry. As a result, the scale of industries will be enlarged, and upstream and downstream industries will be linked. Based on this, hypothesis H3 is proposed: digital inclusive finance promotes rural revitalization by increasing the level of innovation.

3. Research design

3.1. Data sources and selection of variables

260 Chinese cities were chosen as the research sample for this article. Regions such as the Hong Kong, Macao and Taiwan are not included because of the serious data missing. Given that the digital inclusive finance index has been published since 2011, the sample interval of this paper is set as 2011-2020. The main sources of data for this paper are Peking University's digital inclusive finance index, China Rural Statistical Yearbook, and Cathay Pacific database.

3.1.1. Explanatory variable

This study uses the rural revitalization index as its explanatory variable. This paper builds an evaluation system for China's rural revitalization based on research by Xu Xue and Wang Yongyu[13]. It consists of five subsystems, including industrial prosperity, ecological livability, civilization, effective governance, and affluent life, and a total of 30 specific indicators. The weights and rural revitalization index were calculated using the entropy approach.

3.1.2. Core explanatory variables

The development of digital inclusive finance (DFII), which is quantified by the research team at the Digital Finance Research Center of Peking University, serves as the primary explanatory variable in this study. This set of data covers 31 provincial units, 337 prefecture-level cities and about 2,800 counties in Chinese mainland digital inclusive finance index system. The Coverage and Usage indices of the sub-indices will be used for robustness testing. Among them, the Coverage index focuses on the distribution density of Internet users and the coverage of transaction accounts in each region, while the Usage depth focuses on portraying the degree of user participation from online financial services. The digital inclusive finance index, breadth of coverage index, and depth of use index all take logarithms in the empirical operation.

3.1.3. Intermediary variable

The first mediating variable is the level of financial development. This paper uses year-end financial institution loan balances (Debt) to measure the level of financial development of the region, expressed in logarithms. The second mediating variable is the innovation index. The innovation index (INNO) is used to reflect innovation, referring to the construction method of Long et al. The larger the value is, the higher the regional innovation level is indicated.

3.1.4. Control variable

The following are the control variables: Regional GDP is used to determine the economic development level and is stated on a logarithmic scale. Industrial structure, calculated as the difference between the output values of secondary and tertiary industries. Using a logarithmic scale, population density is described. The marketization index is calculated using the marketization level and the statistical bulletin of each prefecture-level city. The marketization level is based on the indicators of marketization of Fan Gang.

3.1.5. Instrumental variable

Although the high-quality development of the economy through other channels is not directly impacted by the Bartik instrumental variable, it is closely tied to the level of digital inclusive financial growth in the region where it is located[14]. This suggests that the potential endogeneity between inclusive digital financial growth and high-quality economic development can be addressed using the Bartik instrumental variable. By removing the confounding effects of other channels, the Bartik instrumental variable allows us to more precisely quantify the effect of digital inclusive financial development on economic high-quality development.

3.1.6. Descriptive statistics for variables

The descriptive statistics of each variable are shown in table 1. From the table below, it can be seen that the rural revitalization index varies greatly among prefectural-level cities, with the minimum value of the index being only 0.0620, which is much smaller than the maximum value of 0.779. This indicates that the development of rural revitalization has already produced large regional differences.

Table 1: Descriptive statistics

Variable	N	Mean	p50	SD	Min	Max.
Rural	2599	0.329	0.357	0.111	0.0620	0.779
lnDFII	2599	5.055	5.217	0.513	2.834	5.766
lnGDP	2599	16.58	16.49	0.874	14.11	19.44
lnDensity	2599	8.025	7.979	0.696	5.733	9.619
lnMAI	2599	2.453	2.468	0.202	1.601	2.980
Indus	2598	1.220	1.125	0.602	0.187	8.802

3.2. Construction of the model

This article establishes the following model to examine the impact of the digital economy on rural revival.

$Rural_{it}$ represents the degree of rural revival in the ith region at time t in the equation above. $DFII_{it}$ stands for the degree of financial inclusion in the digital realm in the ith region at time t. The group of additional control variables affecting $Rural_{it}$ is referred to as $Control_{it}$.The individual fixed effect

and temporal fixed effect are denoted by the letters i and t, respectively. And it represents the phrase for random disruption.

