



*Research article*

## **Does digital finance benefit the income of rural residents? A case study on China**

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**Abstract:** Rural residents' income is one of the core issues of rural economic development, and digital financial inclusion is one of the important influencing factors of rural residents' income. Especially under the background of the implementation of digital financial technology, the relationship between the two has become more complex. Based on the panel data set of 1624 counties in Chinese mainland in the past 2014–2019 years, the paper uses panel regression models to study the impact of digital financial inclusion on rural residents' income. Further, by analyzing the industrial structure, education level and financial development level, the following conclusions are drawn. First, digital financial inclusion significantly promotes the increase of rural residents' income, but there are differences in regional level and different quantiles of rural residents' income. At the regional level, the promotion of control effect at the provincial level is stronger than that at the county level; in different quantiles of residents' income, with the increase of residents' income quantile, the promoting effect is gradually enhanced. Second, the heterogeneous impact of digital financial inclusion on rural residents' income is reflected in three aspects: regional development, education level and financial development level. Third, industrial structure, education level and financial development level will enhance the promotion effect of digital financial inclusion on rural residents' income, but there are significant differences in the intensity of the regulatory effect of the three variables.

**Keywords:** digital financial inclusion; rural residents' income; industrial structure; education level; financial development level

**JEL Codes:** G00

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## 1. Introduction

### 1.1. Background and research motivation

With the acceleration of urbanization, the income gap between urban and rural residents has become one of the common problems in the development stage of various countries, and the income of rural residents, as an important part of this problem, will naturally receive extensive attention. As an important statistical index, rural residents' income can comprehensively reflect the changes of rural residents' income and quality of life, provide a reasonable judgment basis for monitoring rural poverty alleviation, and help governments at all levels and macro decision-making departments to study and formulate corresponding rural economic policies and development strategies. Everyone should enjoy financial services equally. Both urban and rural residents need financial service products such as deposits, loans and insurance. Due to the nature of traditional finance as an industry aimed at maximizing profits, as well as practical problems such as scattered rural population, severe aging, and general lack of collateral for small businesses and farmers, it is difficult for most countries to place many financial service products in vulnerable groups such as microenterprises, rural residents and the poor. For making various groups equally enjoy rich financial services and meet their financial service needs, inclusive finance was born. The United Nations put forward the concept of Inclusive Finance as early as the "International Year of microcredit" in 2005, which means that it can effectively, conveniently and comprehensively provide a complete financial service system for all people and groups in society. With the deep integration of Finance and technology, the term "digital financial inclusion" was officially put forward for the first time at the G20 summit in 2016, which generally refers to all actions to promote inclusive finance through the use of digital financial services, including the use of digital financial services to promote inclusive finance, using digital technology to provide a series of formal financial services for groups who cannot access or lack financial services (Liu et al., 2021). It combines traditional inclusive finance with advanced big data technology, and has the characteristics of convenience, low threshold and low cost, which also provides new ideas and measures for the problem that traditional finance cannot be widely popularized in rural areas.

In view of the inclusiveness of digital financial inclusion, its target groups are mainly vulnerable groups such as small and micro enterprises and rural residents. With the help of Internet, cloud computing, big data and other digital tools, digital financial inclusion effectively reduces the supply cost of financial services for rural residents and other groups, reduces the threshold of financing and entrepreneurship for rural residents, makes rural residents and other groups more convenient and effectively enjoy financial services, and helps them use science and technology finance to improve their labor income (Yu et al., 2020). Therefore, digital financial inclusion can provide abundant funds and advanced technical support for rural residents, creating favorable conditions for improving the income of rural residents. As one of the largest agricultural countries in the world, China's rural residents account for about 41% of the total population, and nearly 500 million people are farmers. Chinese government has continuously strengthened the construction of digital countryside, promoted the development of digital financial inclusion in rural areas, overcome the problems of agriculture, rural areas and farmers, and actively implemented the strategy of Rural Revitalization in recent years. Based on this, taking the relationship between digital financial inclusion and rural residents' income in China as an example, we can fully reflect the relationship between them.

## 1.2. Literature review and contribution

The existing literature mainly focuses on the analysis of the influencing factors of urban and rural residents' income, the relationship between residents' income and traditional finance, and the relationship between digital financial inclusion and rural development. Scholars mainly focus on the following four aspects to explore the income of rural residents and digital financial inclusion.

The first is to study the relevant influencing factors of rural residents' income. Based on the panel data of China's household finance surveys in 2013, 2015 and 2017 and the digital financial inclusion index developed by Peking University, Li et al. (2019) studied the impact of digital financial inclusion on Residents' consumption. The results show that digital financial inclusion can promote residents' consumption, and the asset level can be obtained through heterogeneity analysis. Different levels of financial literacy will affect this promotion (Li et al., 2019). Based on the provincial panel data set of China from 2000 to 2013, Han et al. (2021) studied the relationship between non-agricultural industry development and rural residents' income through panel model. The results show that the development of non-agricultural industry can promote the increase of rural residents' income, and this promotion effect has regional heterogeneity. The income of rural residents depends more on the development of non-agricultural industry in the central and western regions than in the eastern regions (Han et al., 2021). Ao et al. (2021) took 1325 farmers' situations in Lin'an City, China as the research sample, and used the intermediary effect model to analyze the influencing factors of farmers' income level. The study found that the organizational model is an important factor affecting farmers' income level, and access to credit and other financial services, farmers' education level can effectively promote the improvement of rural residents' income (Ao et al., 2021). Taking the data of various countries from 2000 to 2009 as the research sample, Yang and Wang used the fixed effect model to analyze the impact of financial development on the income of urban residents. The results show that financial development promotes the increase of residents' income, and there is regional heterogeneity in the impact of financial development on residents' income (Yang and Wang, 2012). Based on the cross-sectional data of 2037 counties in 30 provinces in China in 2010, Wang et al. (2018) used quantile regression method to study the relationship between credit constraints, credit adjustment and sustainable growth of farmers' income. The empirical results show that credit constraints and adjustment have a significant heterogeneous impact on Farmers' income. Bank credit significantly promotes the income level of farmers with higher income, but may inhibit the income level of farmers with lower income (Wang et al., 2018). Based on the cross-sectional data of 853 counties in 11 western provinces of China, Wang and Liu (2018) used quantile regression and instrumental variable quantile regression to analyze the impact of fiscal expenditure and agricultural loans on the income of rural residents. The empirical results show that there is an inverted "U" relationship between agricultural loans and rural residents' income, and fiscal expenditure will hinder the development of rural residents' income (Wang and Liu, 2018). Wang and Hu (2018) estimated the impact of trade liberalization on rural poverty probability and income level of rural poor residents by using Probit-model according to the survey data of Chinese household panel research. The results show that trade liberalization can effectively reduce the poverty probability of rural residents and increase the income of rural poor residents by promoting economic growth, fiscal expenditure and other transmission mechanisms (Wang and Hu, 2018).

