Digital Inclusive Finance, Industrial Upgrading and Farmers' Income Growth

Ping Yu and Yaqin Feng(✉)

School of Economics, Wuhan University of Technology, Wuhan 430000, China
1395210351@qq.com

Abstract. The interaction mechanism between digital inclusive finance and farmers' income growth is focused on, and the mediating effect of industrial upgrading in it is analyzed. Using provincial panel data from 2011–2018 in China, a fixed-effects model and a mediating-effects model are developed to empirically test the interaction effects and realization paths of digital inclusive finance, industrial upgrading and farmers' income growth. The results show that digital inclusive finance promotes farmers' income growth, and industrial upgrading has a partial mediating effect in the process of digital inclusive finance promoting farmers' income growth, and the ratio of the mediating effect to the total effect is 14.82%, and it is more significant in the central and western regions.

Keywords: digital inclusive finance · industrial upgrading · farmers' income growth

1 Introduction

In recent years, with the rapid development of modern information technology and Internet finance, digital inclusive finance has effectively improved the financial accessibility of disadvantaged groups such as small and micro enterprises and low-income farmers. Theoretically, digital inclusive finance can make basic financial services available to those even in geographically remote rural areas, and enhance the blood-making function of finance for the real economy to a larger extent [1]. However, there are still many issues of concern about the relationship between digital inclusive finance and farmers' income growth; how effective is the effect of digital inclusive finance on farmers' income growth? And what is the interaction mechanism between digital inclusive finance and farmers' income growth? In this context, an in-depth study of the relationship between digital inclusive finance and farmers' income growth can, for one, deepen the understanding of digital inclusive finance; furthermore, it can provide certain theoretical reference and practical reference for realizing rural revitalization and solving the problem of poverty alleviation, which is of great practical significance.

In addition, the impact of upgrading industrial structure on farmers' income growth has been a hot spot of theoretical concern. Upgrading Industrial Structure refers to the process or trend of industrial structure transformation from low-level to high-level [2]. The essence of upgrading industrial structure is to reconfigure various factors of

I. A. Khan et al. (Eds.): HWESM 2023, ASSEHR 760, pp. 243–261, 2023.
https://doi.org/10.2991/978-2-38476-068-8_32

production in society, and ultimately acts on national income distribution. The view that upgrading industrial structure will have an impact on the income growth of urban and rural residents has reached a general consensus in academic circles. However, what is the role of industrial upgrading in digital inclusive finance for farmers' income growth? What is the effect of the role? These questions do not form a unified understanding and require more detailed analysis by scholars. In view of this, this paper mainly selects panel data of 31 Chinese provinces, autonomous regions and municipalities directly under the central government (excluding Hong Kong, Macao and Taiwan) from 2011–2018, and establishes fixed-effects models and mediating-effects models to study the mediating effects of industrial upgrading in the process of digital inclusive finance boosting farmers' income growth, and conducts heterogeneity analysis.

2 Literature Review

The digital era has arrived, and technologies such as big data, cloud computing, and blockchain have made the collection and processing of large amounts of data a reality [3] and are widely used in smart banking [4], financial regulation [5], and smart investment [6]. Meanwhile, the financial industry has undergone a continuous evolution in the digital era, and the current focus has shifted from improving traditional delivery to introducing new business opportunities and models for financial service companies with the value of financial inclusion [7]. The value of inclusive finance is addressed with the Digital Inclusive Finance Index released by Peking University, which also promotes in-depth research on digital inclusive finance on industrial upgrading [8, 9], income growth [10, 11], and income disparity [12, 13], which is the theoretical basis for our analysis of digital inclusive finance, industrial upgrading, and farmers' income growth.

2.1 The Driving Effect of Digital Inclusive Finance on Farmers' Income Growth

Digital inclusive finance has the function and role of low cost, high efficiency, convenient service, and effective information asymmetry mitigation, which can effectively achieve farmers' income growth. The structural and functional imbalance between traditional financial development and farmers' actual needs in China has limited the role of rural finance in promoting rural economic development [14]. Some scholars have found that credit constraints can reverse the entrepreneurial choices of rural households, and digital inclusive finance, which combines digital technology and inclusive financial services, can be more conducive to reducing physical and social costs [15, 16], reducing financial constraints, improving residents' entrepreneurial performance, and achieving farmers' income growth. And abroad in Bangladesh, Sarker S, Ghosh SK, Palit M [18] found that total agricultural production can be promoted by increasing bank agricultural loans, which also has a pulling effect on farmers' income. Meanwhile, some scholars have also found a positive spillover effect of digital inclusive finance on farmers' non-farm income in China through models and indicator systems [19], but disadvantaged households with lower income enjoy significantly lower levels of inclusive finance [20]. Obviously, the study of the driving effect of digital inclusive finance on farmers' income growth and the micro transmission mechanism still needs to be deepened. Based on this, hypothesis H1 is proposed.