To examine the mechanism of digital inclusive finance driving rural revitalization, we adopt the mediated utility model to test the hypotheses proposed in the previous section and sets up the following model.

In the above formula, formula (2) represents the test of digital inclusive financial index $DFII_{it}$ on the mediating variable M. Formula (3) represents the test of digital inclusive financial index $DFII_{it}$ and the mediating variable M on rural revitalization $Rural_{it}$, in which M includes technological innovation (inno) and financial development level (debt). The specific steps are as follows, if the estimated coefficient α1 of digital inclusive financial index $DFII_{it}$ in equation (1) is significantly positive, we believe there is a significant promotion effect of digital inclusive financial index on rural revitalization of *Rural*, based on this, regression is carried out on equation (2) and (3). If the estimated coefficients β_1 in equation (2) and γ_2 in equation (3) are significant at the same time and in line with theoretical expectations, it means that digital inclusive finance affects rural revitalization through mediating factors.

4. Empirical analysis

4.1. Benchmark regression results

Before regression, it is necessary to choose an appropriate econometric model. Wald test and Hausman test strongly reject the original hypothesis, indicating that the fixed effect model is better than OLS and random effect model. Therefore, the relationship between digital inclusive finance and rural revitalization is empirically analyzed using the individual time two-way fixed effect model.

From table 2, the coefficient of digital inclusive finance affecting rural revitalization is significantly positive regardless of whether the relevant variables are controlled, which suggests that digital inclusive finance can promote the growth of rural revitalization. Digital inclusive finance can compensate for the flaws of traditional finance, provide financial support for rural areas, improve the financial availability of rural residents, rural collectives and rural industries, and thus encourage rural resurgence.

Table 2: Benchmark regression results

	(1)	(2)
variant	Rural	Rural
lnDFII	0.048***	0.008***
	(0.001)	(0.002)
lnGDP		0.015***
		(0.003)
lnDensity		0.001
		(0.002)
lnMAI		0.133***
		(0.009)
Indus		-0.006*** (0.002)
_cons	0.086***	-0.293***
	(0.005)	(0.049)
N	2599.000	2598.000
r2	0.506	0.575

4.2. Regression of intermediation effects

4.2.1. Financial level

Financial level. The first step of the mediation effect test, which examines the direct influence of digital inclusive finance on rural rejuvenation, is represented by columns (1) and (2) in table 3. The second step is to test how the level of regional financial development is impacted by digital inclusive finance. The results are significantly positive, showing that the level of regional financial development will be significantly improved by the development of digital inclusive finance. Columns (5) and (6) are the third step to test the joint impact of digital inclusive finance and microfinance balance on rural revitalization, and the results are significantly positive. It is verified that there is a mediating effect, i.e., digital inclusive finance can promote rural revitalization by increasing the level of regional financial development. Hypothesis 2 of this paper is verified.

Table 3: Intermediation effect regression results: financial level

	(1)	(2)	(3)	(4)	(5)	(6)
	Rural	Rural	lnDebt	lnDebt	Rural	Rural
lnDFII	0.048***	0.008***	0.660***	0.167***	0.033***	0.007***
	(0.001)	(0.002)	(0.013)	(0.029)	(0.002)	(0.002)
lnDebt					0.016***	0.009***
					(0.002)	(0.002)
_cons	0.086***	-0.293***	13.121***	4.520***	-0.315***	-0.334***
	(0.005)	(0.049)	(0.064)	(0.623)	(0.050)	(0.049)
N	2599.000	2598.000	2599.000	2598.000	2599.000	2598.000
r2	0.506	0.575	0.541	0.603	0.534	0.581

4.2.2. Innovation Level

Columns (1) and (2) test the direct effect of digital inclusive finance on rural revitalization.The influence of digital inclusive finance on rural innovation level was examined in columns (3) and (4), and the results are significantly positive at the 1% level, showing that the growth of digital inclusive finance significantly encourages local innovation activity. The combined effects of digital inclusive finance and rural entrepreneurship on rural revitalization are tested in columns (5) and (6), and the findings are strongly favorable. Verification of hypothesis 3 of this research shows that there is a mediating impact, i.e., digital inclusive finance can encourage rural regeneration through increasing rural entrepreneurial activity , as shown in Table 4.