The second is to explore the relationship between digital financial inclusion and rural employment and poverty alleviation. Wang and He (2020) used the survey data of 1900 rural families to analyze the economic impact of digital financial services on poor rural residents in China. The results show

that the proportion of farmers using digital financial services is 35.63%, and digital financial services can effectively reduce the impact of poverty on rural residents. Further investigation found that the impact of digital financial services on Farmers' assets is greater than that of traditional financial services such as banks (Wang and He, 2020). According to forty countries' panel data, Geng and He (2020) adopts the instrumental variable method and the 2SLS model to explore the impact of digital financial inclusion on the sustainable employment in Brazil and other countries. The results show that digital finance significantly promotes the sustainable employment of low-income economies, and has a more significant impact on the employment of high-income economies (Geng and He, 2020). Based on the household panel survey data of 21 provinces in China from 2010 to 2016, Yang and Fu explored the relationship between the development of Inclusive Finance and the income of the poor people with different working abilities in rural China. The results showed that there were differences in the poverty alleviation effect of the development of inclusive finance among the poor people with different working abilities. Moreover, the choice of service objects of financial institutions also has a certain impact on this (Yang and Fu, 2019). Based on the data of China Household Finance Survey in 2015, Song et al. (2020) measured the access to financial services from a micro perspective, constructed a digital finance index system, and studied the impact of digital Finance on Rural households according to these indicators. The results show that digital financial inclusion can significantly affect rural families and poor families (Song et al., 2020). Liu et al. (2020) used Chinese household panel research database and intermediary effect model to analyze the poverty reduction effect of digital information technology on different groups. The research shows that the poverty reduction effect of digital information technology on different income groups is significantly different, especially for low-income groups, and the use of digital information technology helps to improve the poverty situation of all groups (Liu et al., 2020).

The third is to explore the relationship between digital financial inclusion and urban-rural income gap. The urban-rural income gap is influenced by digital financial inclusion by Yu and Wang using estimation method and LSDV model, based on the panel data set of 25 provinces in 2014–2018 Chinese mainland in the past 25 years in China. The and model is used to analyze the impact of digital financial inclusion on the income gap between urban and rural residents. They found that digital financial inclusion is conducive to narrowing the disposable income gap between urban and rural residents, mainly by narrowing the wage gap to narrow the total income gap, which helps alleviate poverty and promote economic growth (Yu and Wang, 2021). Based on the data of Guizhou Province in China from 2007 to 2017, the vector autoregressive model is used to construct the inclusive finance index system, and through a series of econometric tests, the relationship between Inclusive Finance and urban-rural income gap in Guizhou is analyzed. It is found that there is a one-way causal relationship between Inclusive Finance and urban-rural gap, and Inclusive Finance will inhibit the expansion of urban-rural income gap (Chen and Ni, 2018). Based on the statistical data of Heilongjiang Province from 1978 to 2008, Tong and Li (2011) explored the influencing factors of the income gap between urban and rural residents by using multiple linear regression model. The empirical results show that the urban-rural dual economic structure and industrial structure will expand the urban-rural income gap, while the level of urbanization and rural financial development will narrow the income gap between urban and rural residents (Tong and Li, 2011). Based on the panel data of 24 provinces in China from 2000 to 2015, Li et al. (2017) used the semi parametric additive model to explore the relationship between rural financial development and rural residents' income gap. The empirical results show that rural financial

development will expand the income gap of rural residents, and they show a “V” shaped nonlinear relationship in the short term (Li et al., 2017). Based on the relevant data from 1978 to 2015, Li et al., (2018) used VAR model to explore the relationship between rural financial scale, financial efficiency and financial risk. The research shows that expanding the scale of rural finance and agricultural financial investment can significantly promote the increase of rural residents’ income, and rural financial efficiency will inhibit rural residents’ income (Li et al., 2018). Based on provincial panel data, Rahman et al. (2019) used quantile regression model to explore the impact of financial development on the income of residents of different income classes. the empirical results show that there is an inverted “U” relationship between financial development and the annual income of different income groups, in which the impact on low-income groups is the greatest, and the balanced financial development helps to narrow the income gap (Rahman et al., 2019). Based on the regional panel data from 2010 to 2018, Li (2020) used fuzzy k-means clustering algorithm to explore the impact of financial industry development and the income gap between urban and rural residents. The empirical results show that the financial scale of the financial industry has a significant impact on the urban-rural income gap (Li, 2020). Based on the panel data set of China from 2007 to 2011, Tan and Yuan (2013) used the dynamic panel model estimated by GMM to explore the relationship between agricultural insurance and urban-rural income gap. The study found that the development of agricultural insurance significantly narrowed the income gap between urban and rural areas by increasing the income of rural residents (Tan and Yuan, 2013). Zhou et al. (2015) took the provincial panel data set of China from 1978 to 2013 as the research sample, and used the fixed effect model to analyze the impact of financial development on the urban-rural income gap. The empirical results show that there is an inverted “U” relationship between financial scale and urban-rural income gap. Improving financial efficiency can significantly narrow the urban-rural income gap (Zhou et al., 2015).

Fourth, exploring the relationship between digital financial inclusion and rural residents’ income. Luo et al. (2021) defined and measured the digital financial capability through the Chinese household financial survey data in 2017. The research found that the development of digital financial capability helps to improve the living standards of vulnerable groups such as rural and underdeveloped areas, and concluded that digital financial capability has significant positive significance on enterprise ownership, financial performance and other indicators (Luo et al., 2021). Based on the survey data of 988 farmers in poor counties in China, Liu et al. (2021) analyzes the impact of Inclusive Finance on Farmers’ entrepreneurial activities in poor rural areas in China. The survey found that Inclusive Finance has a positive impact on Farmers’ entrepreneurial decision-making, and this entrepreneurial model will also improve farmers’ income level (Liu et al., 2021). Gulizhaer et al. (2018) took China’s rural areas as the research object, compiled a structured questionnaire to obtain rural data to analyze farmers’ financing willingness and related financial analysis of Inclusive Finance. The research results found that the improvement of the level of Inclusive Finance can improve farmers’ financial benefits and risks, and the embeddedness of social enterprises will significantly reduce this financial risk, Improve financial returns (Gulizhaer et al., 2018). Based on the panel data of 30 provinces in Chinese mainland in 2005–2017 years, Liu et al. (2021) adopted fixed effect model to explore financial support, Internet technology citation and rural residents’ income. The results show that financial support and Internet popularization significantly promote the income of rural residents. Further analysis shows that digital financial inclusion can help solve the problems of traditional finance in rural areas and improve the income of rural residents (Liu et al., 2021).

Therefore, based on existing studies, this paper adopts panel OLS estimation method to explore the impact and mechanism of digital financial inclusion on rural residents' income by using panel data of 1624 counties in Mainland China from 2014 to 2019. Compared with previous studies, the marginal contribution of this paper is mainly reflected in the following three aspects: First, this paper explores the impact of digital financial inclusion on the income of rural residents at county level through China's county data. China's county data are mainly rural data, which is in line with the vulnerable groups that digital financial inclusion focuses on, thus enriching the research topics in this field. This paper tests the hypothesis that digital financial inclusion promotes the increase of rural residents' income through quantile regression and panel OLS estimation, which provides deeper empirical support for other countries to promote the development of digital financial inclusion in rural areas. Second, this paper further explores the heterogeneous impact of digital financial inclusion on rural residents' income. Due to China's vast territory and obvious differences in resource endowment, there are differences in rural economic development, education level and financial development level among counties. This may lead to differences in the impact of digital financial inclusion on the income of rural residents in different regions. Therefore, this paper uses sub-sample regression to test the heterogeneous impact of digital financial inclusion on rural residents' income, which is mainly reflected in regional differences in resource endowment, education level and financial development level. Thirdly, this paper explores the digital financial inclusion impact on rural residents' income mechanism, through the industrial structure, education level and financial development level closely related to rural residents' income were selected as adjusting variables, found the three variables to digital financial inclusion regulation affect the adjustment of the rural residents' income have positive effect. Finally, this paper verifies the robustness of the conclusion by two-stage least square method. This paper is divided into five parts: the second part is the introduction of theory and the description of research methods; the third part is the empirical results and analysis; the fourth part is further discussion; the fifth part is the conclusion.