H1: The development of digital finance has contributed to the growth of farmers' income.

2.2 The Driving Effect of Digital Inclusive Finance on Upgrading Industrial Structure

The development of traditional finance can promote the flow of capital, optimize the financing environment, and help the development of the industry, thus leading to the upgrading of the regional industrial structure [21, 22]. Based on the digital inclusive finance index [23], Zhang Lin [24] used the SYS-GMM method for empirical evidence and found that digital finance can promote the upgrading of county industries through four aspects: financial supply, demand pull, factor allocation, and innovation and entrepreneurship. With the development of inclusive finance, financial services cover all aspects from urban to remote rural areas, but due to the differences in basic conditions such as natural environment, institutional environment and development stage in different regions, the impact of digital inclusive finance on upgrading industrial structure shows threshold effect and regional heterogeneity [25], for example, digital inclusive finance can promote upgrading industrial structure in non-poor counties, but its effect on relatively poor counties [8]. The effect is not significant for relatively poor counties. Cheng Y. [26] pointed out that digital finance can more effectively promote the inclusive development of the financial industry and achieve the matching between financial capital and industrial capital required by the real economy.

2.3 The Incentive Effect of Upgrading Industrial Structure on Farmers' Income Growth

Cao F. and Nie Y. [27] found that upgrading industrial structure has incentive effects on farmers' income mainly in two dimensions: rationalization and advanced, among which, structural adjustment changes in secondary and tertiary industries are the central force affecting income distribution [28]. And the rise of the proportion of non-agricultural industries can provide non-agricultural employment opportunities to the remaining agricultural labor force, pull up farmers' income and narrow the income gap between urban and rural residents. The structural adjustment of industries gives rise to the integration of rural industries, and industrial integration can influence farmers' income increase through industrial extension, industrial integration, industrial crossover and technological penetration [29]. At the same time, due to economic conditions constraints, the promotion effect of industrial upgrading on farmers' income increase shows heterogeneity, for example, the promotion effect is larger in economically developed countries such as coastal areas, but this promotion effect is somewhat suppressed in less economically developed counties [30]. Based on this, hypotheses H2 and H3 are proposed.

H2: The development of industrial upgrading has contributed to the growth of farmers' income.

H3: The development of digital finance has promoted industrial upgrading, which in turn has contributed to farmers' income growth.

Besides, the development of digital finance in China still faces some urgent issues, on the one hand, the interaction between digital finance and traditional financial sector,

real economic development, financial risk, regulatory innovation and other impact mechanisms; on the other hand, how to develop a monetary policy framework and establish a reasonable business model for digital currency [31].

Through combing the existing literature, the innovative contributions of this paper can be divided into the following three points: first, this paper establishes a sound mechanism to analyze the logical relationship among digital inclusive finance, county industrial upgrading and farmers' income growth. Second, on the basis of sorting out the theoretical relationship between the three, an empirical study is conducted using panel data for eight years from 2011 to 2018 for 31 provinces, autonomous regions and municipalities directly under the central government (excluding Hong Kong, Macao and Taiwan) in China to test the impact of digital inclusive finance on farmers' income growth and the realization path. Third, referring to the regional division of Han L. and Du C. (2012) [32], the full sample is divided into eastern, central, and western regions for heterogeneous research ① with a view to providing empirical evidence for the development of differentiated digital inclusive finance development strategies.

3 Conduction Mechanism

3.1 The Direct Impact of Digital Inclusive Finance on Farmers' Income

Digital financial inclusion reduces the cost of financial institutions' services. Traditional financial services have high access conditions, and due to cost and location, remote rural areas are unable to popularize outlets and thus cannot access the funds brought by the corresponding services, so that poverty still exists. With the continuous development of digital technology, new ways of payment and saving have arisen in residents' lives, and they can quickly handle financial services with the help of the Internet and mobile terminals, which greatly reduces time costs and operation costs. Meanwhile, digital inclusive financial services through big data and information technology can effectively reduce the cost of funds among financial service providers and enhance the convenience level of residents' payments. In short, digital inclusive financial services realize low-cost financial services, which not only effectively reduce the cost of financial services for rural households, but also increase the enthusiasm of financial institutions to provide corresponding services.

Digital inclusive finance has broadened the coverage of financial services. In view of the poor credit environment in remote rural areas of China, rural residents with lower education level and more backward economic status are also often reluctant to take the initiative to accept financial services, resulting in financial exclusion. The combination of finance and the Internet helps alleviate the geographical exclusion and condition exclusion suffered by remote rural areas, and to a certain extent improves financial inclusion, allowing more subjects to more easily access the financial services they need.