Table 4: Mediated effects regression results: innovation level

	(1)	(2)	(3)	(4)	(5)	(6)
	Rural	Rural	lnINNO	lnINNO	Rural	Rural
lnDFII	0.048***	0.008***	1.332***	0.356***	0.014***	0.012***
	(0.001)	(0.002)	(0.014)	(0.026)	(0.002)	(0.002)
lnINNO					0.025***	0.017***
					(0.001)	(0.002)
_cons	0.086***	-0.293***	-5.584***	-22.323***	0.227***	0.078
	(0.005)	(0.049)	(0.070)	(0.551)	(0.009)	(0.062)
N	2599.000	2598.000	2599.000	2598.000	2599.000	2598.000
r2	0.506	0.575	0.801	0.887	0.568	0.590

4.3. Robustness Check

4.3.1. Substitution of explanatory variables

We replace the explanatory variables with the breadth of coverage and depth of use sub-indexes, respectively, which are the indices that best reflect the development of local digital inclusive finance in addition to the composite indexes, and therefore include them in the robustness test. From column (1) and (2), after the explanatory variable is replaced by the breadth of coverage index, we can see that whether or not control factors are included, its effect on rural revitalization passes the significance test at the 1% level and the coefficient is positive. Meanwhile, columns (3) and (4) show that the explanatory variable remains significant after replacing it with the depth of use index. The robustness test is passed after replacing the variables , as shown in Table 5.

Table 5: Robustness tests: replacement variables

	(1)	(2)	(3)	(4)
	Rural	Rural	Rural	Rural
lnCoverage	0.041***	0.005***		
	(0.001)	(0.002)		
lnDepth			0.045***	0.007***
			(0.001)	(0.002)
_cons	0.123***	-0.317***	0.101***	-0.315***
	(0.005)	(0.046)	(0.005)	(0.045)
N	2599.000	2598.000	2599.000	2598.000
r2	0.434	0.574	0.453	0.576

4.3.2. Winsorizing

It is clear from the preceding descriptive statistics that there are significant differences across the prefecture-level cities for both the explanatory variables and the explained variables. To exclude the influence of outliers, both rural revitalization and digital inclusive finance have been winsorized here. Table 6 shows that the impact of digital inclusive finance on rural revitalization is still significantly positive regardless of the inclusion of control variables. The results after winsorizing passes the robustness test.

Table 6: Robustness tests: winsorizing

	(1)	(2)
	Rural_tr	Rural_tr
lnDFII_tr	0.051***	0.006***
	(0.001)	(0.002)
_cons	0.089***	-0.257***
	(0.005)	(0.049)
N	2599.000	2598.000
r2	0.506	0.580

4.3.3. Endogeneity test

The results of the benchmark regression demonstrate that the promotion of rural revitalization is significantly aided by digital inclusive finance, but this estimation is likely to have endogenous bias for two reasons: first, rural revitalization contains more contents and more factors affecting rural

revitalization, and although some control variables are included, it is impossible to control for all the potentially influential factors. Therefore, there is a possibility of omitted variables, and if the omitted variables are significantly related to digital inclusive finance, it will lead to estimation errors. Second, digital inclusive finance is based on digital technology, which has a big influence on economic development and productivity enhancement. And as an important element of rural revitalization, economic development and productivity enhancement will in turn put higher demands on digital technology. Therefore, there may be reverse causality between digital inclusive finance and rural revitalization. To solve the endogeneity problem caused by omitted variables and reverse causality, instrumental variable method is adopted for further estimation. The results show that the statistic of "Cragg-Donald Wald F" is 4109.525, which is much larger than the 10% significance level critical value (10% maximal IV size: 19.93, 15% maximal IV size: 11.59). The statistic of "Anderson canon. corr. LM" is 1595.294, with a corresponding p-value of 0.000. The former shows that weak instrumental factors are not an important concern, whereas the latter rejects the original claim that the chosen instrumental variables are not identifiable. This indicates that the instrumental variables selected for the study in this paper are appropriate. Based on this, we use the instrumental variable method to obtain the results as shown in table 7, after considering endogeneity, the results are significant at 1% confidence level regardless of whether control variables are included or not , and the promotional effect of digital inclusive finance on rural revitalization still holds.