## **2. Materials and methods**

### *2.1. Theoretical analysis and research hypothesis*

Digital financial inclusion with the characteristics of digitization can break the time and space constraints of traditional finance through Internet technology, big data analysis and other tools, effectively reduce the cost and threshold of financial services, and expand the coverage and use of financial services in rural areas. digital financial inclusion well explains the original intention and goal of financial technology and is a digital way for the poor who have long been excluded by the modern financial service industry to enjoy formal financial services (Xie et al., 2020). Rural residents can share convenient, safe, low-cost and low threshold financial services through digital finance, and arrange the use of funds in a planned way so that creating more profits. On the one hand, for the residents engaged in planting and breeding in rural areas, their agricultural production cycle is long and the capital turnover is large. The emergence of digital financial inclusion can effectively alleviate the financial pressure of this type of rural residents, design appropriate financial products for them, and provide kinds of financial help, so that rural residents can further expand the production scale, increase the agricultural output value, and then improve the income of rural residents (Tan and Yuan, 2013). On the other hand, for residents who start businesses in rural areas, they also need a lot of funds to invest in entrepreneurial activities. Because rural residents generally lack collateral and deposit and loan records of the same value, it is

difficult for traditional financial institutions to evaluate their credit and ensure their capital needs. digital financial inclusion can comprehensively evaluate the credit of such residents through tools such as big data and the Internet, give rural residents a reasonable loan range, reduce the risks of financial institutions and rural residents, and meet the financing needs of rural entrepreneurs (Xie et al., 2020). Therefore, digital financial inclusion mainly makes it easier for financial services to enter the countryside by reducing transaction costs and the threshold of financial services, so that rural residents can experience more preferential and safe formal financial services and obtain more financial support, which can improve the income of rural residents. Therefore, hypothesis 1 is proposed as follows:

Hypothesis 1: Digital financial inclusion can promote the increase of rural residents' income.

Due to the imbalance and insufficiency of China's regional economic development, there are great differences in rural development level, industrial structure, education level of rural residents and financial development level among various regions, resulting in differences in rural residents' income among different regions. The development of digital financial inclusion also has regional heterogeneity. From the three dimensions of coverage, use depth and digital level of digital financial inclusion, there are also obvious differences in the development of digital financial inclusion in various regions (Gulizhaer et al., 2018). In general, areas with higher education level of rural residents are easier to improve the financial knowledge and financial literacy of the residents, which helps to solve the problem of difficult popularization of Finance in rural areas and better enjoy digital inclusive financial services from rural residents. Therefore, digital financial inclusion can play a stronger role in areas where rural residents have higher education, drive regional economic development and promote the improvement of residents' income level (Li et al., 2020). Compared with areas with high financial development level, digital financial inclusion is more conducive to alleviate the unbalanced development of traditional finance in rural areas in areas with underdeveloped economy and low financial development level, so that residents in rural areas have more opportunities to participate in financial activities and enjoy formal financial services. Therefore, it can increase residents' income in the area with low financial development level (Zhong and Xiong, 2019). Based on this, hypothesis 2 is proposed as follows:

Hypothesis 2: There is heterogeneity in the promotion effect of digital financial inclusion on rural residents' income, which is mainly reflected in the differences in resource endowment, education level and financial development level among county.

According to the development of digital financial inclusion, it can provide a lot of financial capital for rural areas. Local-residents and enterprises can enjoy better financial services and obtain more financial support, which promotes the transformation and upgrading of rural industrial structure and turns to secondary and tertiary industries with high added value, which is conducive to expanding employment and Entrepreneurship in rural areas, which can increase the income of rural residents (Liu, 2009). At the same time, more capital inflows can drive the infrastructure construction and talent education in rural areas, improve the education level of rural residents, gradually increase the attention and demand of rural residents for digital financial inclusion, and more effectively aggravate the role of digital financial inclusion in promoting the income of rural residents (Ao et al., 2021). The digital technologies brought by digital financial inclusion, such as artificial intelligence, cloud computing, blockchain and big data, can more effectively spread financial knowledge and the importance of financial products, improve the local financial development level, enhance the risk prevention and control ability of financial institutions, and reduce the marginal cost of the dissemination and implementation of financial services in rural areas,

Make rural residents enjoy richer, more convenient and more affordable financial services to meet their personalized needs, which helps to improve the income of rural residents (Ren et al., 2018).

Hypothesis 3: Industrial structure will intensify the promotion of digital financial inclusion on the income of rural residents.

Hypothesis 4: Education level will enhance the promotion effect of digital financial inclusion on rural residents' income.

Hypothesis 5: The level of financial development will improve the role of digital financial inclusion in promoting the income of rural residents.

## 2.2. Research methods

The focus of this paper is to explore the impact of digital financial inclusion on the income of rural residents. Specifically, by testing the impact of Peking University digital financial inclusion index on the income of rural residents in the county, this paper analyzes the regulatory effect of digital financial inclusion on the income of rural residents with industrial structure, education level and financial development level as intermediary variables. Based on the availability of data, the research sample of this paper is 1624 counties in 27 provinces and municipalities in Chinese mainland. Due to the strong heterogeneity of county and rural areas and the missing variables caused by individual changes, this paper controls the individual effect by adding the county's individual virtual variables and dividing 1624 county and rural areas into 27 provinces. At the same time, considering the time trend of rural residents' income in each county with time, time dummy variables are added to the model to control the time trend effect. Based on the panel data of 1624 rural areas in China, and after passing the Hausman test, this paper adopts panel OLS regression model and fixed effect model, and takes model (1) and model (2) as the benchmark model to test whether there is an impact relationship between digital financial inclusion and rural residents' income, and whether there is heterogeneity in this impact relationship, which can verify Hypothesis 1,2.

$$IRR_{it} = \alpha_0 + \alpha_1 DIF_{it} + \sum_j^N \beta_j CV_{ijt} + \tau_i + \gamma_t + \mu_{it} \quad (1)$$

$$IRR_{it} = \alpha_0 + \alpha_1 DIF_{it} + \sum_j^N \beta_j CV_{ijt} + \varepsilon_S + \gamma_t + \mu_{it} \quad (2)$$

Based on models (1)–(2), this paper further analyzes the regulatory effect of industrial structure level, education level and financial development level on the impact of digital financial inclusion on rural residents' income by adding the interactive terms of digital financial inclusion and industrial structure level, education level and financial development level as models (3)–(8), which can verify Hypothesis 3–5.

$$IRR_{it} = \alpha_0 + \alpha_1 DIF_{it} + \alpha_2 FIS_{it} + \sum_j^N \beta_j CV_{ijt} + \tau_i + \gamma_t + \mu_{it} \quad (3)$$

$$IRR_{it} = \alpha_0 + \alpha_1 DIF_{it} + \alpha_2 FIS_{it} + \sum_j^N \beta_j CV_{ijt} + \varepsilon_S + \gamma_t + \mu_{it} \quad (4)$$



$$IRR_{it} = \alpha_0 + \alpha_1 DIF_{it} + \alpha_2 FEL_{it} + \sum_j^N \beta_j CV_{ijt} + \tau_i + \gamma_t + \mu_{it} \quad (5)$$

$$IRR_{it} = \alpha_0 + \alpha_1 DIF_{it} + \alpha_2 FEL_{it} + \sum_j^N \beta_j CV_{ijt} + \varepsilon_S + \gamma_t + \mu_{it} \quad (6)$$

$$IRR_{it} = \alpha_0 + \alpha_1 DIF_{it} + \alpha_2 FFD_{it} + \sum_j^N \beta_j CV_{ijt} + \tau_i + \gamma_t + \mu_{it} \quad (7)$$

$$IRR_{it} = \alpha_0 + \alpha_1 DIF_{it} + \alpha_2 FFD_{it} + \sum_j^N \beta_j CV_{ijt} + \varepsilon_S + \gamma_t + \mu_{it} \quad (8)$$