Digital inclusive finance has improved the risk control capability of financial institutions. With the advent of the era of big data, the traditional way of information collection has been transformed. Digital inclusive finance has improved the risk control capability of financial institutions by establishing risk assessment models through digital technologies such as big data and cloud computing, and conducting data collection and credit assessment of users. For example, Ant Financial Services conducts credit assessment of

rural users based on Alibaba's transaction data, enabling financial institutions to identify and improve financial support to rural residents with sufficient credit, which is conducive to solving the problem of difficult loans for rural residents. The improved risk control capability provides support for building a comprehensive credit collection system, which is more helpful to rural residents who are at a credit disadvantage under the traditional financial environment.

Digital inclusive finance shortens the time of financial service supply. Digital inclusive finance can shorten the time of financial services, simplify the process of financial services and improve the efficiency of financial services. The traditional financial system has cumbersome financial service processes and decentralized financial service departments, so residents often take a long time to complete a financial service, and some applicants, especially agricultural operators, sometimes miss the best investment and production opportunities due to events.

3.2 Indirect Impact of Digital Inclusive Finance on Farmers' Income Generation

Digital inclusive finance has promoted the optimization of industrial structure. First, digital finance enriches the variety of traditional financial products and stimulates the financial demand of residents. Financial demand refers to people's desire to obtain the financial products they need and have the purchasing power in the financial market. Second, digital finance influences the accumulation and flow of capital, enabling relevant institutions to form credit expansion mechanisms and expand the scale of industry, which in turn promotes the optimization of industrial structure. Thirdly, science and technology is the first productive force, and digital finance can help high-tech enterprises raise more capital and help them invest more funds in technological innovation, which in turn promotes high-quality industrial development. In conclusion, stimulating financial demand, increasing capital accumulation and innovating science and technology can have a greater impact on industrial structure upgrading.

Digital inclusive finance has improved the matching between industry and capital demand. Diversified consumer demand fuels the supply of diverse industrial chains. Thanks to the iterative optimization and rapid upgrading of algorithms and computer technology, digital inclusive finance can take advantage of data acquisition, evaluation processing and matching to quickly and accurately match the various demand ends of the industrial chain, provide timely and effective support for industrial development with funds and deeply compatible digital financial services, and then make reasonable and efficient deployment of financial resources to promote industrial optimization and upgrading.

Digital inclusive finance increases industrial capital accumulation. The main contribution on the road to industrial upgrading in China still comes from the huge mobilization and input of capital and other factors, and capital accumulation remains a strong foundation to support the optimal development of industry. With the development of new financial service models represented by digital inclusive finance, the construction of China's multi-level capital market has been improved and the accumulation of capital in the financial system has been enhanced. During the development of digital inclusive finance, financial institutions carrying out related businesses complete the formation and initial accumulation of capital through deposit-taking, and adjust the amount of factor

inputs regarding the optimal capital required by enterprises to carry out production, thus strengthening the allocation function of resources, and the reasonable deployment of credit funds is conducive to industrial structure upgrading.

Digital financial inclusion advances industrial technology innovation. Schumpeter (1939) pointed out that innovation is the source of economic development. Technological innovation acts on the intrinsic mechanism of industrial structure change, and is a strong driving force and specific path for industrial structure optimization. Compared with traditional finance, digital inclusive finance has comparative advantages. While having a profound impact on technological innovation in the financial service industry, it significantly improves the external financing environment of enterprises, promotes efficient R&D investment, technological innovation and industrial total factor productivity improvement at the enterprise level under the synergy of spatial knowledge spillover, and promotes the overall optimization and upgrading of industrial chain and industrial structure.

In general, digital inclusive finance can reduce the threshold effect of finance by reducing service costs, mitigate the financial exclusion effect by expanding the scope of services and improving the risk control capability of financial institutions, or indirectly act on rural areas by improving the upgrading of county industries, thereby increasing the income of rural residents. The transmission mechanism of digital inclusive finance affecting farmers' income increase is shown in Fig. 1.