Table 7: Endogeneity test: instrumental variables approach

	(1)	(2)
	Rural	Rural
lnDFII	0.066***	0.029***
	(0.004)	(0.005)
_cons	-0.007	-0.081
	(0.021)	(0.052)
N	2599.000	2598.000
r2	0.072	0.173

4.4. Heterogeneity test

Table 8: Heterogeneity test

	(1)	(2)	(3)	(4)
	Rural	East	Central	West
lnDFII	0.008***	0.010**	0.002	0.005
	(0.002)	(0.004)	(0.003)	(0.005)
_cons	-0.293***	-0.392***	-0.410***	-0.074
	(0.049)	(0.080)	(0.071)	(0.113)
N	2598.000	930.000	1120.000	548.000
r2	0.575	0.690	0.558	0.489

The provinces in China's eastern and central regions have higher economic development levels, stronger infrastructure, more human capital, and more businesses than the western regions do. The role of digital inclusive finance may also be influenced by local environmental conditions in these regions. Based on the benchmark regression, this study re-estimates the sample into eastern, central, and western cities. Table 8 shows the test findings. The coefficient of digital inclusive finance development in the eastern region is the largest and significantly positive at the 5% level, the coefficient in the central region is smaller and insignificant, and the coefficient in the western region

is positive but insignificant. This means that the effect of digital inclusive finance development on rural revitalization in the prefectures in the central and western regions is not significant. The reason for this result may be the imbalance of credit capital flow and the imbalance of financial infrastructure construction caused by regional development imbalance. Developed regions on the eastern coast have introduced a large number of policies and measures to promote regional financial development, digital inclusive finance to a certain extent to compensate for the "financing difficulties" and "financing expensive" problems of various types of new agricultural business entities at all levels, bringing significant economic dividends. In contrast, the relatively low level of economic development in the central and western regions and the lack of infrastructure make it less attractive to capital and enterprises, which greatly restricts the play of digital inclusive finance. In addition, insufficient financial support and low financial literacy of the population may also be an important reason for the poor results of financial support for agriculture in the central and western regions.

5. Conclusions

Based on the research premise of establishing digital finance for rural revival, this study uses prefecture-level city panel data from 2011 to 2020, constructs an evaluation index system for rural renovation, and evaluates the level of rural renovation in 260 prefecture-level Chinese cities. The influence of the development of digital inclusive finance on rural revival is empirically demonstrated using fixed effect models and mediation effect models. According to the findings, the development of digital finance can considerably support rural renovation. The endogeneity issue has no impact on this promotion effect. Additionally, there is a clear variability in the development of digital finance for supporting rural revitalization. By raising the level of regional financial innovation and growth, digital inclusive finance acts as a powerful vehicle for encouraging rural renovation. The two recommendations below are made in an effort to better encourage rural revival through the development of digital finance.

First, the development of digital inclusive finance should be steadily promoted. The Government needs to consciously guide digital inclusive finance to serve the rural revitalization strategy, and in particular it should attach great importance to the development in less developed regions in the central and western parts of the country. Local governments can use digital information technology to build rural financial and economic service centers, make every effort to meet the financing requirements of various types of financing subjects at all levels, and improve the effectiveness of the use of financial resources in rural areas.

Second, the path of digital inclusive finance to empower rural revitalization should be unblocked. Relevant departments should encourage, support and guide the innovation of enterprises and incorporate it into the transformation process of regional economic development. Especially in the central and western regions, the transformation and upgrading efforts of traditional industries should be accelerated.

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