In the above model,  $IRR_{it}$  represents the income of rural residents in county  $i$  in year  $t$ ;  $DIF_{it}$  represents digital financial inclusion level of county  $i$  in year  $t$ ;  $FIS_{it}$  represents the interaction term between digital financial inclusion and industrial structure in county  $i$  in year  $t$ , Specifically  $FIS_{it} = DIF_{it} * IS_{it}$ ;  $FEL_{it}$  represents the interaction item between digital financial inclusion and agricultural innovation level in county  $i$  in year  $t$ , specifically  $FEL_{it} = DIF_{it} * EL_{it}$ ;  $CV_{ijt}$  represents the  $j$ -th control variables of county  $i$  in year  $t$ ; coefficient ( $i=1,2,3$ ) is the key parameter in this paper;  $\tau_i$  indicates the individual fixed effect,  $\varepsilon_S$  indicates the provincial individual fixed effect;  $\gamma_t$  indicates the time effect;  $\alpha_0$  is a constant term,  $\mu_{it}$  is random interference term.

### 2.3. Variable description and data sources

The explanatory variable of this paper is the income of rural residents, which mainly emphasizes the level of rural per capita income, reflecting the development of rural economy and the basic living standard of rural residents. When analyzing the income of rural residents at the provincial and municipal level, many scholars often consider using the per capita disposable income of rural residents to measure the income level of rural residents. The research object of this paper is 1624 counties in China. In view of the relevant data of the statistical yearbook of China and the statistical yearbooks of individual provinces and cities, the income of rural residents is measured by the ratio of the gross domestic product and the registered residence population in the county area.

The core explanatory variable of this paper is digital financial inclusion, which is characterized by the digital financial inclusion index of Peking University at the county level from 2014 to 2019 (Guo et al., 2020). The index is measured by multi-dimensional indicators such as the scope, breadth, depth and digitization level of digital financial inclusion, which can effectively reflect the development level of local digital financial inclusion.

Digital financial inclusion can bring abundant funds for rural development, rural industrial structure and financial development level will change, and the education level of rural residents will gradually rise, and these three factors are closely related to the income of rural residents (Ao et al., 2021). Therefore, this paper selects industrial structure, education level and financial development level as regulatory variables to further analyze how digital financial inclusion affects rural residents' income. The industrial structure is measured by the ratio of the added value of the tertiary industry to the sum of the added value of the primary and secondary industries. The level of education is depicted according to the ratio of the number of students in the middle school to the registered residence population. The ratio of the sum of the balance of savings deposits of county residents and the balance of loans of financial institutions at the end of the year to GDP is used to measure the level of financial development.

For controlling the impact of other characteristics at the county level on the income of rural residents, referring to the research and analysis of many scholars and the availability of variable data (Wang and Liu, 2016; Wang et al., 2018), this paper mainly selects indicators such as financial support for agriculture, non-agricultural employment, communication development, rural welfare and rural medical treatment. The specific characterization of control variables is detailed in Table 1.

In view of the availability of data, this paper selects the six-year panel data of 1624 counties in China from 2014 to 2019 as the research sample. There are too many missing variable data in some counties and rural areas, so that the data cannot be consistent, and finally deleted. For the missing data of individual county rural areas, this paper uses interpolation method to supplement it. The data of the research variables in this paper comes from the statistical yearbook of China's counties and the statistical yearbooks of provinces, regions and cities. See the data sources in Table 1 for specific information.

**Table 1.** Variable characterization and data source of this paper.

Variable	Abbreviation	Characterization variable	Source
Income of rural residents	IRR	Ratio of gross domestic product to population in rural areas	China county statistical yearbook, provincial statistical yearbook
digital financial inclusion	DIF	Peking University Digital inclusive financial index	China Peking University Digital inclusive financial index
Level of financial support for agriculture	FSA	Ratio of general budget expenditure to regional GDP	China county statistical yearbook, provincial statistical yearbook
Financial development level	FDL	Ratio of the sum of the balance of residents' savings deposits and the balance of various loans of financial institutions at the end of the year to GDP	China county statistical yearbook, provincial statistical yearbook
industrial structure	IS	Ratio of added value of tertiary industry to the sum of added value of primary and secondary industries	China county statistical yearbook, provincial statistical yearbook
Nonagricultural employment level	NAEL	The ratio of the number of employees in the second, third industry to the number of registered residence population in rural areas	China county statistical yearbook, provincial statistical yearbook
Agricultural development level	ADL	Ratio of area occupied by facility agriculture to administrative area	China county statistical yearbook, provincial statistical yearbook
Education level	EL	Ratio of students in ordinary secondary schools to registered residence population	China county statistical yearbook, provincial statistical yearbook
Communication development level	CDL	Number of fixed telephone users	China county statistical yearbook, provincial statistical yearbook
Rural welfare level	RWL	Number of social welfare adoptive units	China county statistical yearbook, provincial statistical yearbook
Rural medical level	RML	Number of beds in medical and health institutions	China county statistical yearbook, provincial statistical yearbook

The descriptive statistics of the variables studied in this paper are recorded in Table 2, which includes the whole sample of China, eastern region, central region and western region. In order to eliminate the heteroscedasticity of data, this paper preprocesses the relevant variable data, and takes the natural logarithm of the variables whose data form is absolute number.

**Table 2.** Descriptive statistics of variables.

VarName	Full sample			Eastern Region			Central region			Western Region		
	Obs	Mean	SD	Obs	Mean	SD	Obs	Mean	SD	Obs	Mean	SD
IRR	974 4	38703.8 6	35933.4 8	300 0	46390.7 7	39971.4 3	372 6	38358.4 5	38017.7 6	301 8	31489.2 3	26193.9 5
DIF	974 4	0.86	0.24	300 0	0.90	0.23	372 6	0.86	0.24	301 8	0.81	0.25
FSA	974 4	0.29	0.23	300 0	0.21	0.13	372 6	0.27	0.17	301 8	0.41	0.30
FDL	974 4	1.57	0.76	300 0	1.58	0.73	372 6	1.51	0.81	301 8	1.62	0.71
IS	974 4	0.74	0.44	300 0	0.73	0.29	372 6	0.71	0.49	301 8	0.78	0.48
NAEL	974 4	0.27	0.15	300 0	0.32	0.17	372 6	0.27	0.15	301 8	0.23	0.11
ADL	974 4	0.01	0.13	300 0	0.02	0.24	372 6	0.01	0.02	301 8	0.00	0.01
EL	974 4	0.04	0.01	300 0	0.04	0.02	372 6	0.04	0.01	301 8	0.05	0.01
CDL	974 4	45822.1 7	56626.6 6	300 0	68925.8 9	73510.6 7	372 6	39711.0 9	49437.0 9	301 8	30400.9 4	33930.6 1
RWL	974 4	18.84	28.35	300 0	24.66	38.71	372 6	19.67	24.55	301 8	12.04	16.76
RML	974 4	2013.03	1488.34	300 0	2298.79	1579.19	372 6	2055.35	1444.53	301 8	1676.73	1379.03

It is worth noting that in the above variable data, through the variable correlation test, there is no multicollinearity problem between variables. The data form of rural residents' income, communication development level, rural welfare level and rural medical level is absolute, but they are not treated by logarithm in descriptive statistics.