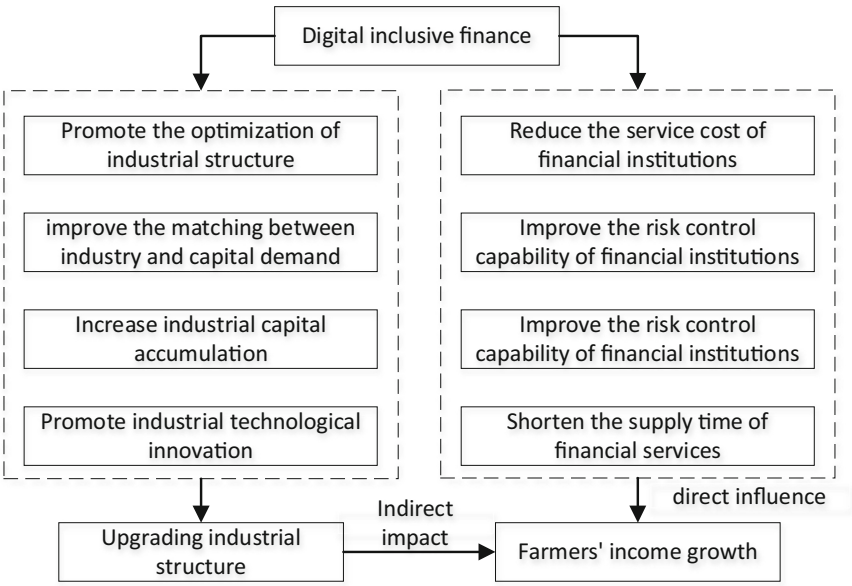

Fig. 1. Mechanistic analysis of digital inclusive finance, county industrial upgrading, and farmers' income growth

4 Study Design

4.1 Model Setting

(1) Digital Finance and Farmers' Income. To explore the impact of digital finance on farmers' income, the following model is set in this paper.

$$FIL_{i,t} = \alpha_0 + \alpha_1 DFI_{i,t} + \alpha_k X_{i,t} + \varepsilon_{i,t} \tag{1}$$

where $FIL_{i,t}$ denotes the income level of rural residents; $DFI_{i,t}$ denotes the level of digital financial inclusion development; $X_{i,t}$ denotes the control variables; $\varepsilon_{i,t}$ denotes the random error term; subscript *i,t* denotes the region and time, respectively. If α_1 is significantly positive, it means that the development of digital finance significantly contributes to farmers' income growth, i.e., H1 is supported by empirical evidence.

(2) Upgrading industrial structure and farmers' income. To explore the impact of industrial upgrading on farmers' income, the following model is set in this paper.

$$IS_{i,t} = \beta_0 + \beta_1 FIL_{i,t} + \beta_k X_{i,t} + \varepsilon_{i,t} \tag{2}$$

where $IS_{i,t}$ represents industrial upgrading. If β_1 is significantly positive, it means that the development of industrial upgrading significantly promotes farmers' income, i.e., H2 is empirically supported.

(3) Mechanism of action test. To test the mechanism of the effect of digital finance on farmers' income, industrial upgrading was used as the mediating variable, the following regression model was established to test the mediating effect, drawing on the ideas and methods of Wen Zhonglin et al. [33] and Lu Caimei et al. [34] (Fig. 2 shows the corresponding path diagram).

$$IS_{i,t} = \gamma_0 + \gamma_1 DFI_{i,t} + \gamma_k X_{i,t} + \varepsilon_{i,t} \tag{3}$$

$$FIL_{i,t} = \delta_0 + \delta_1 DFI_{i,t} + \delta_2 IS_{i,t} + \delta_k X_{i,t} + \varepsilon_{i,t} \tag{4}$$

First, on the basis that model (1) holds, the relationship between digital finance and industrial upgrading is tested using model (3), and if γ_1 is significantly positive, it indicates that the development of digital finance significantly promotes industrial upgrading. Second, digital finance (DFI) and industrial upgrading (IS) are regressed on

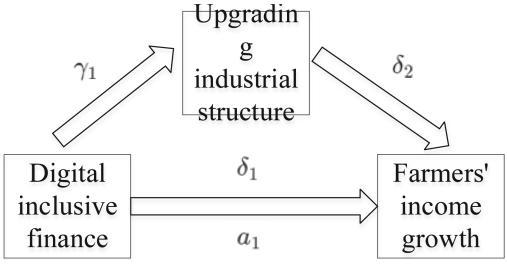

Fig. 2. Schematic diagram of the intermediary model

farmers' income (FIL) as independent variables in model (4) simultaneously, and if the coefficient δ_2 is significantly positive, the mediating effect is significant. Finally, the focus is on δ_1. If δ_1 is significant and $\delta_1 < \alpha_1$, it is called partially mediated; if δ_1 becomes no longer significant, it is called fully mediated.

4.2 Variable Definition and Data Source

Explanatory variable: per capita disposable income of rural residents (FIL). With reference to the current common practice in academia, the per capita disposable income of rural residents in each province and city from 2011–2018 is selected to measure the level of farmers' income, and the data are obtained from the China Rural Statistical Yearbook from 2012–2019. It is worth noting that the statistical caliber of the China Rural Statistical Yearbook has changed since 2013, but the calculation method has not changed significantly, with 2011–2012 being the net income of rural residents and 2013–2018 being the disposable income of rural residents. Therefore, this study continues to use the income of both calibers, collectively referred to as the per capita disposable income of rural residents.