### 3. Empirical results and analysis

#### 3.1. Econometric testing of baseline models

##### 3.1.1. Full sample baseline regression

Based on the benchmark regression model (1)–(2), this paper uses panel OLS estimation and fixed effect model to conduct benchmark regression analysis to explore the impact of digital financial inclusion on rural residents' income. The regression results of the baseline model are shown in Table 3, where Columns (1) shows as the regression results without adding time and individual control effect, and Columns (2)–(4) show the panel OLS regression results that control the individual effect of the county, the fixed effect model regression results and the panel OLS regression results that control the individual effect of the province.

**Table 3.** Full sample baseline regression results for mainland China.

	OLS (1) lnIRR	OLS (2) lnIRR	FE (3) lnIRR	OLS (4) lnIRR
DIF	1.0210*** (61.2512)	0.1837*** (9.8718)	0.1837*** (9.0648)	2.2783*** (47.6788)
FSA	-1.3243*** (-41.8867)	-0.6165*** (-29.8699)	-0.6165*** (-13.5934)	-1.2528*** (-40.9454)
FDL	-0.2698*** (-32.7319)	-0.2898*** (-59.7371)	-0.2898*** (-26.8738)	-0.2701*** (-33.7187)
IS	0.0647*** (4.7352)	-0.0603*** (-7.8408)	-0.0603*** (-5.7580)	-0.0060 (-0.4923)
NAEL	1.0485*** (28.8399)	0.1565*** (8.8304)	0.1565*** (3.8529)	0.8961*** (26.9071)
ADL	1.4203*** (7.0432)	0.0843 (0.7598)	0.0843 (0.6892)	-0.6718*** (-3.4312)
EL	2.2084*** (6.5869)	1.3025*** (6.3410)	1.3025*** (4.5837)	3.6961*** (12.0006)
lnCDL	0.1285*** (23.2553)	0.0155*** (4.7229)	0.0155*** (4.1759)	0.0520*** (9.5152)
lnRWL	-0.0690*** (-15.1907)	0.0011 (0.4477)	0.0011 (0.4501)	-0.0344*** (-8.2534)
lnRML	-0.3111*** (-42.0304)	0.0476*** (6.1228)	0.0476*** (4.7450)	-0.2257*** (-31.8434)
Individual effect	NO	YES	YES	YES
Time effect	NO	YES	YES	YES
_cons	10.9533*** (168.4996)	10.0770*** (149.5055)	9.9220*** (102.4827)	10.4945*** (178.6084)
N	9744	9744	9744	9744

Note: t statistics in parentheses; \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

According to Table 3, the estimated regression coefficients of the variable DIF are significantly positive at the level of 1% in Columns (1)–(4). These empirical results show that digital financial inclusion significantly promotes the improvement of rural residents' income. Through the comparison of the estimated regression coefficients of DIF in Columns (2)–(4), it shows that under the condition of controlling different individual effects, the promotion effect of digital financial inclusion on rural residents' income is different, and the promotion effect of provincial level is greater than that of county level.

### 3.1.2. Full sample quantile regression

For reflecting the trend of digital financial inclusion in different quantiles of rural residents' income, based on model (2), this paper selects five quantiles of 5%, 25%, 50%, 75%, 95% for regression. The specific regression results are shown in Table 4.

**Table 4.** Quantile regression results of full sample in mainland China.

	5% (1)	25% (2)	50% (3)	75% (4)	95% (5)
	lnIRR	lnIRR	lnIRR	lnIRR	lnIRR
DIF	1.7353*** (15.5018)	2.0026*** (27.9719)	2.2825*** (37.8887)	2.3656*** (34.4653)	2.4875*** (18.4199)
FSA	-1.6886*** (-18.5474)	-1.5276*** (-25.4872)	-1.3168*** (-33.5036)	-1.1785*** (-33.4724)	-1.0703*** (-25.8800)
FDL	-0.2142*** (-14.4014)	-0.2416*** (-21.5340)	-0.2719*** (-28.0667)	-0.2884*** (-31.5993)	-0.3060*** (-26.0935)
IS	0.0427** (2.2684)	0.0060 (0.4385)	-0.0134 (-0.9343)	-0.0327** (-2.2277)	-0.0534*** (-2.7803)
NAEL	0.5025*** (9.4189)	0.6861*** (15.3989)	0.7914*** (19.7463)	0.9129*** (21.5275)	1.0282*** (14.3172)
ADL	-0.2848 (-0.9107)	-0.1822 (-0.9593)	-0.5282** (-2.2386)	-0.8182*** (-3.0838)	-0.1650 (-0.3138)
EL	1.0957** (2.3227)	1.7991*** (4.6275)	2.0982*** (5.8354)	4.3327*** (10.3681)	6.8001*** (10.5375)
lnCDL	0.0014 (0.2119)	0.0223*** (4.1946)	0.0453*** (6.8711)	0.0721*** (7.5617)	0.0849*** (5.7553)
lnRWL	-0.0046 (-0.9021)	-0.0222*** (-5.0386)	-0.0294*** (-6.6327)	-0.0435*** (-5.9923)	-0.0737*** (-5.9582)
lnRML	-0.2067*** (-19.5722)	-0.2288*** (-25.6219)	-0.2341*** (-27.0938)	-0.2348*** (-23.1198)	-0.2102*** (-11.7789)
Individual effect	YES	YES	YES	YES	YES
Time effect	YES	YES	YES	YES	YES
_cons	10.8015*** (93.8724)	10.8554*** (138.0831)	10.7030*** (149.8615)	10.5271*** (124.4257)	10.5277*** (77.2894)
N	9744	9744	9744	9744	9744

Note: t statistics in parentheses; \* p < 0.1, \*\* p < 0.05, \*\*\* p < 0.01.

It can be seen from Table 4 that the estimated regression coefficients of the variable DIF are significantly positive at the level of 1% in Columns (1)–(5). These empirical results show that under different quantiles, digital financial inclusion significantly promotes the increase of rural residents' income. By comparing the estimated regression coefficient of DIF in Columns (1)–(5), it is found that the promotion effect of digital financial inclusion on rural residents' income is different under different quantiles, and the promotion effect is gradually enhanced with the increase of quantile.

Based on the empirical results in Table 3 and Table 4, from the perspective of digital financial inclusion, the sign of the estimated coefficient of the mean regression and quantile regression is positive, and the size of the estimated coefficient of the variable DIF will increase with the increase of the quantile. Thus, the development of digital financial inclusion can effectively promote the increase of rural residents' income, and this effect is gradually strengthened. On the other hand, it also shows that the relationship between digital financial inclusion and rural residents' income is stable and long-term.

Further analysis of the above results may have the following reasons. Firstly, the promotion of digital financial inclusion in rural areas can reduce the cost of financial services. Through advanced digital technology and the Internet, digital financial inclusion can effectively solve the limitations of traditional finance in rural development, reduce the cost of financial institutions opening physical outlets in rural areas, and improve the coverage of financial services, so that financial institutions can better serve rural residents and provide them with more high-quality financial and financial products, which is conducive to improving the income of rural residents. Secondly, the infrastructure construction in rural areas, the scale expansion of local enterprises, and the transformation and upgrading of rural industrial structure require a large amount of capital injection (Gorelick and Walmsley, 2020). Digital financial inclusion can provide enough financial assistance for rural development, accelerate the construction of rural roads and water conservancy facilities, better support the development of local enterprises, accelerate the speed of industrial structure transformation and upgrading, which can promote the economic development of rural areas and improve the income of rural residents (Li and Li, 2020). In addition, speeding up the infrastructure construction in rural areas and reducing the cost of material transportation will help to attract foreign direct investment, create more employment opportunities for rural residents, and improve the income of rural residents. With the development of digital financial inclusion in rural areas, the residents can enjoy more scientific and humanized financial services. This helps to broaden rural residents' lending channels and solve their small micro-credit problems. The more preferential, safer formal financial services and digital information technology can encourage rural residents to actively start businesses, expand the scale of rural industries, improve industrial output, and ultimately increase income (Kemfert and Schmalz, 2019). Therefore, digital financial inclusion can indeed promote the increase of rural residents' income, and this promotion will increase with the improvement of digital financial inclusion. Based on this, Hypothesis 1 is valid. Digital financial inclusion can promote the increase of rural residents' income.

### 3.2. *Heterogeneity test*

#### 3.2.1. Regional heterogeneity analysis

Exploring the heterogeneous impact of digital financial inclusion on the income of rural residents in different regions is helpful for the government to implement targeted policies and measures for

different regions, so as to effectively improve the promotion effect of digital financial inclusion on the income of rural residents. Due to China's vast territory and significant differences in resource endowment, there are differences in economic development, education level and financial development level in rural areas of different counties. This may lead to the heterogeneous impact of digital financial inclusion on the income of rural residents in different regions. Therefore, after passing the measurement test of the benchmark model, this paper needs to further analyze the heterogeneous impact of digital financial inclusion on rural residents' income (Li et al., 2020). In the regional heterogeneity test, the whole sample of mainland China is divided into eastern, central and western regions. Based on the benchmark regression model (1), this paper adopted OLS panel estimation and fixed effect model for sample regression analysis. The specific regression results are shown in Table 5. Columns (1)–(2) in Table 5 are listed as the empirical results of the whole sample, Columns (3)–(4) as the empirical results of the eastern region, Columns (5)–(6) as the empirical results of the central region, and Columns (7)–(8) as the empirical results of the eastern region.

**Table 5.** Regional regression results.

	OLS (1)	FE (2)	OLS (3)	FE (4)	OLS (5)	FE (6)	OLS (7)	FE (8)
	lnIRR	lnIRR	lnIRR	lnIRR	lnIRR	lnIRR	lnIRR	lnIRR
DIF	0.1837***	0.1837***	-0.0292	-0.0292	0.3154***	0.3154***	0.2090** *	0.2090***
	(9.8718)	(9.0648)	(-0.6992)	(-0.8846)	(7.1333)	(7.9011)	(6.7625)	(7.6447)
Variable control	YES	YES	YES	YES	YES	YES	YES	YES
Individual effect	YES	YES	YES	YES	YES	YES	YES	YES
Time effect	YES	YES	YES	YES	YES	YES	YES	YES
_cons	10.0770** *	9.9220***	9.6983** *	10.4321** *	10.0768** *	10.1780** *	9.7282** *	9.9663***
	(149.5055)	(102.4827)	(51.4858)	(69.8535)	(64.7910)	(91.4316)	(86.7353)	(107.0933)
N	9744	9744	3000	3000	3726	3726	3018	3018

Note: t statistics in parentheses; \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

It can be seen from Table 5 that the estimated regression coefficients of the variable DIF are significantly positive at the level of 1% in Columns (1)–(2) and Columns (5)–(8). In Table 5, Columns (3)–(4) show that the regression coefficient of variable DIF estimation is not significant and negative. According to the results, digital financial inclusion has heterogeneous effects on rural residents' income in different regions. From the regional perspective, digital financial inclusion significantly promotes the increase of rural residents' income in the central and western regions, and has no significant effect on rural residents' income in the eastern region. From the size of the variable DIF estimation coefficient, the impact of digital financial inclusion on rural residents' income in the central and western regions is greater than that in China, especially in the central region.

Firstly, from the eastern region, the impact of digital financial inclusion on rural residents' income in the eastern region is not significant, which can explain that the level of digital financial inclusion in

the eastern region has little impact on rural residents' income. On the one hand, according to the "China County Statistical Yearbook" data for 2014–2020, the per capita annual income of county household registration residents in the eastern region in 2014–2019 reached 46390.77 yuan in the past five years, compared with 38358.45 and 34489.27 yuan in the central and western regions, respectively. On the other hand, from the digital inclusive financial index of Peking University, the average value of the eastern rural areas in the past five years is 89.87, while the central and western regions are only 85.57, 81.06. Through the above data can be found that the level of economic development and digital financial inclusion in eastern rural areas are much higher than the other two areas. Therefore, it is difficult for digital financial inclusion to promote all-round development of rural areas in the short term through capital and digital technology support in the eastern rural areas, resulting in the situation that digital financial inclusion has no significant impact on rural residents' income in the eastern region. Secondly, combined with the characteristics of the central and western regions to analyze, digital financial inclusion has a significant role in promoting the income of rural residents in the central and western regions. This may be due to the infrastructure construction in the central and western rural areas, and the financial development level is relatively backward. Digital financial inclusion can play a more powerful role in promoting the income of rural residents. Firstly, the level of economic development in the central and western rural areas is relatively backward compared with other developed areas, which requires a lot of funds and advanced technology to speed up rural construction. Digital financial inclusion can provide more benefits and abundant financial assistance for rural areas to solve the financing problem of rural development. At the same time, a series of advanced digital technologies are gradually spread to rural areas through digital financial inclusion, which helps to improve the efficiency of rural technological innovation (Li et al., 2019), accelerate the infrastructure construction in the central and western regions, and build a beautiful new countryside. The further development of digital technology in rural areas enables rural residents to enjoy the convenience brought by high technology, and start entrepreneurial activities through platforms such as the Internet, so as to improve their income levels. Secondly, the traditional financial institutions are often capital profit-seeking, and the low level of financial development in the central and western regions will generally be selectively ignored by traditional financial institutions, resulting in financial exclusion in rural areas, making it difficult to meet the financial needs of rural residents. Therefore, digital financial inclusion has great development potential in regions with low financial development level. It can reduce the threshold of financial services for rural residents, let them enjoy the benefits brought by financial policies, meet the borrowing needs of rural residents, so that rural residents have more financial capital to invest in production and life, so as to promote the improvement of residents' income level. Therefore, the promotion effect of digital financial inclusion on rural residents' income in different regions is indeed different.

### 3.2.2. Heterogeneity analysis of influencing factors

After verifying that digital financial inclusion has a heterogeneous promotion effect on rural residents' income in different counties, this paper further analyzes whether digital financial inclusion has a heterogeneous impact on rural residents' income in counties with different levels of education and financial development. Based on the benchmark model (1), this paper uses 0.5 quantile as the boundary to divide the regions with high education level and high financial development level. The panel OLS estimation and the fixed effect model are used for sub-sample regression analysis. The



specific regression results are shown in Table 6. Among Table 6, Columns (1)–(2) show the regional regression empirical results of rural residents with high education level, Columns (3)–(4) show the regional regression empirical results of rural residents with low education level, Columns (5)–(6) show the regional regression empirical results of high level of financial development, and Columns (7)–(8) show the regional regression empirical results of low level of financial development.