Explanatory variables: Digital Financial Inclusion (DFI), which is measured by the Digital Financial Inclusion Index published by the Digital Finance Research Center of Peking University, currently the most authoritative and most used in China, including indicators of 3 dimensions: breadth of digital financial coverage, depth of digital financial use, and degree of digitization.

Upgrading industrial structure (IS), this paper adopts the upgrading industrial structure coefficient as a measure of industrial upgrading, drawing on Shi Enyi (2018) and others, with a view to more intuitively reflecting the level of industrial structure in each county.

$$IS = y_1 * 1 + y_2 * 2 + y_3 * 3 \tag{5}$$

where, y_n denotes the share of value added of the nth industry, 1 corresponds to the primary industry, 2 corresponds to the secondary industry, and 3 corresponds to the tertiary industry.

Referring to the existing literature, the following control variables are mainly selected in this paper: (1) the level of economic development (GDP), the level of economic development in different regions of China has variability, so it is expected that economic growth is conducive to promoting farmers' income. The regional GDP per capita is selected to measure the local economic development level. (2) The intensity of financial support to agriculture (GE), the proportion of general public budget expenditure to regional GDP in each region is used as a proxy indicator, the larger this indicator is, the greater the intensity of financial services. (3) Informationization level (TX), using the number of cell phone subscribers in each region as a proxy and taking the natural logarithm. (4) Financial development level (FD), measured by the year-end loan balance of financial institutions/regional GDP, the larger the value of this indicator, the higher the level of financial development. (5) Investment level (TZ), using the total investment in fixed assets of the whole society in each region as a proxy, and taking the natural logarithm to process. (6) Education development level (EDU), the improvement of education

level can improve the quality of human capital and increase the income of residents. Considering that the development of education affects residents' employment choices and thus their income levels, the number of junior high school students per 100,000 people in the total population of each region is selected to measure the level of education development in a region. The data of control variables were mainly obtained from the China Statistical Yearbook and China County Statistical Yearbook (County and City Volume) from 2011–2018. The definitions and descriptions of all variables are detailed in Table 1.

Due to some missing data, the data in this paper were processed using the forward/backward fill-in method and the mean method, using data from one time point forward or backward. Since the Digital Finance Institute of Peking University only published the county digital financial inclusion index from 2014–2018, the sample time span of this paper's study is 2014–2018, and the total data sample is $1138 \times 5 = 5690$. Data

Table 1. Variable definitions and descriptions

Variable Type	Variable Name	Variable Code	Variable Description
Explained variables	Farmers' income	FIL	Per capita disposable income of rural residents (unit: yuan)
Explanatory variables	Digital Finance	DFI	Total Digital Inclusive Finance Index
	Industrial upgrading	IS	Industrial structure upgrade factor
Control variables	Economic Development Level	GDP	Regional GDP per capita (unit: yuan)
	Financial support for agriculture	GE	GDP General public budget expenditure/regional GDP
	Informatization level	TX	Number of cell phone subscribers in the region (Unit: Department)
	Level of financial development	FD	GDP Year-end balance of loans from financial institutions/regional GDP
	Investment Level	TZ	Total regional social fixed asset investment (unit: yuan)
	Education Development Level	EDU	Number of junior high school students per 100,000 population (unit: persons)

Table 2. Results of descriptive statistical analysis of variables

Variables	Mean	Standard deviation	Min	Max	Skewness	Kurtosis	Median
FIL	9.2579	0.3909	8.2711	10.3214	0.1599	2.9715	9.2571
DFI	5.0936	0.7141	2.7862	6.0168	−1.2802	4.0791	5.3427
IS	5.4634	0.0529	5.3660	5.6369	1.0740	4.3049	5.4564
GDP	10.7622	0.4304	9.7073	11.8548	0.3660	2.7028	10.6891
GE	0.2809	0.2125	0.1100	1.3800	3.6806	17.8520	0.2300
TX	5.3986	0.1560	4.7987	5.7065	−0.5970	3.6935	5.4093
FD	9.3281	0.3372	8.3100	10.0539	−0.1050	2.8436	9.3284
TZ	18.4705	1.0997	14.6063	20.2623	−1.2154	4.3534	18.6940
EDU	8.0570	0.3092	7.1115	8.7236	−0.7321	3.5360	8.0961

of a few districts and counties come from local government work reports or official websites, individual missing data were complemented by interpolation method. The results of descriptive statistical analysis of all variables are shown in Table 2.