**Table 6.** Regression results of education level and financial development level by sample.

	OLS (1)	FE (2)	OLS (3)	FE (4)	OLS (5)	FE (6)	OLS (7)	FE (8)
	lnIRR	lnIRR	lnIRR	lnIRR	lnIRR	lnIRR	lnIRR	lnIRR
DIF	0.2078** *	0.2078***	0.1374** *	0.1374***	0.1645** *	0.1645***	0.2596***	0.2596***
	(8.1131)	(8.6411)	(4.4197)	(4.8200)	(6.3069)	(7.0855)	(8.7237)	(10.1872)
Variable control	YES	YES	YES	YES	YES	YES	YES	YES
Individual effect	YES	YES	YES	YES	YES	YES	YES	YES
Time effect	YES	YES	YES	YES	YES	YES	YES	YES
_cons	9.6604** *	9.8064***	9.8790** *	10.4763** *	9.8660** *	9.9642***	10.3438** *	10.3603** *
	(76.8223)	(108.4571)	(73.9771)	(104.5813)	(92.9895)	(116.4527)	(85.7980)	(113.3748)
N	4872	4872	4872	4872	4920	4920	4824	4824

Note: t statistics in parentheses; \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

Table 6 shows that the estimated regression coefficient of the digital inclusive financial variable DIF is significantly positive at the level of 1% in the (1)–(4) column. From the size of the estimated regression coefficient of the variable DIF, the parameter estimation value in the areas with high education level of rural residents is greater than that in the areas with low education level of rural residents. These empirical results show that under different educational levels of rural residents, digital financial inclusion has a heterogeneous impact on rural residents' income. With the improvement of rural residents' education level, the promotion effect of digital financial inclusion on rural residents' income is gradually enhanced. For a long time, the credit environment in rural areas is worse than that in urban areas, and the economic situation of rural residents cannot meet the service threshold of traditional financial institutions. Therefore, all aspects of development in rural areas will be limited by insufficient funds, such as the development of education in rural areas requires a lot of capital investment. The emergence of digital financial inclusion has successfully broken this problem, and the level of education in rural areas has increased year by year. In areas where rural residents are highly educated, it is conducive to the implementation of residents' financial education, the teaching of financial knowledge activities, and the improvement of residents' financial awareness, so as to realize digital financial inclusion more convenient to enter rural areas, provide more benefits and preferential policies for rural residents, and ultimately improve the income level of rural residents (Fan and Wang, 2013). Therefore, digital financial inclusion can better play a corresponding role in areas with high educational level of rural residents, promote the development of rural areas and improve the income of residents.

Table 6 illustrates that the estimated regression coefficient of the digital inclusive financial variable DIF is significantly positive at the level of 1% in the Columns (5)–(8), and from the size of the estimated regression coefficient of the variable DIF, the parameter estimation in the region with high financial development level is less than that in the region with low financial development level. These empirical results show that under different levels of financial development, digital financial inclusion also has heterogeneous effects on rural residents' income. With the improvement of rural financial development, the promoting effect of digital financial inclusion on rural residents' income is gradually weakened. This may be because in rural areas with high financial development, digital financial inclusion cannot further improve their income level by giving rural residents more funds and advanced technology in the short term. In general, in regions with low financial development level, their infrastructure construction level, medical facilities, education environment and so on will fall behind other regions with rapid development. The region with large financial development potential is the core target of digital financial inclusion. On the one hand, digital financial inclusion can provide substantial financial capital, accelerate infrastructure assumptions in rural areas, provide more jobs, improve the local educational environment, promote educational development in rural areas and help to increase the income of local rural residents. On the other hand, traditional finance may not be able to popularize financial services in rural areas with low levels of financial development, thus aggravating financial exclusion in rural areas. Digital financial inclusion can more inclusively accept rural areas, reduce the financial threshold of regions with low financial development level, and give rural residents more opportunities to participate in financial activities and enjoy financial services, so as to improve the income level of residents (Li and Liao, 2020).

Based on the above analysis, Hypothesis 2 is valid. Digital financial inclusion has a heterogeneous impact on rural residents' income, which is mainly reflected in regional development, education level and financial development level.

## 4. Further discussion

### 4.1. Impact mechanism analysis

In order to further analyze the impact mechanism of digital financial inclusion on rural resident's income, this paper adds the interaction items of industrial structure, resident's education level, financial development level and digital financial inclusion on the basis of models (1)–(2), which constitutes the regression models (3)–(8). Based on models (3)–(8), this paper uses panel OLS estimation and fixed effect models to analyze the moderating effects of industrial structure, resident's education level and financial development level on the impact of digital financial inclusion on rural resident's income. The specific regression results are showed in Table 7. Among Table7, Columns (1)–(2) show the empirical regression results to explore the adjustment effect of industrial structure, Columns (3)–(4) show the empirical regression results to explore the adjustment effect of the resident's education level, and Columns (5)–(6) show the empirical regression result to explore the moderating effect of financial development level.

**Table 7.** Regression results of the moderating effects of industrial structure, education level, and financial development level.

	FE (1)	OLS (2)	FE (3)	OLS (4)	FE (5)	OLS (6)
	lnIRR	lnIRR	lnIRR	lnIRR	lnIRR	lnIRR
DIF	0.0628*** (3.0828)	2.1966*** (39.7224)	0.0365 (1.4435)	2.0461*** (29.0774)	-0.0300 (-1.4651)	2.1142*** (35.5389)
FIS	0.2089*** (13.8506)	0.1301** (2.4560)				
FEL			3.1519*** (8.5619)	5.0501*** (4.5469)		
FFD					0.1703*** (22.2052)	0.1218*** (3.9987)
IS	-0.2712*** (-15.9352)	-0.1251** (-2.5000)	-0.0590*** (-7.7116)	-0.0077 (-0.6346)	-0.0732*** (-9.7708)	-0.0109 (-0.8953)
EL	1.4262*** (7.0176)	3.6853*** (11.9943)	-1.3239*** (-3.5909)	-0.6130 (-0.6128)	1.3689*** (6.8628)	3.6689*** (11.8839)
FDL	-0.2913*** (-60.7277)	-0.2714*** (-33.9587)	-0.2892*** (-59.8656)	-0.2700*** (-33.8060)	-0.4546*** (-51.7277)	-0.3792*** (-13.0838)
Variable control	YES	YES	YES	YES	YES	YES
Individual effect	YES	YES	YES	YES	YES	YES
Time effect	YES	YES	YES	YES	YES	YES
_cons	10.1865*** (151.8337)	10.5600*** (163.3420)	10.2389*** (146.8669)	10.6938*** (147.7298)	10.3073*** (155.5547)	10.6369*** (153.9450)
N	9744	9744	9744	9744	9744	9744

Note: t statistics in parentheses; \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

It can be seen from Table 7 that the FIS estimated regression coefficient of the interaction term between digital financial inclusion and industrial structure, the FEL estimated regression coefficient of the interaction term between digital financial inclusion and residents' education level, and the FFD estimated regression coefficient of the interaction term between digital financial inclusion and financial development level are significantly positive at the level of 1% in Columns (1)–(6). These empirical results show that at different regional levels, the industrial structure, the education level of rural residents and the level of financial development will enhance the role of digital financial inclusion in promoting the income of rural residents. From the estimated regression coefficients of the three interactive terms, there are also significant differences in the regulatory effects of the three. Among them, the positive regulatory effect of rural residents' education on the impact of digital financial inclusion on rural residents' income is stronger than the other two variables. There may be several reasons for this. First, with the development of digital financial inclusion, the industrial structure in rural areas will be gradually transformed, adjusted and upgraded due to the large inflow of funds. The proportion of the primary industry with low output value in the GDP of rural areas will begin to decline year by year, and the introduction of high-tech digital technology can improve the level of scientific

and technological innovation in rural areas and accelerate the development of the tertiary industry (Pan et al., 2012). Therefore, the high value-added tertiary industry can drive the economic development of rural areas and promote the increase of rural residents' income. Second, education in rural areas will also benefit from digital financial inclusion and flourish, so as to improve the education level of rural residents. Digital financial inclusion can provide abundant funds for the local government to improve the education level in rural areas, improve the teaching environment, and attract more excellent teachers to join the construction of rural education (Kemfert and Schmalz, 2019). In addition, the problems of student loans and learning funds for rural residents have been solved by the emergence of digital financial inclusion. It can be seen that digital financial inclusion can improve rural residents' cognitive ability and learning ability by improving their education level. This will help them understand and accept digital financial inclusion more comprehensively, and increase their income by selecting more appropriate financial products and services. Third, the financial development level of a region is one of the comprehensive manifestations of regional economic strength. Digital financial inclusion can drive the construction of financial infrastructure in rural areas through strong financial capital, set up more service outlets, improve the financial service system and improve the level of regional financial development (Zhong and Li, 2020). In addition, it can also reduce the cost of financial services through advanced digital technology, improve the coverage of financial services in rural areas, improve the risk prevention ability of local financial institutions, and give rural residents a high-quality financial experience. With the improvement of regional financial development level, the types of financial products and the efficiency of financial services will gradually improve, which is conducive to meeting the financial needs of rural residents, so as to improve the income level of residents. To sum up, assumptions 3, 4 and 5 in this paper are valid. Through mechanism analysis, this paper finds that industrial structure, education level and financial development level can enhance the promotion effect of digital financial inclusion on rural residents' income, and the promotion effect of education level is more significant among the three. This shows that education is the core key element of digital financial inclusion affecting rural residents' income.

#### 4.2. Robustness test

For testing the robustness of this conclusion and avoid the endogenous problem in the model, in view of the research of other scholars (Li et al., 2021), this paper uses the two-stage least square method (2SLS) to solve the above problem. On the basis of models (1)–(2), this paper selects the first-order lag term of DIF as the instrumental variable to further analyze the impact of digital financial inclusion on the income of rural residents, so as to test whether the conclusion of this paper is robust. The specific regression results of robustness test are shown in Table 8. In Table 8, Column (1) shows the 2SLS regression results controlling the individual effects of counties, Column (4) lists the 2SLS regression results controlling the individual effects of provinces, and the other three columns are the regression results mentioned above.

It can be seen from Table 8 that the estimated regression coefficients of digital inclusive financial variable DIF are significantly positive at the level of 1% in columns (1)–(5). These empirical results show that under the control effects of different regional levels, digital financial inclusion can significantly improve the income of rural residents. Therefore, the conclusion of this paper is robust.

**Table 8.** Empirical results of robustness test.

	2SLS (1)	OLS (2)	FE (3)	2SLS (4)	OLS (5)
	lnIRR	lnIRR	lnIRR	lnIRR	lnIRR
DIF		0.1837*** (9.8718)	0.1837*** (9.0648)		2.2783*** (47.6788)
L.DIF	0.1214*** (7.3489)			2.1048*** (44.9782)	
Variable control	YES	YES	YES	YES	YES
Individual effect	YES	YES	YES	YES	YES
Time effect	YES	YES	YES	YES	YES
_cons	10.4676*** (106.5617)	10.0770*** (149.5055)	9.9220*** (102.4827)	9.9746*** (137.4780)	10.4945*** (178.6084)
N	8120	9744	9744	8120	9744

Note: t statistics in parentheses; \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

## 5. Conclusions

Based on the panel data of 1624 counties in 27 provinces and municipalities in Chinese mainland during the past 2014–2019 years, this paper analyzes the impact of digital financial inclusion on the rural residents' income and regional heterogeneity, and further explores the moderating effects of industrial structure, education level of rural residents and financial development level on the impact of digital financial inclusion on rural residents' income (Sukharev et al., 2020), and draws the following conclusions.

Digital financial inclusion can significantly improve the income level of rural residents, and the degree of improvement is significantly different at different regional levels and different quantiles of rural residents' income. The study found that the promotion effect of provincial level control effect is greater than county level. In different quantiles of rural residents' income, with the increase of quantiles, the promotion effect of digital financial inclusion on rural residents' income is gradually enhanced (Liu et al., 2019).

Digital financial inclusion has a heterogeneous impact on the income of rural residents in different regions. First, digital financial inclusion has a more significant role in promoting the rural residents' income in the central and western parts of the Chinese mainland, while the impact on the income of the rural residents in the eastern region is not obvious. This shows that digital financial inclusion has a regional differential impact on the income of rural residents. Second, in areas where rural residents have different levels of education, digital financial inclusion also has a heterogeneous impact on rural residents' income. With the improvement of rural residents' education level, the role of digital financial inclusion in promoting rural residents' income is gradually increasing. Third, in regions with different levels of financial development, digital financial inclusion also has a heterogeneous impact on the income of rural residents. With the improvement of rural financial development level, the role of digital financial inclusion in promoting rural residents' income is gradually weakened.

In the mechanism analysis, by exploring the regulatory effects of industrial structure, education level of rural residents and financial development level, this paper finds that these three significantly

increase the promotion effect of digital financial inclusion on rural residents' income. There are obvious differences in the intensity of the regulatory effect of these three variables. The educational level of rural residents has a stronger promoting effect on the impact of digital financial inclusion on the income of rural residents than the level of industrial structure and financial development.

In view of the above research conclusions, this paper puts forward the following enlightenment and suggestions: First, in the process of considering the construction of rural areas, governments should actively promote the development of digital financial inclusion in rural areas (Kawabata, 2019). The government should establish and improve the infrastructure construction of digital financial inclusion as soon as possible so that reducing the cost of financial services, improving the efficiency of financial services, bringing more preferential, safe and appropriate financial credit products to rural residents (Li et al., 2020), and solving the problem of loan difficulty of rural residents.

Second, in view of the regional heterogeneous impact of digital financial inclusion on the income of rural residents, local governments need to adjust measures to local conditions and implement differentiated development strategies while promoting the development of digital financial inclusion in rural areas (Matei, 2020). For the relatively backward areas, we should strengthen rural policy support, constantly improve and improve rural infrastructure construction, and further narrow the gap between urban and rural areas in education, finance, public services and so on.

Third, whether from the theoretical analysis or empirical results, the education level of rural residents, the level of financial development and the industrial structure can improve the role of digital financial inclusion in promoting the income of rural residents (Li and Dong, 2021). Therefore, the government should further accelerate the industrial transformation and upgrading in rural areas, and gradually shift the dependence on the primary industry to the secondary and tertiary industries, which will help to provide more employment opportunities for rural residents, increase the income of rural residents and accelerate the development of rural areas. Secondly, the government and relevant financial institutions should improve the education level in rural areas, promote the dissemination of digital finance education knowledge, and strengthen the education of rural residents in digital financial inclusion. This helps to improve rural residents' cognitive ability and risk identification ability of financial products, so as to realize digital financial inclusion and promote the improvement of rural residents' income. Finally, government departments should further improve the relevant laws and regulations of digital financial inclusion, improve the financial service and supervision system, and speed up the construction of credit investigation system in rural areas. This will help to reduce the risk of rural residents enjoying financial products and services and maximize the interests of rural residents.

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## **Conflict of interest**

All authors declare no conflicts of interest in this paper.

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