4.3 Empirical Analysis

4.3.1 Correlation Analysis of Variables

Table 3 shows the correlation coefficients and their significance test results among the main variables in this paper. The correlation coefficient between digital finance and farmers' income is 0.726 and passes the significance test at the 1% level, which partially verifies the H1 of this paper, that is, the development of digital finance promotes the growth of farmers' income. Industrial upgrading and farmers' income are significantly positively correlated at the 1% level, and the correlation coefficient reaches 0.524, indicating that the development of industrial upgrading promotes farmers' income growth, and H2 is confirmed. Meanwhile, digital finance and industrial upgrading are significantly positively correlated at the 1% level, with the correlation coefficient reaching 0.264. H3 of this paper is partially supported, but the mediating role of industrial upgrading between digital finance and farmers' income needs to be further verified. In addition, the control variables in this paper, except for education level, are all significantly and positively correlated with farmers' income and pass the significance test at the 1% level, indicating that the level of economic development, financial support for agriculture, informationization level, financial development level and investment level all play a positive role in promoting farmers' income in China. Among them, the level of education is significantly and negatively correlated with farmers' income, probably because the increase of education cost affects the income level of farmers.

Table 3. Correlation analysis of variables

	FIL	DFI	IS	GDP	GE	TX	FD	TZ	EDU
FIL	1								
DFI	0.726***	1							
IS	0.524***	0.264***	1						
GDP	0.890***	0.522***	0.578***	1					
GE	0.324***	−0.076	0.136***	−0.376***	1				
TX	0.353***	0.607***	−0.018	0.274***	−0.218***	1			
FD	0.458***	0.415***	0.451***	0.412***	−0.003	0.407***	1		
TZ	0.428***	0.343***	−0.214***	0.371***	−0.772***	0.313***	0.000	1	
EDU	−0.696***	−0.326***	−0.514***	−0.778***	0.284***	−0.019	−0.412***	−0.228***	1

Note: * * *, * * and * represent the significance levels of 1%, 5% and 10% respectively. (The same below)

4.3.2 Analysis of Regression Results

(1) Digital Finance and Farmers' Income

Table 4 shows the regression results of digital finance and farmers' income. As can be seen from column (1) of Table 4, without adding any control variables, the regression coefficient of digital finance on farmers' income is 0.324 and passes the 1% significance test; after adding a series of control variables, the fit of the model improves, and the regression coefficient of digital finance is still significantly positive at the 1% level, and H1 is supported by empirical evidence. Further, from column (2) of Table 4, it can be seen that for every 1 unit increase in digital finance, the per capita income of farmers will increase by about 0.073 units on average, and the rapid development of digital finance is important to solve the long-standing problem of farmers' income in China.

(2) Industrial upgrading and farmers' income

Table 5 shows the regression results of industrial upgrading and farmers' income. As can be seen from column (1) of Table 5, without adding any control variables, the regression coefficient of industrial upgrading on farmers' income is 2.570 and passes the 1% significance test; after adding a series of control variables, the fit of the model improves and the regression coefficient of industrial upgrading is still significantly positive at the 1% level, and H2 is empirically supported. Further, from column (2) of Table 5, it can be seen that for every 1 unit increase in industrial upgrading, the per capita income of farmers will increase by about 0.527 units on average, and the rapid development of industrial upgrading is conducive to solving the long-standing problem of farmers' income in China.

(3) Mechanism of action test

Table 6 shows the results of the mediating effect test. From column (1) of Table 6, the regression coefficient of digital finance on farmers' income is 0.073 and passes the 1% significance test; from column (2), the regression coefficient of digital finance

Table 4. Regression results of digital finance and farmers' income

Variables	FIL	
	(1)	(2)
DFI	0.324*** (0.008)	0.073*** (0.014)
GDP		0.550*** (0.053)
GE		0.679*** (0.207)
TX		0.248*** (0.069)
FD		0.124*** (0.035)
TZ		0.147*** (0.032)
EDU		−0.076 (0.049)
Constant term	7.606*** (−0.040)	−1.826*** (0.616)
Observations	248	248
Adjustment R^2	0.887	0.965
F-value	1694.85***	802.83***

Note: Robust standard errors are indicated in parentheses. (Same below)

promotes industrial upgrading at the 1% level; in column (3), both digital finance and industrial upgrading are put into the model to regress with farmers' income. The results show that the regression coefficient of digital finance is 0.062 at the 1% level of significance, which is significantly lower than in column (1) (from 0.073 to 0.062). In summary, some mediating effects of industrial upgrading in the relationship between digital inclusive finance and farmers' income growth do exist, and the ratio of the mediating effect to the total effect is calculated to be 14.82% (0.026 * 0.416/0.073 * 100% = 14.82%). Meanwhile, to enhance the reliability of the model, the Sobel test is included in the last column of Table 6. In which, the Z-value of Sobel is 1.173 and is significantly positive at the 1% level, and the mediating effect passes the significance test. Therefore, H3 is empirically supported.

(4) Heterogeneity analysis

To further investigate whether there is regional heterogeneity in the mediating effect of digital finance affecting farmers' income through industrial upgrading, the sample is divided according to the east, middle and west. As can be seen from Table 7, the test results in the east, central and west are basically consistent with the whole

Table 5. Regression results of industrial upgrading and farmers' income

Variables	FIL	
	(1)	(2)
IS	2.570*** (0.5565)	0.527*** (0.118)
GDP		0.594*** (0.053)
GE		0.962*** (0.204)
TX		0.327*** (0.069)
FD		0.135*** (0.036)
TZ		0.212*** (0.029)
EDU		0.179*** (0.046)
Constant term	−4.783 (-3.089)	−5.774*** (0.827)
Observations	248	248
Adjustment R^2	0.087	0.964
F-value	20.65	802.83

country, i.e., the effect of digital inclusive finance on the income growth of rural residents in different regions of China is significant, which confirms the robustness of the obtained findings. Among them, the impact of digital inclusive finance is the largest in the central region and the smallest in the eastern region, indicating that there is regional variability in the impact of digital inclusive finance index on farmers' income. Meanwhile, the impact of industrial upgrading is the largest in the western region and the smallest in the eastern region, indicating that there is regional variability in the mediating effect of industrial upgrading on farmers' income. In the central and western regions, where the economy is less developed, the financial infrastructure is backward, and the degree of openness to the outside world is lower, digital inclusive finance is more conducive to alleviating the uneven development of traditional finance, so that residents in the backward rural areas also have the opportunity to participate in finance, thus promoting their income increase. Therefore, in terms of poverty alleviation, the central and western regions are likely to achieve a bend in the road with the help of digital inclusive finance, which also proves that digital inclusive finance is conducive to alleviating the unbalanced and insufficient problems existing among regions in China.

Table 6. Results of intermediate effect test

Variables	(1)	(2)	(3)
	FIL	IS	FIL
DFI	0.073*** (0.014)	0.026*** (0.008)	0.062*** (0.014)
IS			0.416*** (0.115)
GDP	0.550*** (0.053)	0.002 (0.031)	0.549*** (0.052)
GE	0.679*** (0.207)	−0.134 (0.121)	0.736*** (0.202)
TX	0.248*** (0.069)	−0.045 (0.040)	0.267*** (0.067)
FD	0.124*** (0.035)	0.009 (0.020)	0.120*** (0.034)
TZ	0.147*** (0.032)	−0.014 (0.019)	0.153*** (0.031)
EDU	−0.076 (0.049)	0.029 (0.029)	−0.088 (0.049)
Constant term	−1.826*** (0.616)	−5.513*** (0.358)	−4.120*** (0.874)
Observations	248	248	248
Adjustment R^2	0.965	0.106	0.967
F-value	802.83***	3.56	768.88***
Sobel test			1.173*** (0.00)

Note: The Sobel test reports the z-value of the mediated effects test, with the p-value in parentheses. (Same below)

4.3.3 Robustness Tests

First, the variable substitution method. The depth index is used to measure digital finance, and the sum of the value added of secondary and tertiary industries as a proportion of regional GDP is used to measure industrial upgrading. Second, the method of excluding extreme values. In order to exclude the bias of extreme values on the regression results, the sample data are shrunken and the relationship between digital finance, industrial upgrading and farmers' income is re-estimated. The results of the above two tests did not change substantially, i.e., the findings of the previous study are robust and reliable.

Table 7. Results of heterogeneity analysis

Variables	Eastern Region			Central Region			Western Region		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
	FIL	IS	FIL	FIL	IS	FIL	FIL	IS	FIL
DFI	0.075***	0.046**	0.067***	0.094***	−0.006	0.098***	0.093***	0.012	0.082***
	(0.018)	(0.008)	(0.018)	(0.022)	(0.005)	(0.022)	(0.025)	(0.011)	(0.024)
IS			0.152			0.661			0.763***
			(0.115)			(0.612)			(0.273)
GDP	0.735***	−0.086*	0.748***	0.495***	0.086***	0.438***	0.877***	0.111*	0.792***
	(0.046)	(0.031)	(0.047)	(0.120)	(0.026)	(0.131)	(0.144)	(0.063)	(0.139)
GE	0.306	−0.166	0.331	2.118***	0.164	2.009***	0.699*	0.009	0.692*
	(0.319)	(0.121)	(0.318)	(0.652)	(0.142)	(0.659)	(0.367)	(0.161)	(0.348)
TX	0.276**	−0.128	0.295***	0.593***	0.074*	0.544***	0.047	−0.182**	0.186
	(0.110)	(0.040)	(0.111)	(0.177)	(0.039)	(0.183)	(0.162)	(0.071)	(0.162)
FD	0.401***	−0.004	0.401***	0.055	0.008	0.049	0.059	0.001	0.058
	(0.062)	(0.020)	(0.062)	(0.072)	(0.016)	(0.072)	(0.059)	(0.026)	(0.056)
TZ	−0.008	−0.012	−0.006	0.013	0.006	0.008	0.002	−0.018*	0.016
	(0.013)	(0.019)	(0.013)	(0.018)	(0.004)	(0.019)	(0.022)	(0.010)	(0.022)
EDU	−0.044**	−0.026	−0.040**	0.014	−0.016	0.025	0.014	−0.027	0.034
	(0.018)	(0.029)	(0.018)	(0.056)	(0.012)	(0.057)	(0.072)	(0.031)	(0.069)
Constant term	−3.859***	7.408***	−4.986***	−1.045	4.049***	−3.723	−1.912*	5.734***	−6.288***
	(0.758)	(0.358)	(1.136)	(1.004)	(0.219)	(2.674)	(1.018)	(0.446)	(1.842)
Observations	248	248	248	248	248	248	248	248	248
Adjustment R^2	0.981	0.124	0.982	0.967	0.840	0.968	0.960	0.163	0.965
F-value	525.38***	1.41	464.89***	236.13***	42.12***	207.38***	217.76***	1.75	212.06***
Sobel test			0.258***			1.438***			−0.323***
			(0.00)			(0.00)			(0.00)

5 Conclusion

As the industrial economy is an important component of national economic development, it is also the concentration area of the "three rural issues" and the main battlefield of relative poverty management. It is of great practical significance to study the relationship between digital inclusive finance, industrial upgrading and farmers' income growth to promote rural economic growth and relative poverty management. Based on panel data of 31 provinces, autonomous regions and municipalities directly under the central government (excluding Hong Kong, Macao and Taiwan) in China from 2011 to 2018, this paper establishes a fixed-effects model to empirically test the impact of digital inclusive finance on industrial upgrading and farmers' income growth and the mediating effect of industrial upgrading on the relationship between digital inclusive finance and farmers' income growth.

(1) Digital inclusive finance has a facilitating effect on both farmers' income growth and industrial upgrading, and this facilitating effect is greater in the central and western regions than in the eastern regions.
(2) In the process of digital inclusive finance advancing farmers' income growth, industrial upgrading plays a part of the mediating effect, that is, digital inclusive finance partly promotes farmers' income growth directly and partly promotes farmers' income growth indirectly through industrial upgrading.
(3) The mediating effect of industrial upgrading in digital inclusive finance and farmers' income growth is the largest in the central and western regions and the smallest in the eastern regions.
(4) Factors such as the level of economic development, financial support to agriculture, informationization level, financial development level and investment level all affect farmers' income growth.

Based on the above conclusions, the author believes that to promote the stable growth of farmers' income through the development of digital inclusive finance, it is necessary not only to take multiple measures to continuously improve the development level of digital inclusive finance to release its direct effect on farmers' income growth, but also to continuously accelerate the industrial transformation and upgrading in collaboration with multiple parties to give full play to the indirect effect of industrial upgrading on farmers' income growth. Specifically, we can start from the following aspects:

(1) Improve the construction of infrastructure for digital inclusive finance. In addition to the necessary township banks and loan companies, modern Internet banks need to be established to realize the informatization of rural data, enabling banks to lend more scientifically and rationally to help rural SMEs and poor individual households to overcome difficulties.
(2) Industrial restructuring for remote rural areas in central and western China. On the one hand, develop the integration of rural primary, secondary and tertiary industries, and establish a joint meeting mechanism for agricultural industrialization in central and western provinces to work together and improve efficiency; on the other hand, carry out technology sharing, develop multiple related industries at the same time, and incentivize urban enterprises to share non-critical core digital technologies with

rural enterprises through commendation and other reward policies, so as to achieve a win-win situation of reputation enhancement of urban enterprises and technological progress of rural enterprises, and ultimately achieve the increase of farmers' income.

(3) Increase financial support for rural education. The level of knowledge not only affects the popularity of digital finance, but also the technological innovation of the industry, which is one of the important influencing factors to change the low income in rural areas, however, the high cost of education becomes a major barrier. On the one hand, the government can increase preferential subsidies for education and reward farmers who send their children to school; on the other hand, the government should increase policy subsidies for teachers who teach in rural areas, and provide financial support and employment incentives for teachers who have taught for more than a certain number of years.

Note

① The eastern region includes 11 provinces and municipalities directly under the central government: Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan. The central region includes 8 provinces and municipalities directly under the central government: Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan. The western region includes 12 provinces and municipalities: Inner Mongolia Autonomous Region, Guangxi Zhuang Autonomous Region, Chongqing Municipality, Sichuan Province, Guizhou Province, Yunnan Province, Tibet Autonomous Region, Shaanxi Province, Gansu Province, Qinghai Province, Ningxia Hui Autonomous Region and Xinjiang Uygur Autonomous Region.

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